The proposed course aims at explaining the nature of the subject. It throws light on the importance of geography and describes the nature of geography as a subject. It attempts to enrich knowledge and illustrate basic concepts as well as technical terms which are building blocks of geographic knowledge. Effort, however, has been made to develop the concepts in a graded and sequential manner and deepen the interest in the subject.

Geography is one of the oldest earth science and its roots date back in the works of the early Greek scholars. The word ‘geography’ was first used by the Greek scholar Eratosthenes in the third century B.C.

Geo “Earth” and Graphy “to describe” literal meaning of geography is to describe about the earth’s surfaces. In other words “Geography is largely the study of the interaction of all physical and human phenomena and landscapes created by such interactions.” It is about how, why, and where human and natural activities occur and how these activities are interconnected.

Geography has undergone changes in its approach. The earlier geographers were descriptive geographers. Later, geography came to be developed as an analytical science. Today the discipline is not only concerned with descriptions but also with analysis as well as prediction.

In this lesson you will learn how important geography is in everyday life. This study will encourage you to understand your own place and spaces with greater interest.

**OBJECTIVES**

After studying this lesson, you will be able to:

- appreciate the use of Geography in daily life;
- trace development of Geography as a discipline;
The study of Geography as a discipline

- understand man-environment relationships and their impacts on each other;
- illustrate the systematic and regional approaches of Geography;
- understand various analytical techniques in Geography;
- identify the different branches of Geography and its scope.

1.1. GEOGRAPHY IN DAILY LIFE

You must have noticed that the earth’s surface is ever changing; in general, the natural phenomena like mountains, rivers, lakes etc. change slowly while the cultural elements like buildings, roads, crops, change fast. Travelling from one place to another you notice that the trees number and types of trees change from area to area. All this is because of the continuous interaction between the environment in which we live in and the way we use it. The study of Geography is about observing such patterns. Another aspect of geography is to understand the factors or reason behind areal differentiation, how do social, cultural, economic and demographic factors change our physical landscape and create new or altered landscapes by human interventions. For example, human settlements are transformation of forest or barren lands for living purpose by human being.

Geography is often thought of as the art of making and studying maps. Maps give us a much more correct and graphic view of the way the Earth’s surface looks compared to a picture of drawing. As earlier, even today geographical information about an area is available through reports, travel diaries and gazeteers. At present maps can be drawn by using satellite images using Geographic Information Systems (GIS) tools. Computers easily convert the information from satellite images into maps to show what changes development can bring about. Such information is of benefit to the society. Such mapmakers are in great demand today. Nowadays geographers, engineers, environmental scientists, city planners, social scientists, and many others learn to use GIS to understand the Earth better.

Geography, not only investigates what is where on the Earth, but also why it is there. Geographers study the location of the activities, carefully identify patterns using maps and find out the reasons for these patterns. The areas are then described based on the distribution of land forms, population, house type and agriculture. They discover the linkages and movements between places and are able to infer the spatial processes that are working in an area.

Today, all over the world there are problems related to providing food security, health, effective energy use and environmental conservation. Equally important are equality issues and sustainable development. All these can be achieved by using our resources in sustainable ways. Study of geography is, therefore, necessary to learn more about environmental processes and to understand how land use planning can help us to overcome problems.
Nature of Geography as a discipline

In brief:
1. Geography is a science of space.
2. Maps are an essential tool of geographers.
3. Digital Geographical Information system is a new tool for making maps.
4. Spatial Planning can be done using both maps and the study of geography

Basic Concepts

Geography has been defined differently through different periods of its history. Geographical work in ancient Greece had followed two distinct traditions. One was the mathematical tradition which was focused on fixing the location of places on the earth’s surface, and the other was gathering geographic information through travels and field work. According to them, the purpose of geography was to provide a description of the physical features and conditions in different parts of the world. The emergence of regional approach in geography also emphasized the descriptive character of geography. According to Humboldt, geography is the science related to nature and it studies and describes all material things found on earth. Another important school of thought defined geography as the study of man-environment relationships.

- Geography as a study of the earth’s surface.
- Geography as the study of man-environment relationships.

INTEXT QUESTION 1.1

1. What is geography

________________________________________________________

2. Why is earth’s surface changing

________________________________________________________

3. Which are the two distinct traditions followed by Greeks

(i) ____________________________ (ii) ____________________________

1.2 DEVELOPMENT OF GEOGRAPHY

(A) Ancient Period

The earliest records illustrate the interests of scholars in understanding the physical domain of the earth by making maps and astronomical measurements. The Greeks are given the credit of being the earliest geographers, prominent among them being Hower, Herodotus, Thales Aristotle and Eratosthenes.
Nature of Geography as a discipline

(B) Pre-Modern Period
This period starting from the middle of 15th century and continuous with 18th early provides us enormous information about the physical and cultural nature of the world by the travels and explorations of early geographers. The early seventeenth century witnessed the beginnings of a new scientific geography. Christopher Columbus and Vasco de Gama, Fesdinend Meghelan and Thomas Cook were important explorers and travelles among those. Varenius, Kant, Humboldt and Ritter led the geographers of this period. They contributed in the development of cartography and discovering new lands, and developing geography into a scientific disciplines.

(C) Modern Period
Ritter and Humboldt are frequently referred to us the founders of modern geography. Generally, latter half of nineteenth century is considered as a period of modern geography. The first modern geographer in true sense was Ratzel who built the structure of modern geography on the foundations laid down by classical geographers.

(D) Recent Period
The development of geography during the post Second World War period has been very rapid. The American and European geographers such as Hartshorne have contributed the maximum during this phase. Harthshorne described geography as a science dealing with areal differentiation. The present day geographers look upon regional approach and systematic aproach as complimentary rather than contradictory.

1.3 SCOPE OF GEOGRAPHY
Geography has now acquired the status of science that explains the arrangements of various natural and cultural features on the earth surface. Geography is a holistic and interdisciplinary field of study engaged in understanding the changing spatial structure from past to the future. Thus, the scope of geography is in various disciplines, like armed services, environment management, water resources, disaster management, meteorology and planning and various social sciences. Apart from that, a geographer can help in day to day life like tourism, commuting, housing and health related activities.

1.4 APPROACHES TO STUDY OF GEOGRAPHY
Today, geography is the only discipline that brings all natural and human sciences on a common platform to understand the dynamics of the spatial configuration of the earth surface. There are two main approaches in geography:
1. Systematic
2. Regional

1. Systematic Approach
A study of specific natural or human phenomenon that gives rise to certain spatial patterns and structures on the earth surface is called systematic study. Ordinarily, systematic geography is divided into four main branches.
Nature of Geography as a discipline

(i) Physical geography,
(ii) Biogeography, including environmental geography,
(iii) Human geography,
(iv) Geographical methods and techniques

(i) It deals earth systems like atmosphere (air), the hydrosphere (water), the lithosphere (earth solid rock) and biosphere, which encompasser all of earth’s living organisms.
(ii) It focusses on various kinds of forests, grasslands, distribution of flora and fauna, human nature relationships and the quality of the living environment and its implications for human welfare.
(iii) It describes culture, populations, dynamics of social, economic, and political aspects of space.
(iv) It deals with methods and techniques for field studies, qualitative quantitative and cartographic analysis and Geographic Information System and Global positioning system (GIS and GPS) and remote sensing.

- Geography has developed in four periods i.e. ancient period, pre-modern period, modern period and recent.
- Contribution of Harthshorne is pioneering in the field of geography in recent period.
- Geography is a holistic and interdisciplinary field of study engaged in understanding the changing spatial structure at different territorial levels.

2. Regional Geography

Unlike systematic geography, regional geography starts with the spatial imprints of one or all the systematic geographic processes discernible as regions of different sizes. Regions could be based on a single factor like relief, rainfall, vegetation, per capita income. They could also be multifactor regions formed by the association of two or more factors. Administrative units like, states, districts, tehsils also can be treated as regions. The main sub branches of regional geography are:

(i) Regional studies
(ii) Regional analysis
(iii) Regional development
(iv) Regional planning including areas and community planning.

- Two main approaches in geography i.e (i) systematic and (ii) regional
- Systematic geography is divided into four branches.
- Regional geography has also four branches.
INTEXT QUESTION 1.2

1. Which are the four branches of systematic geography.

(i) _____________ (ii) _____________ (iii) _____________ (iv) _____________

2. Name the main branches of regional geography.

________________________________________________________________________

1.5 GEOGRAPHY AND SOCIETY

Geographical thinking and concepts affect our daily decisions in a number of ways—

For example when urban master plans are made or rural development strategies are considered, it is important to understand the physical structure, climatic conditions and availabilities of resources in an area. The decision to shift industries from city areas would require the extension of industrial land use into farming areas. This would displace farmers and their source of income. Similarly, the construction of a railway line or highway causes ribbon development. Many economic activities concentrate along such corridors. Now a days with the need to provide relief material to all affected persons after a flood or an earthquake requires a good understanding of the geography of the area. Distribution of relief is functional and related to the needs of people, according to climate or terrain.

1.6 METHODS AND TECHNIQUES OF GEOGRAPHY

Each branch of systematised knowledge has certain methods / tools and techniques on which it depends to further its basic objectives. Geography too has its tools, techniques and methods. Important among them are globes, maps, diagrams, relief models and spatial analytical methods. Cartography is concerned with preparation of maps and diagrams to show distribution of geographical phenomena. Important methods in geography are deductive and inductive in nature. Various statistical techniques and models are used for regional analysis and to understand spatial distribution and interaction.

(A) Cartography

Most of us are fascinated with maps. “Cartography” is the study and practice of making maps and diagrams. It represents the earth with maps and abstract symbols. Maps have traditionally been made using pen, ink and paper, but computers have revolutionised cartography and with GIS methods one can prepare maps and diagrams with greater choice and efficiency.

Spatial data is obtained from measurement and other published sources and can be stored in a database, from which it can be extracted for a variety of purposes. Current trends in this field are moving away from drawing with ink or paper type
Nature of Geography as a discipline

methods of map making towards the creation of increasingly dynamic, interactive maps that can be manipulated digitally. Most commercial quality maps are now made with map making software that falls into one of three main types; Computer aided data management (CAD), Geographic Information Systems (G.I.S) and Global Positioning systems (GPS).

Cartography has grown from a collection of drafting techniques into an actual science. Cartographers must understand which symbols convey information about the Earth most effectively, and make such maps that will encourage everyone to use the maps to find places or use it for their daily work. A cartographer must learn geodesy and fairly advanced mathematics to understand how the shape of the Earth affects the distortion of map symbols projected onto a flat surface for viewing.

“Geographic Information Systems” deals with the storage of information about the Earth for automatic retrieval by a computer in an accurate manner. In addition to other sub disciplines of geography, GIS specialists must understand computer science and database systems. Maps have traditionally been used to explore the Earth and to exploit its resources. GIS technology, as an expansion of Cartographic science, has enhanced the efficiency and analytic power of traditional mapping. Now, as the scientific community recognizes the environmental consequences of human activities, GIS technology is becoming an essential tool in the effort to understand the process of global change. Various map and satellite information sources can combine in ways that recreate the interactions of complex natural systems. Such visualisation can help to predict what will happen to an area if it is repeatedly flooded, or what changes are expected if a particular industry is located or developed in an area.

Next to Survey of India, inherited from the British Ordinance Survey, the NATMO is a premier organization for mapping in India. Its maps of one million series are well known. The organisation of the Cartographic Unit in 1960s at the French Institute, Pondicherry, brought a significant impact on the development of Geography in India. Its publication of Vegetation and Soil maps at the scale of 1:100000 were very well received for their cartographic appreciation and resource mapping. This Unit was upgraded in 1995 as a Geomatics Laboratory with an emphasis of computer cartography and GIS.

(B) Quantitative methods in Geography

These aspects of geographical techniques deal with numerical methods most commonly found in geography. In addition to spatial analysis, you are likely to find methods like cluster analysis, discriminant analysis in geographic studies. These statistical techniques are introduced to you in later chapters and you will find that when you undertake the local area study, you yourself will see how useful these methods are in finding patterns and identifying relationships between space and the activities that are performed in them.

(C) Regional science method

In the 1950s, the regional science movement arose led by Walter Isard. This
provided a more quantitative and analytical base to geographical questions, in contrast to the more qualitative tendencies of traditional geography. Regional Science comprises the body of knowledge in which like regional economics, resource management, location theory, urban and regional planning, transportation and communication, human geography, population distribution, landscape ecology, and environmental quality are examined for regional development.

1.6 BRANCHES OF GEOGRAPHY

Variable phenomena on the earth’s surface can be treated separately or in association. They are classified and categorised into physical phenomena and human phenomena. Thus geography has three main branches: Physical Geography, Human Geography and Regional Geography.

![Fig 1.1: Branches of Geography]
A. Physical Geography

Physical geography is concerned with the study and explanation of physical phenomena, encompassing the other such fields like geology, meteorology, zoology and chemistry. It became a very popular subject during the later part of the nineteen century. It has a number of sub-branches which treat different kind of physical phenomena.

(i) Astronomical Geography: It studies the celestial phenomena which concern the Earth’s surface particularly Sun, Moon and Planets of the Solar System.

(ii) Geomorphology: It is concerned with the study of the landforms on the Earth’s surface. It includes origin and development of landforms through erosional, transportational and depositional processes of water, wind and glaciers.

(iii) Climatology: Climatology is the study of the atmospheric conditions and related climatic and weather phenomena. It includes the study of atmospheric composition, climatic regions seasons, etc.

(iv) Oceanography: It is concerned with the study of various types of Oceanic formate component and processes related to ocean floor depths, currents, corals reefs, and continental drifts etc.

(v) Soil Geography: It studies various soil forming processes, their physical, chemical and biological constituents, their colour and types, texture, and distribution and carrying capacity etc.

(vi) Bio-geography: It is concerned with the biological phenomena in space, especially in terms of the distribution of various kinds of floral and faunal species. Biogeography may be subdivided into plant or floral geography, animals or faunal geography, and human ecology.

B. Human Geography

Human Geography is the synthetic study of the relationship between human societies and the earth’s surface. It is made up of three closely linked components: the spatial analysis of the human population; the ecological analysis of the relation between human population and its environment and the regional synthesis which combines the first two themes in an areal differentiation of the earth’s surface.
The study of Geography as a discipline

Nature of Geography as a discipline

Human geography has a number of sub-branches.

(i) **Anthropogeography**: It largely deals with racial phenomena in their spatial context.

(ii) **Cultural geography**: It focusses on the origin, components and impact of human cultures, both material and non-material.

(iii) **Economic geography**: It refers to the study of the location and distribution of economic activities at the local, regional, national and world scale. Economic geography can be studied under the following heads: Resource geography, Agricultural geography, Industrial and transport geography.

(iv) **Political geography**: It is the study of political phenomena in their spatial context. Main focus remains for creation and transformation of political and administrative region.

(v) **Historical geography**: Spatial and temporal trends of geographical phenomena are studied in Historical geography.

(vi) **Social geography**: It is the analysis of social phenomena in space. Poverty, health, education, livelihood are some important fields of study in social geography.

(vi) **Population geography**: It is the study of various dimensions of population like its population distribution density, composition, fertility, mortality, migration etc.

(viii) **Settlement geography**: It is the study of Rural/Urban settlements, their size, distribution, functions, hierarchy, and off various other parameters of settlement system.

(C) **Regional geography**: Aspects such as delineation of regions, their geographical characteristics and processes of change constitute regional geography.

---

**INTEXT QUESTION 1.3**

1. What are the two branches of geography?
   (i) ____________________________  (ii) ____________________________

2. Name the two techniques of geographical study?
   (i) ____________________________  (ii) ____________________________

3. What is Anthropogeography?
   ________________________________
Nature of Geography as a discipline

- Geography has three main branches: physical, human, and regional.
- Physical geography deals with the nature of physical phenomena such as climatology, soil, and vegetation.
- Human geography deals with the relationship between human societies and the earth’s surface.
- Geography as an interdisciplinary subject.

1.7 GEOGRAPHY AS AN INTERDISCIPLINARY SUBJECT

Geography has its strong relation with mathematics, natural sciences, and social sciences. While other sciences deal with distinctive types of phenomena, geography studies several kinds of phenomena, each already studied by another science. In an integrated manner, thus, geography has firmly established itself as a discipline of synthesis. Fig. 1.2 gives the idea of integrating science.

WHAT YOU HAVE LEARNT

Geography is a science of space. Geography is both a natural and social science.
Nature of Geography as a discipline

as it studies both environment and the people. It connects the physical and cultural world. Physical geography studies the earth systems that create natural environment. Human geography is concerned with the political, economic, social, cultural and demographic processes. It is concerned with the different ways in which resources are used.

Earlier geography merely described places. Even though, this is still a part of geography, the pattern of description has changed a lot in recent years.

Geographical phenomena and processes are generally described by two approaches viz. (i) regional and (ii) systematic. Regional approaches are characterized by understanding the formation and characteristics of regions. They try to focus on how and why areas are different from each other. Regions can be physical, social, economic, political, demographic etc.

Systematic approach is organized in terms of particular phenomena of general geographic significance. Each phenomena is studied in terms of the relations of its areal differentiations with the others.

Now we understand the cause and impact of natural and human phenomena in creating physical and human landscapes.

Geography has three main branches: Physical, human and regional. Physical geography is further subdivided into several other branches namely, geomorphology, climatology, oceanography, soil and biogeography. Human Geography is also subdivided into other branches like, cultural, population, social, economic and political. Regional geography is subdivided in other branches like Macro, Meso and Micro. All these subjects are interrelated to each other.

TERMIAIL QUESTION

1. Answer the following questions in brief:
   (i) Define the term Geography.
   (ii) Why is geography called the mother of all sciences.
   (iii) What are the two basic approaches in geography.
   (iv) What are the four phases of development of geography.
   (v) Define the terms physical and human geography.

2. Distinguish between the following
   (i) Systematic and regional geography.
Nature of Geography as a discipline

(ii) Physical geography and biogeography.
(iii) Population and economic geography.

3. Why is human geography an important part of geography. Explain with suitable explains.

4. Discuss the techniques of geographical studies.

**ANSWER TO INTEXT QUESTIONS**

1.1

1. Geography is largely the study of the interaction of all physical and human phenomena and landscapes created by such interactions.

2. Earth surface is changing because of the continuous interaction between the environment in which we live in and the way we use it.

3. (i) Mathematical tradition,
   (ii) Geographic information through travel and field work.

1.2

1. (i) Physical Geography, (ii) Biogeography,
   (iii) Human Geography and (iv) Geographical Methods and techniques.

2. (i) Regional studies, (ii) Regional analysis,
   (iii) Regional development and (iv) Regional planning.

1.3

1. (i) Physical (ii) Human

2. (i) Cartography (ii) Quantitive methods or (iii) Regional science method

3. It deals largely with racial phenomena in their spatial context.

**HINTS TO TERMINAL QUESTIONS**

1. (i) Refer to para one.
   (ii) Refer to 1.1
   (iii) Refer to 1.4
The study of Geography as a discipline

(iii) Refer to 1.6 (B)

1. Refer to 1.4

2. (i) Refer to 1.4
   (ii) Refer to 1.6 (A)
   (iii) Refer to 1.6 (B)

3. Refer to 1.6 (B)

4. Refer to 1.4
EARTH’S INTERIOR AND ITS MATERIAL

The earth is the only known planet with developed life in the universe. Like most of the celestial bodies, the earth is spherical in shape. You also know that hot water and molten lava eject out from the earth’s interior. This indicates that the temperature below the earth’s surface is very high. World’s deepest mining is limited only to the depth of less than 5 kilometers. These activities can be explained by getting a better understanding of Earth’s interior. As we know that the land features seldom retain any fixed form. Their shape is constantly changing. One group of exogenetic forces includes those which weaken and disintegrate the rocks at their original location. The second group consists of indogenetic forces which remove the disintegrated rocks from high lands and deposit them in the low lands. These two processes have been responsible for disintegrating rocks and shaping new landforms. They are also partly responsible for the formation of soil, which is very important for us.

In this lesson, we will study about the earth’s interior and the materials that form the upper portion of the earth’s crust. You will also learn about, weathering and its types, the process of gradation and the significance and formation of soils.

OBJECTIVES

After studying this lesson, you will be able to:

- explain the limitations of direct observations of the earth’s interior;
- compare the different layers of the earth’s interior with reference to thickness, temperature, density and pressure;
- distinguish between rock and mineral;
Earth’s Interior and Its Material

- classify rocks according to their mode of formation;
- describe the economic significance of rocks;
- explain the term weathering and describe its types with suitable examples;
- explain the various gradational processes changing the face of the land;
- differentiate between degradation and aggradations;
- relate weathering with soil formation and
- explain the various factors contributing to soil formation;

2.1 EARTH’S INTERIOR

It is not possible to know about the earth’s interior by direct observations because of its huge size and the changing nature of its internal composition. Through mining and drilling operations we have been able to observe the earth’s interior directly only up to a depth of few kilometers. The rapid increase in temperature below the earth’s surface is mainly responsible for setting a limit to direct observation inside the earth. The temperature in the earth’s interior is so high that it can even melt any tool used for drilling. This fact also restricts deep drilling, thus causing hindrance to direct observation of the materials of the earth’s interior.

The huge size of the earth and increasing temperature with depth has set a limit to direct observation of the earth’s interior.

Fig. 2.1 Concentric Zones showing layers of the Earth’s interior
Earth’s Interior and Its Material

2.2 STRUCTURE OF THE EARTH’S INTERIOR

The above diagram (see fig. 2.1) shows the concentric layers of the earth’s interior. The innermost layer surrounding the earth’s centre is called core, which is about 3500 kms in radius. Core is the most dense layer of the earth with its density range from 9.5 to 14.5 and sometimes even higher. It is composed mainly of the iron and nickel thus commonly known as Nife. (Nickel+Ferrum). Core consists of two sub-layers. The inner one is solid (C₀ of fig. 2.1) and the outer one is semi-liquid (C₁ of fig. 2.1). The layer surrounding the core is known as mantle, a rock shell about 2900 kms thick and is composed of basic silicates. Major constituent elements of mantle are magnesium and silicon, hence, this layer is termed as Sima (Silica+Magnesium). The density of this layer varies from 3.3 to 5.7. Mantle is surrounded by the outermost layer of the earth, known as lithosphere and its density varies from 2.70 to 2.95. Major constituent elements of lithosphere are silica (Si) and aluminium (Al), thus this layer is termed as Sial (Silica+Aluminium). The outermost part of the lithosphere in known as crust, normally about 8 to 40 kms thick.

- Core, mantle and crust are the three main concentric layers of the earth’s interior.
- Core is the innermost layer and has the highest density. It is made up mainly of nickel and iron.
- Mantle is the layer lying between the core and lithosphere. Its major constituents are silicon and magnesium.
- Crust is the outermost layer of the earth and is mainly composed of silicon and aluminium.

INTEXT QUESTIONS 2.1

1. Give the most important factor limiting direct observation of the earths interior to a few kilometers

__________________________________________________________________________

2. Name the three layers of the earth’s
   (a) ___________________ (b) ___________________ (c) ___________________

3. Name the innermost layer of the earth.

__________________________________________________________________________

4. What is the density of the core?

__________________________________________________________________________

5. Which layer includes the earth’s crust?

GEOGRAPHY
### NOTES

6. Name the thinnest layer of the earth

<table>
<thead>
<tr>
<th>Earth’s Interior and Its Material</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6.</strong> Name the thinnest layer of the earth</td>
</tr>
</tbody>
</table>

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#### 2.3 TEMPERATURE, PRESSURE AND DENSITY OF THE EARTH’S INTERIOR

**Temperature**

Rise in temperature with increase in depth is observed in mines and deep wells. These evidences along with molten lava erupted from the earth’s interior, support that temperature increases towards the centre of the earth. The different observations show that the rate of increase of temperature is not uniform from the surface towards the earth’s centre.

It is faster at some places than at others. In the beginning this increase is at an average rate of 1°C for every 32 metres increase in depth. At such a constant rate of increase in temperature, at 10 km depth, the temperature will be approximately 300°C and at 40 km depth it will be 1200°C. At this rate, earth’s interior should be in a molten state. Yet it is not so because the rocks buried under the pressure of several km thickness of overlying rocks melt at higher temperature than similar rocks at the surface. A basaltic lava rock which melts at 1250°C at the surface will melt at 1400°C at 32 km depth. The extra heat required for melting is produced by radioactivity. It is the result of breakdown of atomic nuclei of minerals emitting radiant energy in the form of heat from the rocks.

The behaviour of earthquake waves is another evidence for this phenomenon. They further confirm that the composition of different layers is as variable as is the rate of change of temperature. While in the upper 100 km, the increase in temperature is at the rate of 12°C per km, in the next 300 km it is 20°C per km but is only 10°C per km below it. Thus the rate of increase of temperature beneath the surface decreases towards the centre. The temperature at the centre is estimated to lie somewhere between 3000°C and 5000°C. Such a high temperature inside the earth may be due to chemical reactions under high pressure conditions and disintegration of radioactive elements.

**Pressure**

The pressure also increases from the surface towards the centre of the earth due to huge weight of the overlying rocks. Therefore in deeper portions, the pressure is tremendously high. The pressure near the centre is considered to be 3 to 4 million times the pressure of atmosphere at sea level. At high temperature, the material beneath will melt towards the central part of the earth. This molten material under tremendous pressure conditions acquires the property of a solid and is probably in a plastic state.
Density

Due to increase in pressure and presence of heavier materials towards the earth’s centers, the density of earth’s layers also goes on increasing. Obviously the materials of the innermost part of the earth are very dense as already stated.

**INTEXT QUESTIONS 2.2**

1. What is the temperature at the centre of the earth?
   
2. How much is the pressure at the earth’s centre?
   
3. Why does the density increase towards the centre of the earth?
   
**2.4 MATERIALS OF THE EARTH’S CRUST**

The outermost part of lithosphere is called crust. This is the most significant part of the earth because it is occupied by humans. The material of the crust is made up of rocks. The rocks are of different types. They are hard like granite, soft like clay and loose like gravel. Rocks have a great variety of colour, weight and hardness.

Rocks are composed of minerals. They are aggregates or physical mixture of one or more minerals. Minerals on the other hand are made up of two or more elements in a definite ratio. They have a definite chemical composition. Crust is made up of more than 2000 minerals, but out of these, 6 are the most abundant and contribute the maximum to this uppermost part of the earth. These are feldspar, quartz, pyroxenes, amphiboles, mica and olivine.

Granite is a rock and its constituent minerals bound together are quartz, feldspar and mica which make it a hard rock. Change in the ratio of these minerals give rise to granites of different colours and hardness. The minerals containing metals are called metallic minerals. Haematite, a major iron ore is a metallic mineral. Ores are metallic minerals which can be profitably mined. Rocks are of immense economic importance to us.

**2.5 TYPES OF ROCKS**

Rocks differ in their properties, size of particles and mode of formation. On the basis of mode of formation rocks may be grouped into three types:

(a) Igneous

(b) Sedimentary and

(c) Metamorphic

**Igneous Rocks**

The word igneous is derived from the Latin word ‘ignis’ meaning fire. Igneous
rocks are formed by the cooling of highly heated molten fluid material, known as magma. The word magma is derived from a Greek word which means ‘dough’. It requires a greater quantity of heat to melt the rocks under overlying pressure than at the surface. We do not know the exact depths at which magma forms but probably it is formed at different depths not exceeding 40 km. Molten rocks produce an increase in volume which is responsible for causing fractures or cracks in the crust. The overlying pressure gets weakened along these openings, thus forcing out the magma through them. Otherwise it can’t escape due to great overlying pressure.

When magma is ejected to the surface, it is called lava. Igneous rocks are formed from solidified molten magma below or on the earth’s surface. As they comprise the earth’s first crust and all other rocks are derived from them, these are called the parent of all rocks or the ‘primary rocks’. In simple words, all rocks can be described as of igneous origin because at one time or another, they were erupted to the surface: A younger series of igneous rocks is still being formed. About 95% of the volume of outermost 16 km of the earth is composed of them. These are largely hard and massive because of their magmatic origin and are crystalline in appearances.

On the basis of their mode of occurrence, igneous rocks can be classified as: extrusive or volcanic rocks and intrusive rocks.

(i) Extrusive igneous rocks are formed by cooling of lava on the earth’s surface. As lava cools very rapidly on coming out of the hot interior of the earth, the mineral crystals forming these rocks are very fine. These rocks are also called volcanic rocks. Gabbro and basalt are very common examples of such rocks. These rocks are found in volcanic areas. Deccan plateau’s regur soil in India is derived from lava.

(ii) Intrusive igneous rocks are formed when magma solidifies below the earth’s surface. The rate of cooling below the earth’s surface is very slow which gives rise to formation of large crystals in the rocks. Deep seated intrusive rocks are termed as plutonic rocks and shallow depth intrusive rocks are termed as hypabyssal. Granite and dolerite are common examples of intrusive rocks. From this point of view, therefore, igneous rocks can, in accordance with their mode of formation, be classified as (a) Plutonic, (b) Hypabyssal and (c) Volcanic rockmasses. The huge blocks of coarse granitic rocks are found both in the Himalaya and the Deccan Plateau.
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Let us look at the Fig. 2.2. It illustrates that magma, on cooling, produces rocks of different shapes and sizes, depending on the space available after it forces itself into the crust. Common forms of intrusive igneous rocks are batholiths, sills and dykes etc. Batholiths are huge masses of solidified magma. They vary in size; some are as much as several hundred kilometers across and thousands of kilometers thick. They generally form the core of the major mountains, as shown in this diagram. Their irregular dome shaped roofs sometimes appear on the surface after erosion of millions of years. *Sill* is the horizontal intrusion of solidified magma between the layers of pre-existing rocks. *Dyke* is similarly a more or less vertical formation from few metres to several kilometers in length and from few centimeter to hundreds of metres in thickness.

On the basis of chemical properties, igneous rocks are classified into acidic and basic rocks. These are formed as a result of solidification of acidic or basic lava. Acidic igneous rocks are composed of 65% or more of silica. These rocks are light coloured, hard and very strong. Granite is an example of an acidic rock. Basic igneous rocks contain less than 55% of silica and have more of iron and magnesium. These rocks are dark coloured and weak enough for weathering. Gabbro, basalt and dolerite are examples of basic rocks.

- Igneous rocks are formed by the solidification of hot molten material called magma or lava.
- Extrusive igneous rocks are formed by cooling of lava on the earth’s surface e.g. basalt, gabbro.
- Intrusive igneous rocks are formed by solidification of magma below the earth’s surface, e.g. granite.

**INTEXT QUESTIONS 2.3**

1. Define the term mineral.

2. Give the names of any three minerals which are found extensively on the earth’s crust.

3. Give a term for each of the following
   (i) Deep seated intrusive igneous rock.
   (ii) A hot sticky molten material erupted on the earth’s surface.
4. How are dykes and sills formed?
   (i) ______________________________________________________
   (ii) ____________________________________________________

5. Tick (✓) the correct answer
   (i) Igneous rocks are formed due to
       (a) cooling (b) heating (c) neither cooling nor heating
   (ii) Which one of the following is an example of intrusive igneous rock?
       (a) Granite (b) Basalt (c) Gabbro
   (iii) Primary rocks are the result of
       (a) sedimentation (b) solidification (c) metamorphism

Sedimentary Rocks

These rocks are formed by successive deposition of sediments. These sediments may be the debris eroded from any previously existing rock which may be igneous rock, metamorphic or old sedimentary rock. Sedimentary rocks have layered or stratified structure. The thickness of strata varies from few millimeters to several metres. So these rocks are also called stratified rocks. Generally, these rocks have some type of fossil between their strata. Fossil is the solid part or an impression of a prehistoric animal or plant embedded in strata of sedimentary rocks. Sedimentary rocks are widely spread on the earth surface but to a shallow depth.

The individual rock particles are first broken from rocks and then transported by running water, ocean currents, glaciers or even by wind from one place to another. The process by which rock forming material is laid down is called sedimentation or deposition. It may settle in calmer waters of lakes or oceans or at places where the transporting agent has no longer enough energy to carry them farther. These are identified as riverine, lacustrine (formed by lake), glacial or aeolian (formed by wind) sedimentary rocks with reference to their deposition near rivers, lakes, glacier or deserts respectively.

The sediments are often loose, unconsolidated, soft rock material, in the beginning like sand and clay, but in course of time they get hardened to a compact material by excessive pressure and cementation to form sedimentary rocks. The deposition of sediments in the beginning is generally horizontal but it may get tilted afterwards due to movements in the earth’s crust. Sandstone, shale, limestone and dolomite are examples of sedimentary rocks.

Sediments get sorted by the transporting agents. Sediments of different sizes may get bound by cementing material under suitable conditions. Conglomerate is an
example of such a sedimentary rock. This type of formation of consolidated material is termed as mechanically formed sedimentary rock. The consolidation of organic matter derived from plants and animals forms sedimentary rocks of organic origin. Coal and limestone are organic sedimentary rocks. The sediments may also result from chemical reaction. Direct precipitation of minerals from their solution in water may give rise to sedimentary rocks of chemical origin. Gypsum, rock salt and nitre are examples of such sedimentary rocks.

Huge folded mountains of the world like Himalayas, Andes etc. are made up of sedimentary rocks. All the alluvial deposits of the world are also due to sedimentary accumulations. All river basins, particularly their plains and deltas, e.g. Indo-Gangetic plain and Ganga-Brahmaputra delta are good examples of sedimentary accumulations.

- Sedimentary rocks are formed by the successive deposition of sediments.
- These rocks have layered structure, therefore they are also known as stratified rocks.
- Fossil is the solid part or an impression of a prehistoric animal or plant embedded in sedimentary rocks in which they are buried.

**Metamorphic Rocks**

Most rocks in mountainous regions show an evidence of change. All these in course of time become metamorphic or changed forms of rocks. Metamorphic rocks are formed under the influence of heat or pressure on sedimentary or igneous rocks. Tremendous pressure and high temperature change the colour, hardness, structure and composition of all types of pre-existing rocks. The process which bring about the change is known as Metamorphism and the ultimate products, formed due to operation of such processes are defined as the Metamorphic rocks.

Temperature, pressure stress and access of chemically reactive substances are the main agents, which are responsible for metamorphism. Heat causes the minerals to recrystallise in the rock. The process of change by heat is called thermal or contact metamorphism. When molten magma or lava comes in contact with surrounding rocks, it bakes them and changes them into metamorphic rocks. Similarly the formation of metamorphic rocks due to tremendous pressure is known as dynamic or regional metamorphism. Slate, gneiss, schist, marble and diamond are good examples of metamorphic rocks. Metamorphic rocks are hard and tough in comparison to the parent rocks from which they are formed. Examples of metamorphic rocks are given in the table 2.1 with their parent rock from which they have been formed.
Table 2.1

Parent Rock and its Metamorphic Changed Form

<table>
<thead>
<tr>
<th>NAME OF THE ROCK</th>
<th>TYPE OF ROCK</th>
<th>NAME OF THE METAMORPHIC ROCK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone</td>
<td>Sedimentary Rock</td>
<td>Marble</td>
</tr>
<tr>
<td>Dolomite</td>
<td>Sedimentary Rock</td>
<td>Marble</td>
</tr>
<tr>
<td>Sandstone</td>
<td>Sedimentary Rock</td>
<td>Quartzite</td>
</tr>
<tr>
<td>Shale</td>
<td>Sedimentary Rock</td>
<td>Slate</td>
</tr>
<tr>
<td>Slate</td>
<td>Metamorphic Rock</td>
<td>Phylite/Schist</td>
</tr>
<tr>
<td>Coal</td>
<td>Sedimentary Rock</td>
<td>Graphite/Diamond</td>
</tr>
<tr>
<td>Granite</td>
<td>Igneous Rock</td>
<td>Gneiss</td>
</tr>
<tr>
<td>Phyllite</td>
<td>Metamorphic Rock</td>
<td>Schist</td>
</tr>
</tbody>
</table>

Different types of metamorphic rocks are found all over the world. In India, marble is found in Rajasthan, Bihar and Madhya Pradesh, whereas slates are available in plenty in Orissa, Andhra Pradesh and Haryana. In Kangra and Kumaun regions of Himalaya, slates of different colours are found.

- Metamorphic rocks are formed by the effect of heat or pressure on sedimentary or igneous or even metamorphic rocks.
- Thermal metamorphism is the process by which a rock undergoes change as a result of great heat.
- Dynamic metamorphism is the modification of rock, by tremendous pressure during extensive earth movements.

2.6 ECONOMIC SIGNIFICANCE OF ROCKS

Man has been interacting with the surface of the earth since long. With time and advancement in technology he is making different uses of rocks and minerals. The importance of rocks is given below:

(a) **Soils:** Soils are derived from rocks. Soils provide suitability for that agricultural products that provide food for mention and provide raw material for many industries.

(b) **Building Material:** Rocks are the source of types of building material directly or indirectly. Granite, gneiss, sandstone, marble and slates are extensively used in the construction of buildings. Tajmahal is made of white marble, Red Forts of Delhi and Agra, are made of red sandstone. Slates are used for roof purposes in different parts of India.

(c) **Mineral Source:** Minerals are the foundation of the modern civilization. Metallic minerals provide all metals ranging from very precious gold, plati-
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num, silver, copper to aluminium and iron. These metals are obtained from different rocks.

(d) Raw Material: Certain rocks and minerals are used as raw material for many industries. In cement industry and limestone kilns different type of rocks and minerals are used for production of finished goods. Graphite is used in crucible and pencil manufacturing as raw materials.

(e) Precious Stones: Precious stones and metals are obtained from different metamorphic or igneous rocks. Diamond is a precious stone used in jewelry and is a metamorphic rock. Similarly other precious stones like gems, rubies and sapphires are obtained from different type of rocks.

(f) Fuel: Fuel in the form of coal, petroleum, natural gas and nuclear minerals are derived from different rocks.

(g) Fertilizer: Fertilizers are also derived from some rocks. Phosphatic fertilizers are obtained from phosphorite mineral found in abundance in some parts of the world.

- Rocks and minerals are the main source of all metals, precious stones, solid fuel and raw materials for industries.

INTEXT QUESTIONS 2.4

1. What are rocks?

2. Classify rocks.

3. Give single term for each of the following
   (i) Process of the formation of metamorphic rock due to pressure.

   (ii) Rocks which contain strata.

   (iii) Rocks formed by the effect of heat or pressure on sedimentary or igneous rocks.

   (iv) Sedimentary rocks deposited in lakes

4. Tick (✓) the correct answer;
   (i) Marble is
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(a) a sedimentary rock (b) an igneous rock (c) a metamorphic rock (d) a plutonic rock

(ii) An example of sedimentary rock is
(a) granite (b) marble (c) sandstone (d) basalt

2.7 WHAT IS WEATHERING?
Weathering is the general term applied to the combined action of all processes that cause rock to disintegrate physically and decompose chemically because of exposure near the Earth’s surface through the elements of weather. Among these elements, temperature, rainfall, frost, fog, and ice are the important ones. Weathering begins as soon as rocks come in contact with one or more than one element of weather on the surface of the earth. In nature, generally both the disintegration and decomposition act together at the same time and assist each other. We must remember that the weathered material (i.e. disintegrated and decomposed) lie in situ (i.e. at its original position). In this process no transportation or movement of material is involved other than its falling down under the force of gravity.

- Weathering is the process by which exposed rocks are disintegrated and decomposed in situ (i.e. their original position).

2.8 TYPES OF WEATHERING
We can recognize three types of weathering?
1. Physical Weathering
2. Chemical weathering
3. Biotic weathering

PHYSICAL WEATHERING
When the rocks are broken up into smaller fragments without any chemical change in their composition, it is called physical weathering. The term mechanical weathering is also used for physical weathering.

Physical weathering takes place in different ways in different types of areas. They have been explained here with examples.

(a) Block disintegration

We all know that the successive heating and cooling causes expansion and contraction of the rocks. In hot desert regions, day temperatures are very high while nights are very cold. This high diurnal range of temperature causes successive expansion and contraction of the rocks which tend to enlarge the joints. Finally, the rocks disintegrate into smaller blocks. This process is known as block disintegration.
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Fig. 2.3: Block Disintegration

(b) Exfoliation

Rocks are generally poor conductors of heat. As a result of intense heating the outer layers of the rock expand rapidly while the inner layers remain almost unaffected by heat. Due to successive expansion and contraction, the outer layer of the rock subsequently peels off from the main mass of the rock in the form of concentric shells. The peeling of rocks in layers by this process is very similar to the peeling of successive layers of an onion. The process is called exfoliation. Almost all rounded forms of dolerite blocks of rocks in Singhbhum district of Bihar are due to this process. Granite domes of Mahabalipuram, particularly ‘Krishna Ka Laddu’ and those near Jabalpur on Madan Mahal Hill are good examples, of exfoliation.

Fig 2.4 Peeling of Layer of the Rock

(c) Frost Action

One of the most important physical weathering processes in cold climates is frost action, the alternate freezing and melting of water inside the joints of the rocks, splits them into fragments. This is because conversion of water into ice increases the volume of water by 10 percent. In cold regions rocks are disintegrated into small particles through this process. It is called frost action.
disintegration of rocks into smaller fragments without any change in their chemical composition is called mechanical weathering.

The rapid heating and cooling of the rocks creates a series of joints and cracks which lends to breaking up into smaller blocks. This process is known as block disintegration.

A weathering process by which the outer layers of the rock peel out in concentric cells due to difference of temperature in the outer layers is called exfoliation.

Breaking up of rocks due to freezing of water in the rock joints and cracks, in very cold regions, is called frost action.

**INTEXT QUESTIONS 2.5**

1. Name three types of weathering.
   (a) ____________________ (b) ____________________ (c) ____________________

2. In which areas is mechanical weathering more pronounced?
   ______________________________________________________

3. Give appropriate technical terms for each of the following statements:
   (a) Peeling of successive layers of rocks like the layers of an onion
       ______________________________________________________
   (b) Widening of joints and cracks due to alternative freezing and melting of water in them
       ______________________________________________________
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(c) Disintegration of rocks without any change in their chemical composition

CHEMICAL WEATHERING

Chemical change in the rocks through formation of new compounds or formation of new substances is called chemical weathering. Chemical processes include oxidation, hydrolysis, and acid solution.

- Decomposition of rocks by chemical processes with the help of water and atmospheric gases is called chemical weathering.

Chemical weathering involves four major processes:

(a) **Oxidation**

This is the process in which atmospheric oxygen reacts with the rock to produce oxides. The process is called oxidation. Greatest impact of this process is observed on ferrous minerals. Oxygen present in humid air reacts with iron grains in the rocks to form a yellow or red oxide of iron. This is called rusting of the iron. Rust decomposes rocks completely with passage of time.

(b) **Carbonation**

This is the process by which various types of carbonates are formed. Some of these carbonates are soluble in water. For example, when rain water containing carbon dioxide passes through pervious limestone rocks, the rock joints enlarge due to the action of carbonic acid. The joints enlarge in size and lime is removed in solution. This type of breakdown of rocks is called carbonation.

(c) **Hydration**

This is the process by which water is absorbed by the minerals of the rock. Due to the absorption of water by the rock, its volume increases and the grains lose their shape. Feldspar, for example, is changed into kaolin through hydration. Kaolin on Vindhyan Hills near Jabalpur has been formed in this manner.

(d) **Solution**

This is the process in which some of the minerals get dissolved in water. They are therefore removed in solution. Rock salt and gypsum are removed by this process.

- Chemical weathering involves the process of oxidation, carbonation, hydration-and solution.
INTEXT QUESTION 2.6

1. In which region is chemical weathering more effective?

2. Which process is involved when gypsum gets dissolved in water?

3. Which process of chemical weathering causes rusting of iron?

4. Which chemical action is predominant in limestone region?

BIOTIC WEATHERING

Biotic weathering is carried out by plants, animals and man.

(a) Plants

Plants contribute to both mechanical and chemical weathering. The roots of the plants penetrate into the joints of the rocks. They grow longer and thicker. In this manner they exert pressure on the rocks and the rock joints are thereby enlarged and break into smaller fragments.

(b) Animals

Burrowing animals like earthworms, rats, rabbits, termites and ants breakdown the rocks. These disintegrated rocks can easily be eroded or removed.
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by wind etc. Hooves of animals break the soil and thus assist soil erosion. The role of earthworms and termites is of special significance. According to scientists, there is a possibility of occurrence of about 1,50,000 earthworms in an acre and they can convert 10 to 15 tonnes of rock mass into good soil and bring it to the surface.

(c) Man

Human beings play a very important role in weathering of various rocks. Man breaks a large amount of rocks in the course of his activities, like agriculture, construction of houses, roads etc. He quarries for mining minerals, thus helps in weathering by breaking, weakening and loosening the rocks.

- Biotic agents like plants, animals and man also contribute to physical and chemical weathering.

INTEXT QUESTIONS 2.7

1. Which important matter is formed by weathering?
   (a) ________________ (b) ________________ (c) ________________

2. Where does humus in soils come from?
   ___________________________________________________________________

3. Give examples of two activities of man helping in weathering.
   (a) ________________ (b) ________________ (c) ________________

2.9 WEATHERING AND SOIL

We have studied the process of weathering and have learnt how different types of land features are produced in areas of different types of climate through this process. Weathering also plays an important role in formation of soil which provides basis for agriculture and world’s food supply.

Mechanical weathering of the surface rocks disintegrates the rock and converts it into a fine powder. These small particles are deposited in layers with the help of water. biotic weathering produces humus. This organic matter is formed through the action of plants and animals which helps in the formation of soil. Various processes of weathering help in giving different colours and properties of soil.
The process of weathering contributes significantly to soil formation besides disintegrated of rocks.

### 2.10 Gradation

Exogenetic forces are constantly working to bring about leveling or the gradation of land. They attempt to achieve a condition of balance between erosion and deposition which mean a graded position. The above forces operate through the process called the process of gradation. Agents of gradation like rivers, glaciers, winds, sea waves and underground water perform their task with the help of the triple action of weathering, erosion and deposition. The leveling down of elevated portions of the earth’s surface is done by erosion. The filling up of depressions is done by deposition of the eroded material transported by the external agents of gradation as spoken earlier.

We have studied that the endogenetic forces of the earth give rise to major landforms on the earth surface and the exogenetic forces level them down.

The work of gradation has two components (a) degradation and (b) aggradation.

(a) Degradation

When rocks are removed by scraping, scratching and cutting as a result of the process of erosion, thereby lowering the elevation of the land, it is called degradation. Degradation, first of all includes the work of weathering that is the movement of scarped and scratched material aided by the great force of gravity. It also includes the work of erosion implying the transportation of the rock material by an agent of gradation. The increase in the movement of rock-debris increases both its erosional and transportational capacities.

(b) Aggradation

Filling up of low-lying areas of depression by eroded material is called deposition. Deposition starts when the agents of gradation lose their force or have obstruction in their way. As a result eroded material is deposited in depressions which not only creates new landforms but also modifies the existing ones.
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Let us now look at the figure. It explains the total process of gradation and its two components—degradation and aggradation. It shows the elevated portions continuously being lowered by weathering and erosion. The debris consisting of the eroded material is transported and deposited in the low lying areas. The surface of the lower areas on the other hand is raised through deposition of this debris. Finally, the position of a uniform or near uniform level is achieved. The process of gradation is not performed by a single agent. It is rather a result of the work of all agents of gradation acting simultaneously. It is however possible for a single agent of gradation to be more active in particular area or at a particular time.

- Levelling and smoothening of land surface is called gradation includes both degradation and aggradation.
- The weathering of the land surface by erosion is called degradation and raising or filling up of depressions by deposition is called aggradation.

INTEXT QUESTIONS 2.8

1. Which process is involved in the levelling of the earth’s surface?
   ____________________________________________________

2. Which two processes constitute gradation?
   (a) __________________________ (b) __________________________

3. Which term is used for raising or filling up of depressions by depositing?
   ____________________________________________________

4. What is degradation?
   ____________________________________________________

2.11 SOIL AND ITS FORMATION

Soil is the uppermost layer of the land surface that plants use and depend on for nutrients, water and physical support.

(A) FACTORS OF SOIL FORMATION

The five factors, which control the formation of soil are parent rock, relief, time, climate and plant and animal organisms. The former three are called the passive factors while the later two are the active factors. The parent material and climate are the most important because these two affect the other factors.

(a) Parent rock

A soil is derived from the underlying rock or the parent rock material con-
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The parent rock gets broken into tiny pieces and is decomposed slowly by physical and, chemical weathering. It furnishes inorganic mineral particles of the soil. The parent rock also influences the rate of soil formation, the chemical composition, colour, texture, structure, mineral content and fertility.

(b) Relief

Topography of an area affects the degree of erosion of the parent rock material and the rate of surface run off of water. thus, the relief affects directly and indirectly the processes involved in soil formation. Steep slopes are subjected to more rapid run-off of surface water than the gentle slopes. Therefore, there is less infiltration of water on steeper slopes, which retards soil forming processes. In addition, rapid run-off on steep slopes often erodes their surface faster than soil can develop. It is because of this that the mountainous topography develops coarse, thin and infertile soil and the plain areas have rich well developed fertile soils.

(c) Time

The soil forming process is very slow. A well developed soil results as an end product of physical, chemical and biological processes operating collectively for a very long period of time.

(d) Climate

It is by far the most important factor in the sense that over a long period of time it not only tends to reduce the difference caused by the parent material but also influences biological activities within the soil. Due to this factor two different parent materials may develop the same type of soil in one type of climatic region. For example, granite and sandstone have developed into sandy soil in dry Rajasthan desert. On the other hand, two different types of soils may develop from the same parent material in two climatic regions. For example, the crystalline granites have developed laterite soils in monsoon regions and non laterite soils in sub humid regions.

The process of weathering, its effectiveness and the type of plant and animal organisms in a region are directly linked with the seasonal change of temperature and distribution and nature of precipitation. Hence, climate plays an important role in soil forming processes.

Fig. 2.8 Factors of Soil Formation
Plant and Animal Organisms

Plants and animals play an active role in transforming parent materials into a mature soil. Dead plants and animals contribute to the organic content of the soil. The process of decay, added by bacterial action, transforms organic matter into humus. Humus is responsible for the fertility of the soil. It also enhances water retention capacity of the soil. This organic material helps the soil to support plant life. The plant cover in turn protects rich upper layer of the soil from erosion by increasing the proportion of rainfall entering into the soil rather than running off the surface. It also prevents greater evaporation of soil moisture by its thick canopy, thus allowing soil to mature and become fertile.

- The climate, plant and animal organisms are the active factors of soil formation.
- The parent material, relief and time are the passive factors of soil formation.

SOIL HORIZONS

A layer of soil which lies more or less parallel to the surface and has fairly distinctive soil properties is known as soil horizon. Soil horizons are distinctive layers found in soils that differ in physical or chemical composition, organic content or structure. The display of horizons on a cross section through the soil is termed as soil profile.

Let’s review briefly the main types of horizons and their characteristics.

Four main horizons are important - A, E, B and C. The A horizon is the upper most horizon and rich in organic matter. Next is the E horizon. Clay particles and oxides of aluminum and iron are removed from the E horizon by downward seeping water, leaving behind pure grains of sand or coarse silt. The B horizon receives the clay particles, aluminum and iron oxides, as well as organic matter washed down from the A and E horizons. Beneath the B horizon is the C horizon, which is not considered part of the soil. If consists of the parent mineral matter of the soil.
Soil profile is the arrangement of the soil into layer like horizons which are physically, chemically and biologically different from each other.

INTEXT QUESTIONS 2.9

1. Name two active factors of soil formation.
   (a) __________________________ (b) __________________________.

2. Name the three passive factors of soil formation.
   (a) ___________________ (b) _______________ (c) _______________.

3. Fill in the blanks with appropriate word given in the blanks below: (organic material, inorganic mineral particles, biological activities).
   (a) The parent material provides _________ within the soil.
   (b) The climate of a region influence __________ within the soil.

4. Give the Geographical term for each of the following.
   (a) The dynamic, upper layer of earth’s crust composed of solid liquid and gaseous substances.
   (b) A vertical arrangement of different layers of soils.
   (c) The horizon of soil rich in humus.
   (d) The horizon of soil, that accumulates soil colloids.

2.12 SOIL EROSION

The removal of soil at a greater rate than its replacement by natural agencies (water, wind etc.) is known as soil erosion.

(a) Type of Soil Erosion

Soil erosion is of four types: wind erosion, sheet erosion, rill erosion and gully erosion.

(i) Wind Erosion

Winds carry away vast quantity of fine soil particles and sand from deserts and spread it over adjoining cultivated land and thus destroy their fertility. This type of erosion is known as wind erosion. It takes place in and around all desert regions of the world. In India, over one lakh kilometers of land is under Thar Desert, spread over parts of Gujarat, Haryana, Punjab and Rajasthan states. These areas are subject to intense wind erosion.
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(ii) **Sheet Erosion**

Water when moves as a sheet takes away thin layers of soil. This type of erosion is called sheet erosion. Such type of erosion is most common along the river beds and areas affected by floods. In the long run, the soil is completely exhausted due to removal of top soil and becomes infertile.

(iii) **Rill Erosion**

The removal of surface material usually soil, by the action of running water. The processes create numerous tiny channels (rills) a few centimeters in depth, most of which carry water only during storms.

(iv) **Gully Erosion**

When water moves as a channel down the slope, it scoops out the soil and forms gullies which gradually multiply and in the long run spread over a wide area. This type of erosion is called gully erosion. The land thus dissected is called bad lands or ravines. In our country, the two rivers Chambal and Yamuna are famous for their ravines in U.P. and M.P. states.

The controlling factors in the last two types of erosion are the velocity and amount of surface run off, the erodability of the soil, nature of slope, the texture and structure of the soil, nature of precipitation and vegetation cover. The speed and frequency of winds or dust storms and vegetation cover are the controlling factors in wind erosion. Seawaves are responsible for eroding soils along the coasts formed by weak rocks such as limestone etc. This type of erosion is wide spread along Kerala coasts. Substantial soil erosion is also caused by changing river channels and snowfall specially in river basins and hilly regions.

- The removal of soil material naturally or by human action is called soil erosion.
- Soil erosion is of four types: wind erosion, sheet erosion, rill erosion, gully erosion.
- Factors influencing soil erosion are velocity and amount of surface run off, nature of slope, texture and structure of soils and frequency and speed of winds.

### 2.13 SOIL CONSERVATION

Soil is one of the most important natural resources, which sustains different types of lives directly or indirectly. Moreover, soil forming is a slow natural process. The process of soil erosion not only destroys this wonderful gift of nature in a shorter span of time, It creates new problems like floods, damage to roads and rail bridges, hydro electric projects, water supply and pumping stations.
Soil conservation constitutes those methods which prevent soil from being removed. The methods to control soil erosion of different types in different parts of the world are as under:

(a) **Protection of forests**: Indiscriminate felling of trees in the forests has been one of the major causes of soil erosion. Since roots of the trees hold the soil material together, it is desirable to protect these trees from such felling. This has led governments to declare forests as reserved in which felling of trees has been banned. This method of soil conservation is most suited to all types of landscapes. Forests are also harbinger of rain which increases the process of soil formation.

(b) **Afforestation**: Planting of trees along river courses, waste lands and mountainous slopes is another method of soil conservation. It reduces excessive erosion taking place in these regions. Afforestation is also effective in controlling wind erosion along the desert regions. Tree plantation along desert boundary stops swallowing of agriculture land by desert sands. In our country large scale planting of trees is being carried out in Rajasthan, Haryana, Gujrat and Punjab to control the extension of Thar Desert.

(c) **Flood Control**: During rainy season, the amount of water in rivers, increases exceedingly which in turn increases soil erosion. Dams are being constructed to control floods and consequently the soil erosion. This can also be done by diverting river water to dry regions through canals and by other well planned methods of water conservation.

(d) **Planned Grazing**: Over grazing on hill slopes has helped loosening and washing away of soils in these areas. If grazing is carried out in a planned way it will reduce soil erosion by protecting vegetation cover in these areas which are comparatively more prone to soil erosion.

(e) **Bunding**: Construction of bunds or obstruction is applied in lands affected by gully erosion. This method is not only helpful in controlling soil erosion but also in maintaining soil fertility, conserving water resources and levelling of sloping lands.

(f) **Terracing**: To conserve poorly developed thin soils on mountain slopes, terracing is another method. Terracing refers to the construction of terraces across the slope in a mountainous region. This helps in controlling soil erosion and using water resources of these areas economically and effectively for growing different crops on these terraces.

(g) **Contour Ploughing**: This method of soil conservation is most suited to areas having rolling landscape. Ploughing and tilling of land along the contour levels in order to cause furrows to run across the landslope reduces the rate of soil erosion. This method is also applied to maintain the fertility and soil moisture.
Earth’s Interior and Its Material

(h) **Adoption of Strip Farming:** This method is most suited in rolling plains and regions situated in arid and semi-arid regions. Fields are divided into strips and the farming in one year is done on one strip while the other strip is left uncultivated. The grassy vegetation cover of the left strip controls soil erosion and maintains fertility of soils. Next year, the process is reversed.

(i) **Crop Rotation:** Crop rotation refers to a systematic succession of different crops cultivated in a given piece of land in order to avoid exhaustion of the soil. Thus, rotation of crops is applied to conserve the fertility of soil from over cultivation of growing continuous crops from where population pressure is more on limited agricultural lands. This method is applied in most of the countries of the world.

(j) **Reclamation of Lands:** Soil erosion is also being controlled by levelling lands gullied down by water channels and converted into waste lands or ravines. This method of soil conservation is most suited in river basins and hilly terrains. Vast areas have been levelled in Chambal and Yamuna ravines, in our country.

- Soil conservation methods include protection of forests, afforestation, bunding, reclamation of lands; controlling floods, over grazing; terracing, strip farming, contour ploughing and crop rotation.

---

**INTEXT QUESTIONS 2.10**

1. Fill in the blanks with the appropriate words given in the brackets:

   (a) The complete removal of soil cover is known as ______________
       (Gullying, wind, sheet erosion)

   (b) ________________ is the best suited method of soil conservation in
       desert outskirts, (strip farming, afforestation, bunding)

   (c) Sheet erosion is mostly caused by ________________ (foods, rains,
       deforestation).

2. Give the geographical term for each of the following:

   (a) Removal of soil material naturally or by man’s action.

   (b) Removal of soil by water channel.

   (c) Planting of trees in deforested lands.

   (d) Removal of soil by dust storms.

   (e) Tilling of land along the contour levels.
Earth is a spherical body. The direct observations into its interior are limited to a depth of a few kilometers. Temperature, pressure and density increase from the earth’s surface to its centre. Earth’s interior is divided into three concentric layers; Crust, mantle and core. Crust is the thinnest and outermost layer, mantle middle one whereas core is the innermost and the most dense layer of the earth. The material of the crust is composed of rocks. Rock is composed of one or more minerals. Minerals have a definite chemical composition. On the basis of their mode of formation, rocks are classified into three types - igneous, sedimentary and metamorphic. Igneous rocks are formed by the solidification of molten lava or magma. Granite, basalt and gabbro are examples of igneous rocks. Molten material solidified beneath the earth’s surface to form intrusive and above the earth surface to form extrusive igneous rocks. Sedimentary rocks are formed by the consolidation of sediments. These are layered and may contain fossils. Shale, limestone and sandstone which are examples of sedimentary rocks. Metamorphic rocks are formed by the effect of heat or pressure on any pre-existing rock. Rocks are of immense use to us. They provide precious metals and stones, building material and fuel etc. for our use.

Landforms undergo a constant change. The exogenetic forces act upon them to make the surface level.

The rocks undergo various types of changes in their own location under the process of weathering. The rocks become weak due to the impact of the weather elements - temperature, moisture, frost etc. They develop cracks and disintegrate into small boulders, pebbles or fine fragments. This is called mechanical weathering. This type of weathering is more pronounced in areas of hot and dry or very cold climates. Rock minerals undergo chemical changes due to the effect of water and gases as a result of oxidation, carbonation, hydration and solution. This is called chemical weathering. This type of weathering is more important in areas of warm and humid climates. Plants, animals, insects and men are the agents of biotic weathering and they contribute to both mechanical and chemical weathering.

Soil is a natural resource of unestimated value to man as he gets his food, clothing and other things directly or indirectly from it. Soil is a thin layer of loose inorganic and decayed organic matter covering the earth’s surface. Different factors such as parent materials, climate, plants and animal organism, water and time along with processes such as mechanical, chemical and biological are responsible in making this valuable resource. Mature soils develop a profile which constitutes four horizons, each having different characteristics.

Soil erosion is a natural process of destruction and removal of soil material from its place. Running water, winds, sea waves and glaciers are the most active agents of
Erosion. Erosion of soils takes place in four ways viz., wind erosion, sheet erosion, rill erosion and gully erosion. Removal of soil cover depends on velocity and speed of water, nature of slope, texture and structure of soils, frequency of dust storms and nature of precipitation. Man through his misdeeds, has also helped natural forces in increasing the problem of soil erosion. Methods to prevent soils from being eroded constitute soil conservation. These methods are protection of forests, afforestation, contour ploughing, terrace and strip farming, bunding, flood control, etc.

**TERMINAL QUESTIONS**

1. What are the limitations of direct methods in the determination of the earth’s interior?
2. Draw and label a diagram showing earth’s interior and its density and depth of each layer.
3. Distinguish between a rock and a mineral with suitable examples.
4. Discuss the classification of various types of rocks on the basis of their mode of formation. Support your answer with examples.
5. Explain in brief the economic significance of rocks and minerals.
6. Compare the processes of formation of metamorphic and sedimentary rocks.
7. What is weathering? Name the different types of weathering.
8. How does chemical weathering take place?
9. Differentiate between
   (a) Disintegration and Decomposition
   (b) Degradation and Aggradation
   (c) Oxidation and Solution
10. Explain the process of gradation.
11. How does man become an important agent of weathering?
12. Explain the following processes of weathering by drawing simple diagrams:
   (a) Block disintegration
   (b) Frost action
   (c) By plant action
14. Discuss various factors responsible for soil formation.
16. What is soil erosion? Explain the different ways in which soil is eroded. Discuss the various methods being used to conserve soil.

**ANSWER TO INTEXT QUESTIONS**

**2.1**

1. Rapid increase of temperature below the earth’s surface
2. (a) Lithosphere (b) Mantle (c) Core
3. Core or Nife
4. More than 11.0
5. Lithosphere
6. Lithosphere

**2.2**

1. 3000°C to 5000°C
2. 3 to 4 million times the atmospheric pressure at sea level.
3. Due to immense pressure of overlying rocks and the presence of heavier materials.

**2.3**

1. Mineral is a naturally occurring inorganic substance which possesses physical properties and has a definite chemical composition. 2. Feldspar /Quartz/ Pyroxenes/Amphiboles/Mica/Olivine 3. (i) Plutonic rocks (ii) Lava 4. (i) When the magma cools in their sheets in vertical fractures within the earth’s crust dykes are formed and (ii) when it solidifies in horizontal starta it is called a sill. 5. (i) cooling (ii) Granite (iii) Solidification

**2.4**

1. Rocks are aggregates of Minerals and are the individual units constituting the crust of the earth. 2. Igneous, Sedimentary and Metamorphic rocks. 3. (i) Dynamic metamorphism (ii) Sedimentary rocks/Stratified rocks (iii) Metamorphic rocks. (iv) Lacustrine 4. (i) a metamorphic rock (ii) Sandstone.

**2.5**

1. (a) Physical weathering (b) Chemicals weathering (c) Biotic weathering.
2. In dry and very cold regions.
3. (a) Exfoliation (b) Frost action (c) Physical weathering.

**2.6**

1. In warm and humid regions.
2. Solution
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3. Oxidation
4. Carbonation

2.7
1. (a) Plants (b) Animals (c) Man.
2. The cracks in rocks are widened and the rocks are broken.
3. (a) Agriculture (b) Mining

2.8
1. Gradation
2. (a) Degradation or lowering down of raised surfaces.
   (b) Aggradation or raising up of low lying areas.
3. Aggradation.
4. Lowering down of raised portions through erosion of material.

2.9
1. (a) Climate (b) Plant and animal organisms
2. (a) Parent rock (b) relief or topography (c) Time
3. (a) Inorganic mineral particles (b) Biological activities
4. (a) Soil (b) Soil profile
   (c) Top soil (d) zone of weathered parent rock

2.10
1. (a) Sheet erosion (b) Afforestation (c) Floods
2. (a) Soil profile (b) Gully erosion
   (c) Afforestation (d) Wind erosion
   (d) Contour ploughing

HINTS TO TERMINAL QUESTIONS
1. The rapid increase of temperature below the earth’s surface. Mining activity restricted to few kilometres. High temperature melts drilling tools.
2. See Fig. 2.1 - Concentric zone showing layers of Earth’s interior.
3. Rock is the solid part of the crust composed of minerals. They are aggregates or physical mixture of one or more minerals for e.g. granite. Minerals are inorganic substances made up of one or more elements in a definite ratio, e.g. feldspar. Change in the ratio of minerals gives rise to different rocks.
4. Igneous rocks, sedimentary rocks and metamorphic rocks (give definition of each with examples of each type of rock).
5. See economic significance of rock (para 2.6)
6. Sedimentary rocks are formed due to weathering, erosion and deposition of rock fragments of older rocks which become hard due to compaction, chemical changes or cementation of organic matter, whereas metamorphic rocks are formed due to the pressure and high temperature of the magma when it comes in contact with both igneous and sedimentary rocks.

7. Weathering is a process by which rocks are disintegrated and decomposed in situ. See para 2.7.

8. See para 2.8 under “Chemical weathering”.

9. (a) disintegration of rock of physical breaking up or shattering of rock under the influence of temperature or frost action. Decomposition is due to chemical change by which rock minerals break up or get dissolved. Give example of each type.

(b) See para 2.10 (a) and (b)

(c) See para 2.8 (a) and (d) under “Chemical Weathering”.

10. See para 2.10 (a) and (b) and Fig. 2.7

11. See para 2.8 (c) biotic weathering.

12. See Fig. 2.3, 2.5 and 2.6.

13. Points to be discussed in detail include:

   Meaning of soil profile-refer to 2.11 Section B. Answer is to be illustrated with the help of Fig. 2.9.

14. Points to be elaborated - parent rock, relief, time, climate and plant and animal organism (Active and non-active factors) Importance of each of these points should be highlighted (Refer 2.11 Section A).

15. Soil erosion refer 2.12 Section

   Types of soil erosion - wind erosion, sheet erosion, gully erosion (Refer 2.15 Section)

   Methods to conserve soils - Protection of forests, afforestation, flood control, planned grazing, reclamation of lands, bunding, terracing, contour ploughing, strip farming, crop rotation (Refer to 2.13 Section).
In the previous lesson, we have learnt that the interior of the earth is very hot. Earthquakes and volcanoes are concentrated along a few narrow belts. The type and density of rocks of the crust are variable. The surface features are dynamic in character. This dynamism is due to two forces — endogenetic and exogenetic. Endogenetic forces are those which are caused from below the surface. Due to this, an area may get elevated or gets submerged. These forces try to make the surface irregular while exogenetic forces are those which operate from above the surface. They try to eliminate the irregularities of the surface through the process of denudation about which we will be reading in lesson. In this lesson we will be studying about the endogenetic forces.

OBJECTIVES

After studying this lesson, you will be able to:

- define isostasy;
- describe the variation in relief features on the earth’s surface;
- explain the isostatic adjustment by various experiments;
- explain the views of Airy and Pratt and distinguish between the ideas of both;
- explain the concept of continental drift;
- enumerate the evidences of continental drift;
- explain the concept of plate tectonics;
- identify and locate different plates on the world map;
3.1 CONCEPT OF ISOSTASY

The term “Isostasy” is derived from “Isostasios”, a word of Greek language meaning the state of being in balance. You already know and must have seen that the mountain have many peaks and relatively great heights. Similarly plateau and plain have flat surfaces. They have moderate and lower height, respectively. On the contrary oceanic beds and trenches have greater depths. There is a great difference in height among these features. You also know that the earth is rotating while keeping perfect balance among its various features. Thus, our earth is considered to be in isostatic equilibrium.

Example:- Suppose you are holding one stick each in your both hands vertically with varying heights, say 5’ and 15’ and you are moving in a particular direction. Do you have any difficulty in maintaining a balance in congruence with your body as well as two sticks together? Definitely, smaller stick will be easy to make a balance than the longer one. It is just because of the centre of gravity. The centre of gravity with smaller stick will be nearer to your holding hand in comparison to the longer stick. In the same way smaller surface features like plains are more stable than the tall mountains.

A. Isosatic Balance: views of Airy

Airy, a geologist, considered the density of different columns (plains, plateaus, mountains, etc.) to be the same. Hence, he proposed the idea of ‘uniform density with varying thickness’. We know that the upper crust of the earth is made up of lighter material. In this layer, silica and aluminium are found in abundance, hence it is known as ‘Sial’. It is less denser than the lower one. Airy assumed that the Sialic crust is floating over the Sima (silica and magnesium, lower denser layer). Crustal layer is uniform in terms of density with varying length of columns. Therefore, those columns are projecting down into the asthenosphere depending upon the proportions of the column. It is due to this reason that the root has developed or the sima has been displaced from below.

To prove this concept, Airy took an example of wooden blocks of various sizes and immersed them into water (Figure 3.1). All blocks are of same density. They get immersed differently in proportion to their sizes. In the same way higher features with great height seen on the surface of the earth have deeper roots whereas short in length has shorter roots beneath. It is the concept of root which is sustaining the higher elevation. He is of the openion
that the landmasses are floating like a boat in the substratum (magmatic asthenosphere). According to this concept, the root beneath the Mt. Everest would be 8848×8 = 70784 metre below the sea level. On this bases Airy has been criticized that the root is not possible to be at such a great depth. Because the root material will melt due to higher temperature found at that depth.

**B. Isostatic Balance: views of Pratt**

Pratt considered landblocks of various heights to be different in terms of their density. The taller landmass has lesser density and smaller height features to be denser. In other words, there is an inverse relationship between height and density. If there is a higher column, density will be lesser and if there is a shorter column, density will be higher. Assuming this to be true, he accepted that all blocks of different height get compensated at a certain depth into the substratum. In this way a line is being demarcated above which there is equal pressure with varying heights. Thus, he denounced the root concept of Airy and accepted the ‘concept of a level of compensation’. For proving his concept he took a number of metal bars of varying density with same weight and put them into mercury (Figure 3.2). In this way they form a line by all those bars, which he regarded to be the level of compensation.
Differences between the views of Airy and Pratt

The differences between the views of Airy and Pratt can more clearly be presented in a tabular form:-

<table>
<thead>
<tr>
<th>Views of Airy</th>
<th>Views of Pratt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Uniform density of crustal material.</td>
<td>Varying density of crustal material.</td>
</tr>
<tr>
<td>2. Varying depth upto which root penetrates.</td>
<td>Uniform depth upto which crustal material reaches.</td>
</tr>
<tr>
<td>3. Deeper root below the mountain and smaller beneath plain. (Figure 3.1)</td>
<td>No root formation, but a level of Compensation. (Figure 3.2)</td>
</tr>
</tbody>
</table>

C. Global Isostatic Adjustment

It is quite apparent that there is no complete isostatic balance over the globe. The earth is unstable. Endogenetic forces often disturb the crustal balance. The regular earthquakes and volcanic eruptions along a particular belt do not signify any balance but a sort of adjustment is needed continuously. Endogenetic forces and their tectonic effects are the causes of imbalance on the surface but nature always tries to make an isostatic adjustment with itself.

Exogenetic forces are trying to eliminate the differences on the surface of the earth and in this process they are peeling off, transporting down to far flung places, and depositing them. In this process, isostatic balance is maintained by the underneath flowage of material by subsidence at the place of deposition and upliftment at the peeling of place in their proportion to the denudation (Figure 3.3).

Fig. 3.3 : Mechanism of isostatic adjustment
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**INTEXT QUESTIONS 3.1**

Fill in the blanks:-

1. Isostasy means _____________.

2. Airy considered the density of different columns to be _____________.

3. Pratt considered landblocks of various height to be different in terms of their _____________.

4. According to Airy there is ____________ root below the mountain and ____________ beneath plain.

5. Pratt postulated the concept of ____________ root formation but a ____________ of compensation.

6. Endogenetic forces often ____________ the crustal balance.

7. Regular earthquakes and volcanic eruptions along a particular belt does not signify ________________ but a sort of continuous ________________ ____________.

---

**3.2 CONTINENTAL DRIFT**

According to Alfred Wegener, the entire landmass of the globe was together about 280 million years ago. It was termed as Pangea, a super continent. The huge water body surrounding the Pangea was known as Panthalasa. From 280 to 150 million years ago, Pangea was broken latitudinally into northern and southern parts known as Laurasia (Angaraland) and Gondwanaland, respectively. Both of them drifted away and in between a shallow sea emerged by filling up the water from Panthalasa. It was known as Tethys sea. Later on Laurasia and Gondwanaland rifted and finally drifted to form the present day distribution of land and water on the earth (Figure 3.4).
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Fig. 3.4 Pangea
Dynamic Surface of the Earth

Evidences of Drift

Wegener gave a number of evidences in support of the unification of landmass in geologic past. They are such which cannot be negated even today.

a. **Jig-saw-fit:** Eastern coast of South America is identical to Western coast of Africa which fits to a certain depth in the ocean. To a certain extent coastal areas and continental shelves have been modified by oceanic waves through denudation (Figure 3.5)

![Fig. 3.5 Wegners map of continental drift-Fitting of the continents bordering the Atlantic Ocean](image)

b. **Geological similarities:** The mountain systems of Southern Atlantic coast in South America and Africa show the similarity of the extension in both continents.

c. **Coal and Vegetation evidences:** The distribution of coal and vegetation over South America, Africa, India and Australia proves that they were together in geological past. The classical glacial deposits during carboniferous period over these landmasses resemble each other which tells the story of togetherness. Today they lie in different climatic zones.
Apart from above evidences put forward by Wegener, other evidences (known later) are also there which support the idea of continental drift.

d. **Evidences from paleomagnetism** :- Paleomagnetism is the study of the direction of pole through ages. Magnetically susceptible minerals like haematite, pyrhotite magnetite etc. get aligned with the magnetic pole of the earth and recorded in the solidification of magma during that time. It is found that periodic changes have occurred and poles have wandered which is not possible for the entire earth. Hence, it is the twist and turn of the landblock and not for the entire earth which has again explained that the continents have shifted their positions.

e. **Sea floor spreading** :- Along the mid Atlantic ridge, magma comes out at the sea bed and gets solidified. A new zone is formed and this process is continuing since millions of years. It is leading for diversion of continental block, and hence the size of the Atlantic ocean is increasing which is termed as sea floor spreading. It is the classical example of the shifting of continents. The explanation of continental drift through sea floor spreading and the study of paleomagnetism is commonly known as Plate Tectonics. (Figure 3.6)

*Fig. 3.6 Stages in continental rapture and the opening-up of a new basin*
INTEXT QUESTIONS 3.2

1. Fill in the blanks:-
   a. Alfred Wegener termed the supercontinent as ____________.
   b. Premordial ocean was known as ______________.
   c. Pangaea was broken into two ____________ in the north and __________ in the south.
   d. North and South America drifted towards ____________.
   e. Tethys sea emerged between ____________ and __________ by filling up of the water of ____________.

2. Name three evidences of continental drift put forwarded by Wegener -
   a. ______________________________________________________
   b. ______________________________________________________
   c. ______________________________________________________

3. Name two evidences of continental drift, but not mentioned by Wegener
   a. ______________________________________________________
   b. ______________________________________________________

3.3 PLATE TECTONICS

The uppermost outer solid and rigid layer of the earth is called crust. Its thickness varies considerably. It is as little as 5 km thick beneath the oceans at some places but under some mountain ranges it extends up to a depth of 70 km. Below the crust denser rocks are found, known as mantle crust. This upper part of mantle up to an average depth of 100 km from the surface is solid. This solid mantle plus upper crust form a comparatively rigid block termed as lithosphere. Mantle is partially molten between 100 to 250 km depth. This zone is said to be asthenosphere, also known as Mohr discontinuity, a simplification of Mohorovicic, the name of the seismologist who discovered it. All these things you have already read in the previous lesson.

The lithosphere is broken into several blocks. These blocks are known as plates, which are moving over asthenosphere. There are seven major plates. (Figure 3.7)
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Fig. 3.7 Tectonic plates, spreading sites and subduction sites

1. Eurasian plate,
2. African plate,
3. Indo-Australian plate,
4. Pacific plate,
5. North American plate,
6. South American plate and
7. Antarctic plate.

Apart from these major plates minor plates are about 20 in number, a few important among them are :-

Arabian plate,
Philippine plate,
Cocos plate,
Nazca plate,
Caribbean plate,
Scotia plate, etc.

The major and minor plates constitute the whole surface of the earth.
Plate tectonics is a method or way of understanding the land-water distribution of the earth. Tectonics is a sort of movement of plates. Through the movement,
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internal forces are explained which are responsible for the distribution of earth’s crust, formation of mountain chains and distribution of earthquakes and volcanism.

Mechanism of plate Movement

Arthur Holmes, a British geologist, in 1928 – 1929, proposed that convectional currents exist underneath the lithosphere. The centre of convectional current is not exactly known, but it is believed that it has an average depth of about 100 to 250 km below the surface. The inception of the current is initiated by heat generation due to radio-active minerals. Due to integration and disintegration of atomic minerals heat is produced and hence the melting of surrounding rocks. In this way currents start operating. These currents are classified into rising and falling with divergence and convergence activities, respectively.

With rising convectional current, transport of hot and viscous matter takes place upwardly. After reaching about 100 kms below the surface that current gets diverged leading to split into the upper part. The molten material penetrates into the split and thus creation of new surface and the draft of the mammoth plate in opposition direction. It happens below the mid-oceanic ridge. On the other hand two sets of diverging thermal convectional currents brings two plates together and it is called convergent boundary where subduction takes place. Plates of lithosphere are constantly in motion because of convectional currents. Their relative motion depends upon the force operating over them.

Plate boundaries are very important and significant structural features. Boundaries are very distinct and easy to identify. They are associated with newly formed mountain systems, oceanic ridges and trenches. Plates are moving continuously and have relative direction of movement. Based on the direction of movement three types of plate boundaries can, easily, be identified. (Figure 3.8)

![Fig. 3.8 Types of plate boundaries](http://smartprep.in)
(i) Divergent boundary
(ii) Convergent boundary
(iii) Fracture or transform boundary fault

The convectional current are caused due to radio-activity. These currents get diverted on approaching the crust layer. Diverging currents produce tension at the contact-zone of crust leading to fracture. Maganatic material penetrates into the fractures and gets solidified. This continuous process pushes the blocks in opposite direction and creates a new zone, known as “zone of construction”.

At convergent boundary, two adjacent plates come further and further closer to each other and collide. When both sides are of continental nature, a mountain formation is evident. When one of the two is continental and the other maritime again mountain comes into being along the boundary. In this case, continental plate overnides the maritime. When both plates are of maritime, both of them break, subduct and penetrate below and, hence, trenches are formed. Along this boundary earthquakes and volcanic activities are prominent. In all these three situations, surface area is reduced, therefore, this is also known as “zone of destruction”.

Transform fault is the one when two adjacent plates slide past each other. Direction of movement may be along or against but they move parallel to each other. Therefore, neither there is any construction of fresh area nor it has any destruction. Hence, it is known as “zone of preservation”.

Plates are not a permanent features but they vary in size and shape. Plates can split or get welded with adjoining plate. Almost all tectonic activities occur along the plate boundaries.

Prior to the advent of plate tectonic theory, the continental drift theory which was proposed by Wegener was criticized, particularly about the forces. In fact, it was outrightly rejected inspite of apparent evidences. But further reserches about the material of sea floor and paleomagnetism supported the theory but the proposition of plate tectonic theory in 1960’s has solved the problem of the mechanism of movement.

**Plate Tectonics Vs Earthquakes and Volcanoes**

The distribution of earthquakes and volcanoes over the globe (Figure 3.9) clearly reveals that they are strongly associated with the boundaries of plates. Plate boundaries are the zones where every sort of tectonic activity does take place. The release of energy created because of the movement of plates is manifested in this zone in the form of earthquakes and volcanic eruption.
Fig. 3.9 The Major Earthquake and volcanic belts of the world

INTEXT QUESTIONS 3.3

1. Fill in the blanks:-
   a. The uppermost outer __________ layer of the earth is called __________.
   b. Crust and upper part of mantle upto an average depth of __________ is __________.
   c. Lithosphere includes __________ and __________.
   d. Tectonics is sort of __________ of lithospheric plate.
   e. The concept of convectional current was first explained by __________ in __________.
   f. Convectional currents are classified into __________ and __________; they __________ and __________, respectively.
   g. Plate boundaries are associated with __________, __________ and __________.

2. Name seven major plates
   a. __________________________
   b. __________________________
   c. __________________________
   d. __________________________
   e. __________________________
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3. Name some important minor plates –
   a. __________________________
   b. __________________________
   c. __________________________
   d. __________________________
   e. __________________________
   f. __________________________

4. Enumerate different types of plate boundaries
   a. __________________________
   b. __________________________
   c. __________________________

WHAT YOU HAVE LEARNT

The surface of the earth is dynamic. This dynamism is due to the forces operating from inside the surface (endogenetic forces) as well as on the surface/atmospheric forces (exogenetic forces). It is existing on the earth while itself is rotating and revolving. The surface is irregular. Hence, a sort of dynamic equalibrium is always in operation which is termed as isostasy. Apart from many scholars the views of Airy and Pratt are more distinct. Airy propounded the idea of uniform density of all rocks on the surface but has its roots depending upon the height of the column. A greater root will be found beneath the higher and lofty body of mountains and having smaller root under lower columns like plateau or plain. Pratt accepted that the rocks found on the earth have different densities. At a particulars depth, the weight of all columns of varying height will be compensated. Hence, higher column of mass will have lower density and lower column will have higher density. Therefore, both of them are explaining the same problem of isostatic balance, but with different perspective.

The distribution of land and water on earth surface is not static. It has changed, it is changing and it will change in future too. This changed position is said to be continental drift in crude way which was conceived by Wegener, but the mechanism explained by him was not scientific. Therefore, his ideas of continental drift was denounced inspite of his strong unfutile and testifying evidences.
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With the concept of convective current theory of Holmes and proposition of plate tectonics, a new thinking came in understanding the surface of the earth. Study on paleomagnetism as well as sea floor spreading have supported the plate tectonics theory. According to this theory, the earth surface is made up of several broken blocks of enormous size with great depth considered to be a plate. There are seven bigger size plates and twenty seven smaller size plates. As per the concept of convective current, their movement takes place in three possible ways. First, two adjacent plates move away (divergent) and where a new zone is constructed. Second, two adjacent plates come closer (convergent) and get subducted and where a zone is destroyed. Third, in which two adjacent plates slide past each other (fracture) where the margins of both plates are preserved. Because of these different tectonic activities, earthquakes and volcanoes are associated with plate margins.

**TERMINAL QUESTIONS**

1. What is isostasy?
2. Explain the concept of isostasy according to Airy.
3. Explain the isostatic balance of the earth as proposed by Pratt.
4. Differentiate the ideas between Airy and Pratt.
5. Discuss the isostatic balance at global level.
6. Discuss the evidences of continental drift.
7. What is plate? Explain the mechanism of plate movement.
8. Discuss the activities at plate margins.
9. Describe the distribution of earthquakes and volcanoes with the help of plate boundaries.

**ANSWERS TO INTEXT QUESTIONS**

3.1

1. the state of being balance
2. same
3. density
4. deeper, lower
5. no, level
6. disturb
7. any balance, adjustment is needed.
3.2
1. a. Pangeea
   b. Panthalasa
   c. Laurasia (Angaraland), Gondwanaland
   d. West
   e. Angaraland, Gondwanaland, Panthalasa

2. a. Jig-saw-fit
   b. geological similarities
   c. coal evidences

3 a. evidences from paleomagnetism
   b. sea floor spreading

3.3
1. a. solid and rigid, plate
   b. 100 km, solid
   c. upper solid mantle, crust
   d. movement
   e. Arthur Holmes, 1928-29
   f. Rising, falling; diverge, converge
   g. Newly formed mountain systems, oceanic ridges, trenches

2. a. Eurasian plate
   b. African plate
   c. Indo-Australian plate
   d. Pacific plate
   e. North American plate
   f. South American plate
   g. Antarctic plate

3. a. Arabian plate
   b. Philippine plate
   c. Cocos plate
   d. Nazca plate
   e. Caribbean plate
   f. Scotia plate
Dynamic Surface of the Earth

4. a. divergent boundaries  
   b. convergent boundaries  
   c. fracture or transform fault/boundaries

HINTS TO TERMINAL QUESTIONS

1. Please refer to section 3.1
2. Please refer to section A of 3.1
3. Please refer to section B of 3.1
4. Please refer to section C of 3.1
5. Please refer to section 3.2
6. Please refer to section 3.2, Evidence of drift.
7. Please refer to section 3.3
8. Please refer to section 3.3
9. Please refer to section 3.3
EVOLUTION OF LANDFORMS DUE TO INTERNAL FORCES

We live on an unstable earth, the surface of which is uneven. While travelling, we come across a variety of landforms such as mountains, hills, plateaus, plains, cliffs and ravines. We also come across tilted, broken and twisted layers of rocks which are originally deposited in horizontal forms. You have already studied about different types of rocks, their formation and characteristics. There is a close relationship between rock types and the shape of landforms. But all deformation on the face of the earth are due to the continuous influence of internal and external forces. In this lesson, we will study about the internal forces deriving their strength from earth’s interior and playing their role in shaping what we see on the earth’s crust:

OBJECTIVES

After studying this lesson, you will be able to:

- explain the endogenetic forces and the landforms produced by them;
- distinguish between sudden and slow movements;
- differentiate between vertical and horizontal movement;
- differentiate between folding and faulting;
- explain the causes of volcanic activity;
- describe the different types of volcanoes;
- locate on the outline map of the world, important volcanoes and areas affected by earthquakes;
- explain the causes of earthquakes and their effects.
Evolution of Landforms Due to Internal Forces

4.1 INTERNAL FORCES

The variety in the types of land forms on the earth is the end result of two types of forces working simultaneously and continuously both inside and outside on its surface. The forces which originate from within the earth’s crust or inside the earth are called internal or endogenetic forces. The sources providing them energy are the internal heat, chemical reactions taking place within the earth, and the transfer of rock materials on the earth’s surface by external forces.

4.2 EARTH MOVEMENTS

Though we generally hear people using phrase like “as hard as rock” and “as stable as the earth”, but these phrases are not true. Neither the earth is stable nor are the rocks of which its crust is made, are so hard. Since the origin of earth, there have been major changes in the distribution of continents and oceans, the land and the oceans. The earth has experienced innumerable earth movements which have brought about vast changes in its surface. Some of the examples of these movements are submergence of forest in Bombay harbour, the Mahabalipuram temple now standing on the sea and changes in the ground level in Rann of Kuchchh of India.

The forces working from inside the earth in turn cause movements in its crust. These movements are called earth movements. Since, these movements pertain to or rise from, the movements of the actual structure of the earth’s crust, they are also called tectonic movements. The word tectonic is derived from the Greek word, “tekton” which means builders. This word is true to its meaning because these are the earth movements which are constructional and have been responsible for buildings of different types of land forms.

From Figures 4.1. (a) and 4.1. (b) it is quite evident that the physiography of India was entirely different about 60 million years ago. The vast Tethys sea existed in that area where the Himalayan ranges and Indo-Gangetic plain exist. The Tethys sea was gradually filled up by the sediments brought by rivers from the surrounding regions. Later, the sedimentary rocks formed in the beds of this sea gradually emerged in the form of the Himalayas in the north and Indo-Gangetic plain to its south.
The Malwa plateau and Deccan traps of India, Columbia and Snake Rivers Plateau of North America, Kimberlay Plateau of Australia and Parana and Patagonian Plateaus of South America were also formed by the solidification of molten lava which had escaped from the earth’s interior to its surface at different geological times. The evidences clearly show that the surface of our earth never remained the same as it is today and neither it will be the same in future.

- Movements caused by internal or endogenetic forces affecting the earth’s crust are known as Earth Movements.
- Earth movements are also called tectonic movements as they help in building the relief features on earth’s crust through subsequently or simultaneously undergoing changes.

4.3 CLASSIFICATION OF EARTH MOVEMENTS

The earth movements are classified on various basis. On the basis of time taken by such movements, they are divided into:

(a) slow movement and
(b) sudden movement.

(a) Slow Movement

The movement which bring about changes on the Earth’s crust very gradually or slowly taking hundreds or thousands of years and which cover a period much longer than a human life span are called slow movements. These movements act on the earth’s crust either vertically or horizontally. Acting vertically, they cause uplift or subsidence of a part of the crust. The raised sea-beaches along the Kathiawar coast of India which contain the shells of marine life clearly point out that this coast was once below the sea level. Similar raised beaches are found in Orissa, Andhra Pradesh, and Tamil Nadu along the eastern coast of India as well. These beaches have been uplifted to a height ranging between 15 to 30 metres above the mean sea level.

On the other hand there are numerous examples of submergence. Such as the presence of peat and lignite beds found below the sea-level in Sunderban Delta, the submerged forest in Tirunelveli in Tamil Nadu and the submerged forest on the east coast of Bombay Island.

(b) Sudden Movements

Contrary to the slow movements, there are certain movements which bring about abrupt changes in the crust. The examples of such movements are volcanic eruptions and earthquakes. The changes brought about by these two events are so sudden that the courses of rivers undergo a change,
and the lava flow result in the formation of mountains, uplands and plateaus in a matter of days. Landslides occur in mountainous regions due to these movements.

- Sudden movements bring about abrupt changes on the earth’s surface
- Volcanic eruptions and earthquakes are the result of sudden movements
- The movement which bring changes slowly and gradually over a long period of time are known as slow movements.
- Uplift, submergence and subsidence of the earth’s crust are the result of slow movements.

**INTEXT QUESTIONS 4.1**

1. Give geographical term for internal forces

2. What is Earth Movement?

**4.4 VERTICAL AND HORIZONTAL MOVEMENTS**

The slow movements can further be divided into vertical and horizontal movements on the basis of the uplift or subsidence of a part of the Earth’s surface.

(a) **Vertical movements**

Vertical movements originate from the centre of the earth and affect its surface. Consequently large scale uplift or subsidence of a part of the earth’s surface takes place. These movements are slow and wide spread and do not bring changes in the horizontal rock strata. These movements are mainly associated with the formations of continents and plateaus, hence these are also known as continent building or plateau building movements. Besides, these movements are also called epeirogenetic movements. ‘Epeiros’ in Greek language means ‘continent’ In the previous lesson on rocks, you have studied that sedimentary rocks are deposited and formed in the oceans and seas. The presence of these sedimentary rocks is wide-spread in continents. This clearly shows that these were uplifted or raised to form continents.

Contrary to the above, there are countless evidences of submerged buildings, river-valleys and cities due to subsidence into the sea. Some of such examples include the submerged ancient buildings in Mediterranean in its Crete Island and the ancient city of Dwaraka in Saurashtra, India. These changes clearly point out the downward movement of the Earth’s surface.
(b) Horizontal Movements

There are forces which act on the earth’s crust from side to side i.e. horizontally or tangentially. Naturally, they cause a lot of disruption in the horizontal layer of strata as they do involve a good deal of compression and tension of the preexisting rocks since these forces act horizontally or tangentially to the earth’s spherical surface. These are known as horizontal or tangential movements.

We can divide them into two types:

(i) Forces of compression, and

(ii) Forces of tension.

(i) **Forces of compression**: involve pushing of the rock strata against a hard plane from one side or from both sides. To understand their working, let us take a piece of cloth and spread it on the table. Push the cloth with your both hands towards its centre, it will form wrinkles rising into up and down folds. Likewise rock strata also bend in the same fashion when forces of compression act on them from opposite directions. In this way, the compressional forces lead to the bending of rock layers and thus lead to the formation of fold mountains. In them the rock strata primarily of sedimentary rocks get folded, into wave like structure. This process of bending, sometimes warping and twisting of rock strata is referred to as their folding. The upfolds are called anticlines and downfold are called synclines. (Fig 4.2).

![Fig. 4.2 The Earth's crust before (A) and after folding (B)](image)

When folding takes place on a gigantic scale, it represents the mountain building process. Most of the great mountain chains of the world viz, the
Evolution of Landforms Due to Internal Forces

Himalaya, the Rockies, the Andes, the Alps and others of this sort have been formed by compressional forces resulting in mountain building on a large scale. These are also called Orogenetic Movements.

- Horizontal movements are produced by forces of compression and tension.
- Folding is the bending of rock strata due to compression.
- Upfolds are called anticlines and downfolds synclines.
- Folding on gigantic scale results in mountain building movement generally referred as orogeny.

(ii) **Forces of tension**: are produced when these forces are working horizontally in opposite directions i.e, away from a given plane or point. Under the operation of intense tensional forces, the rock strata is broken or fractured. As a result cracks and fractures develop. The displacement of rocks upward or downward from their original position along such a fracture is termed as faulting. The line along which displacement of the fractured rock strata takes place is called the fault line. Like wise the plane along which displacement of rock strata takes place is known as fault plane (Fig. 4.3)

- Forces of tension produce faults.
- The plane along which displacement of fractured rock strata takes place is called its fault plane.

forces of compression give rise to the operation of the forces of tension. Thus faults are closely related to the formation and occurrence of folds. It implies that folding generally leads to or is accompanied by fracturing and faulting in rock strata.

Faulting results in the formation of well known relief features such as rift valleys and the block mountains. A rift valley is formed by sinking of rock strata lying between two almost parallel faults. (fig. 4.4). The classical

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**Fig. 4.3 A Fault**

forces of compression give rise to the operation of the forces of tension. Thus faults are closely related to the formation and occurrence of folds. It implies that folding generally leads to or is accompanied by fracturing and faulting in rock strata.

Faulting results in the formation of well known relief features such as rift valleys and the block mountains. A rift valley is formed by sinking of rock strata lying between two almost parallel faults. (fig. 4.4). The classical
examples of rift valleys in the world include the Midland Valley of Scotland, the Rhine Valley, the Valley of Nile, the Dead Sea basin and the Great Rift Valley of East Africa comprising few lakes of this region. Some geographers are of the opinion that the Narmada and Tapti valleys are also rift valleys. The coal deposits of the Damodar valley are said to be originally laid in a synclinal trough resembling a rift valley.

A rift valley is a trough with steep parallel walls along the fault lines. Such a valley is also called a graben. A rift valley may also be formed by upliftment of two blocks along the fault line. These uplifted blocks are called horsts or block mountains. The well known examples of horsts are the Vosges and the Black forest mountains on both sides of Rhine rift valley and the Plateaus of Palestine and Trans Jordan.

The escarpments (escarp/faces see Fig 4.3) are the characteristic features of rift valleys and horsts. They are very steep or have highly precipitous slopes in a continuous line facing one direction. The escarpments of Western Ghats ones looking the Arabian Sea are thought to be the result of faulting. The escarpments of Vindhyachal Mountain are also ascribed to the faulting and formation of narrow Narmada Valley.

- Faulting leads to the formation of rift valleys, horsts and escarpments.
- A rift valley is a trough with steep parallel walls along the fault line.
- A horst is a uplifted land mass with steep slopes on both the sides.
- An escarpment is a very steep slope in a continuous line along a fault.

INTEXT QUESTION 4.2
1. Name the earth movements caused by forces of compression.
Evolution of Landforms Due to Internal Forces

2. Give geographical term for mountain building movements.

4.5 VOLCANOES

Have you ever seen an active volcano. Even if you have never seen a volcano, you have probably seen pictures or films of erupting volcanoes. These conical forms are one example of the land forms we will study in this chapter.

A volcano is a vent or an opening in the earth’s crust through which molten rock material, rock fragments, ash, steam and other hot gases are emitted slowly or forcefully in the course of an eruption. These materials are thrown out from the hot interior of the earth to its surface. Such vents or openings occur in those parts of the earth’s crust where rock strata are relatively weak.

![Fig. 4.5 A Volcanic Cone](image)

You may be wondering why such eruptions take place. Actually, volcanoes are evidence of the presence of the intense heat and pressure existing within the earth. Hot molten rock materials beneath the solid outer crust is known as magma. When this magma is thrown out from the magma chamber to the earth’s surface it is known as lava (Fig 4.5). The magma and the gases stored within the earth’s surface keep trying to come out to the surface through a line of weakness anywhere in the crust. The tremendous force created by magma and its gases creates a hole in the crust and the lava spreads out on the surface along with ash and fragmented rock material. The process by which solid liquid and gaseous materials escape from the earth’s interior to the surface of the earth is called vulcanism.

- A volcano is an opening in the earth’s crust through which molten rock material are thrown out slowly or forcefully depending upon the force of eruption.
- The cause of volcanic eruption is the excessive pressure exerted by the magma and hot gases on the earth’s crust.
The process by which solid, liquid and gaseous materials escape from the earth’s interior to its surface is known as Vulcanism.

The volcanic materials accumulate around the opening or hole taking the form of a cone. The top of the cone has a funnel shaped depression which is called its crater (Fig 4.5).

(A) TYPES OF VOLCANOES

Volcanoes are classified on the basis of the nature of vulcanism. The basis include the frequency of eruption, mode of eruption or fluidity and the manner in which volcanic material escapes to the surface of the earth.

On the basis of the frequency of eruption, volcanoes are of three types:

(i) Active
(ii) Dormant and
(iii) Extinct.

The volcanoes which erupt frequently or have erupted recently or are in action currently are called active volcanoes. Important among these include Stromboli in Mediterranean, Krakatoa in Indonesia, Mayon in Philippines, Mauna loa in Hawai Islands and Barren Island in India. The volcanoes which have not erupted in recent times are known as dormant volcano. They are as such the ‘sleeping volcanoes’. Important among these are Vesuvious of Italy, Cotopaxi in South America.

Contrary to these two, there are volcanoes which have not erupted in historical times. These are called extinct volcanoes. Mount Popa of Myanmar (Burma) and Kilimanjaro of Tanzania are important extinct volcanoes. It is not, always very simple to categorise a volcano as dormant or extinct. For example the Vesuvious and Krakatoa became suddenly active after lying dormant for hundreds of years.

- On the basis of the frequency of eruption, volcanoes are classified into active, dormant and extinct volcanoes.
- Active volcanoes are erupting currently or have erupted recently.
- Dormant are those volcanoes which have erupted at least once in human history and are not active now.
- Extinct volcanoes are those which have not erupted during long human history.

On the basis of mode of eruption, volcanoes are divided into two types:

(i) Central type of volcanoes and
(ii) Fissure type volcanoes
Evolution of Landforms Due to Internal Forces

When the eruption in a volcano takes place from a vent or a hole, it is called a central type of volcano. Different types of domes or conical hills are formed by this type of eruption depending on the nature of erupted materials. Majority of volcanic eruptions in the world are of this type. The other characteristic of this mode of eruption is that it is marked by violent explosion due to sudden escape of gases and molten rocks through the hole. Visuvius and Fuji-yama belong to this group of volcanoes.

Sometimes, deep elongated cracks develop due to earthquakes or faulting. The magma starts flowing through them quietly. This mode of eruption is called fissure type of eruption. This eruption helps in the formation of thick horizontal sheets of lava or a low dome shaped volcano with broad base. It may also form what are identified as lava plateaus, and lava shields, Deccan Traps of India is one example of fissure type of eruption.

- Central type of volcanoes erupt from a vent or hole and result in the formation of a conical hill.
- Fissure type of volcanoes erupt through a crack or fissure and cause formation of plateaus and shields.

On the basis of the fluidity of lava there are two types of volcanoes:

(i) Volcanoes of basic lava and
(ii) Volcanoes of acid lava.

Since the basic lava is rich in metallic minerals and has a low melting point, it has greater fluidity. In this type of eruption, lava flows far and wide quietly with greater speed and spreads out in thin sheets over a large area. Thus, it leads to the formation of shields and lava domes. The shield volcano of Hawaiian Island in Pacific ocean is one of these volcanoes.

Contrary to basic lava, acid lava is rich in silica and has a relatively high melting point. Therefore: it is highly viscous and solidifies quickly. Hence, the, acid lava volcanoes cause the formation of usually higher land features with steeper slopes. Acid lava cones are of steeper slopes than basic lava shields. (Fig. 4.6).

![Fig. 4.6 (a) Basic lava shield (b) Acid lava cone](http://smartprep.in)
Basic lava is highly fluid and flows readily and extensively. It causes the formation of shields.

Acid lava is highly viscous. This type of eruption of steep sided cones.

(B) DISTRIBUTION OF VOLCANOES

There are about 500 volcanoes in the world. Most of these volcanoes are found in three well defined belts, The Circum-Pacific belt, the Mid-World Mountain belt and the African Rift Valley belt. Thus, volcanoes are closely related to the regions of intense folding and faulting. They occur along coastal mountain ranges, on islands and in the mid-oceans. Interior parts of continents are generally free from their activity. Most of the active volcanoes are found in the pacific region. About 83 active volcanoes are located in Mediterranean region (Fig. 4.7).

Circum-Pacific region has the greatest concentration of volcanoes, that is why, it is called ‘Pacific Ring of Fire’. This ring extends along Andes mountains of south America to Alaska and from the Aleutian Islands to Japan, Philippines, Indonesia to NewZealand.

The Mid-world mountain belt occupies the second position with regard to the numbers of volcanoes. It runs from Alps in Europe to Asia Minor and crossing through Himalayan region joins the Circum-Pacific belt. The African rift valley region ranks third. Most of the volcanoes are extinct here. Mt. Cameroon is the only active volcano which is situated in Central West Africa.

Fig. 4.7 The Distribution of Volcanoes
There are about five hundred volcanoes in the world. They are located in three well-defined belts namely the Circum-Pacific, the Mid World Mountain and East African Rift Valley belts. Most of the active volcanoes are located in the Circum-Pacific belt which is known the Pacific Ring of Fire.

**INTEXT QUESTIONS 4.3**

1. Answer the following questions:

   (i) Name the process by which magma is ejected out of the earth’s interior

   (ii) Name three types of volcanoes on the basis of the frequency of eruption.
       (a) __________________ (b) _______________ (c) __________________

   (iii) Name two types of volcanoes on the basis of the mode of eruption
       (a) _______________ (b) __________________

   (iv) State two types of lava on the basis of their fluidity
       (a) __________________ (b) __________________

**4.8 EARTH QUAKE**

You have probably seen television news accounts of disastrous earthquakes and destruction caused by them. An earthquake is a motion of the ground surface, ranging from a faint tremor to a wild motion capable of shaking buildings apart. The earthquake is a form of energy of wave motion transmitted through the surface layer of the earth.

All the earthquakes are not of the same intensity. Some of them are very severe, others are very mild and still others are not even noticed. Major or strong earthquakes are only a few. Though our earth experiences many earthquakes everyday, however the frequency of earthquakes varies largely from place to place. The network of seismographic stations all over the world records dozens of earthquakes every day. But, occurrence of severe earthquakes is limited to a few regions. The instrument used for recording the earthquakes is known as seismograph. ‘Sesamos’ is a Greek word which means an earthquake.

The point within the earth’s crust where an earthquake originates is called the focus. It is also referred as seismic focus. It generally lies within the depth of 60 kilometres in the earth crust.

The point vertically above the focus on the earth’s surface is known as ‘epicentre’. The impact of the earthquake is carried from the point of its origin by earthquake waves. These earthquake waves originating from the focus travel in all directions. But their intensity is the highest at the epicentre. That is why the maximum destruction occurs at and around the epicentre. (Fig 4.8). The intensity of vibrations decreases as one moves away from the epicentre in all directions.
An earthquake is a motion of the ground surface, ranging from a faint tremor to a wild motion capable of shaking buildings apart.

A seismograph is an instrument used for recording earthquakes.

Focus is the point within the earth’s crust where the earthquake originates.

The epicentre is the point on the earth’s surface vertically above the focus.

(A) CAUSES AND EFFECTS OF EARTHQUAKES

Folding, faulting and displacement of rock strata are the main causes of earthquakes. Some examples of this type of earthquakes are the San Francisco earthquakes of California in 1906, the Assam earthquakes of 1951, the Bihar earthquakes of 1935.

The second important cause lies in the phenomenon of volcanic eruption. The violent volcanic eruptions put even the solid rocks under great stress. It causes vibrations in the earth’s crust. But, these earthquakes, are limited to the areas of volcanic activity. Its important example is the earthquake which continued for six days preceding the eruption of Mauna Loa volcano of Hawaii Island in 1868.

Minor earthquakes often accompany or are the result of landslides, seepage of water causing the collapse of the rocks of cavern or underground mines and tunnel. These are least damaging earthquakes.

Violent earthquakes are generally very disastrous. They may themselves cause landslides, damming of river course and occurrence of floods, and sometimes, the depressions leading to the formation of lakes. An earthquake often forms cracks and fissures in the earth’s crust. It changes the drainage system of an area as was witnessed in Assam after its 1951 earthquake. Earthquakes also
Evolution of Landforms Due to Internal Forces

cause vertical and horizontal displacement of rock strata along fault line. They prove most catastrophic and devastating when they cause fires and seismic sea waves. Such tidal waves are called Tsunamis. These waves may wash away coastal cities. Buildings and bridges collapse causing death of the thousands of people. Lines of transport, communication and of electric transmission get disrupted. The after effect of earthquake is spread of epidemics like cholera.

(B) DISTRIBUTION OF EARTHQUAKES

The occurrence of earthquake is a phenomenon of almost every part of the world. But, there are two well-defined belts where they occur more frequently. These belts are the Circum-Pacific belt and the Mid-world mountain belt.

The first belt i.e., the Circum Pacific comprises the western coast of North and South America; Aleutian Islands and island groups along the eastern coasts of Asia such as Japan and Philippines. As it encircles the Pacific Ocean from end to end, it is named as such. The earthquakes in this belt are associated with the ring of mountains and volcanoes. It is estimated that about 68 percent of earthquakes of the world occur in this belt alone.

The second belt-extend from Alps with their extension into Mediterranean the Caucasus and the Himalayan region and continues into Indonesia. About 21, percent of total earthquakes of the world originate in this belt. Remaining 11 percent occur in the other parts of the world.

- Most of the earthquakes of the world occur in two belts namely the Circum Pacific and Mid world mountain belts.

Fig. 4.9 Major Earthquake Belts
Changing face of the Earth

INTEXT QUESTIONS 4.4

1. Define an earthquake?

2. Which instrument records the earthquake waves?

3. Define ‘Focus’.

4. How is ‘Tsunami’ caused?

WHAT YOU HAVE LEARNT

Landforms of different types present on the earth’s surface are the result of continuous work of both internal and external forces. Internal forces are responsible for creating inequalities in altitudes of different relief features. These forces originate in the interior of the earth. They are also known as endogenetic forces. These forces cause movements of the earth’s crust which are called earth movements. Slow movements bring slow and gradual changes in the relief features while sudden movements bring abrupt and rapid changes. Internal forces affect the earth into two ways radially and horizontally. When they affect radially they cause subsidence or upliftment of the earth’s crust. Such earth movements are called vertical movements. Contrary to this; when these forces affect horizontally or side to side, they result in folding and faulting of the rock strata. These are called horizontal movements. Volcanoes are landforms marking the eruption of lava at the earth’s surface. The shape and size of volcanoes depend on the frequency of eruption, fluidity of lava and type of eruption. Earthquakes are vibrations of the earth’s crust caused by the operations of the tectonic forces and volcanic activity. The volcanic activity is confined to three well-defined belts of the world. The occurrence of earthquakes is also closely connected with two of these belts.

TERMINAL QUESTIONS

1. What is meant by internal forces? List causes of the origin of these forces.

2. Give four examples to prove that the earth’s crust is unstable.

3. Draw diagrams to show
   (i) Displacement of rock strata along a fault plane,
   (ii) Anticline and synclines of rock strata.

4. Differentiate between vertical and horizontal movements.

5. Distinguish between folding and faulting.
Evolution of Landforms Due to Internal Forces

6. What is a volcano? Describe different types of volcanoes with examples.

7. Distinguish between acid and basic lava and land forms developed by each of them.

8. What causes an earthquake?

9. List the effects of earthquakes on earth’s surface.

10. Define the following terms:
   (a) Fault plane (b) Central type eruption (c) Fissure type eruption (d) Dormant volcano.

11. Locate and label the following in the outline map of the world:
   (a) An active volcano in India (b) A volcanic plateau in south America.
   (c) A rift valley in Europe (d) An extinct volcano in Myanmar (e) An extinct volcano in Africa (f) A volcano in Hawaii island.

ANSWER TO INTEXT QUESTIONS

4.1

1. Endogenetic forces

2. Movement caused by internal forces affecting the earth’s crust are known as ‘Earth Movement’.

4.2

1. Horizontal movements 2. Orogenetic movements

4.3

1. (i) Vulcanism (ii) (a) Active (b) Dormant (c) Extinct (iii) (a) Central type (b) Fissure type (iv) Basic lava (b) Acid lava

4.4

1. An earthquake is a motion of ground surface, ranging from a fain tremor to a wild motion capable of shaking building apart.

2. Seismograph

3. This point within the earth’s crust originate of called the ‘Focus’.

4. The seismic sea waves which originate due to earthquake in octaves, are called ‘Tsunami’.

HINTS TO TERMINAL QUESTIONS

1. Refer to Section 4.1
2. Refer to Section 4.2
3. Refer to Figure 4.1
4. Refer to Section 4.4
5. Refer to Section 4.4 (b) (i) and (ii)
6. Refer to Section 4.5
7. Refer to Section 4.6
8. Refer to Section 4.6
9. Refer to Section 4.6 (A)
10. (a) The plane along which displacement of rock strata takes place is known as fault plane.
    (b) When the eruption in a volcano takes place from a vent or hole, it is called central type eruption
    (c) When the eruption takes place through deep elongated cracks, it is known as fissure type eruption
    (d) The volcanoes which have not erupted in recent times is known as dormant volcano.
11. Refer Maps.
The work of running water and underground water

Changing face of the Earth

Notes

GEOGRAPHY

In the previous lesson we have learnt that the ultimate result of gradation is to reduce the uneven surface of the earth to a smooth and level surface. These agents produce various relief features over the course of time. Amongst all the agents of gradation, the work of running water (rivers) is by far the most extensive. In this lesson we will study how running water and underground water act as agents of gradation and help in the formation of different relief features.

OBJECTIVES

After studying this lesson, you will be able to:

- explain the three functions of running water viz erosion, transportation and deposition, in the different parts of the river’s course;
- explain with the help of diagrams the formation of various erosional and depositional features produced by the action of running water;
- explain the cause of fluctuating water table from place to place and season to season;
- explain with the help of diagrams the formation of various relief features formed by underground water;
- distinguish between (i) stalactites and stalagmites, (ii) wells and artesian wells, (iii) springs and geysers.

5.1 THE THREE FUNCTIONS OF A RIVER

Running water or a river affects the land in three different ways. These are known as the three functions of a river. They are (i) erosion (ii) transportation and (iii) deposition. Throughout its course a river displays all the three activities to some extent.

GEOGRAPHY
The work of running water and underground water

(1) EROSION

Erosion occurs when overland flow moves soil particles downslope. Weathering and erosion supply this rock material which is the load of the river. This load acts as the grinding tool. It thus helps in cutting the bottom and sides of the river bed, resulting in deepening and widening of the river channel.

Both the cutting and removal of rock debris by the river is called river erosion. The work of river erosion is accomplished in four different ways, all of which operate together. These four ways are:

(a) Corrasion or Abrasion

As the rock particles bounce, scrape and drag along the bottom and sides of the river, they break off additional rock fragments. This form of erosion is called corrasion. This is the mechanical grinding of the rivers against the banks and bed of the river. Corrasion takes place in two different ways:

(i) Lateral Corrasion: This is sideways erosion which widens the river valley.
(ii) Vertical Corrasion: This is the downward erosion which deepens the river valley.

(b) Corrosion or Solutions

This is the chemical or solvent action of water on soluble or partly soluble rocks with which the river water comes in contact. For example, limestone or calcium carbonate, when it comes in contact with water, it is easily dissolved and removed in solution.

(c) Hydraulic Action

This is the mechanical loosening and sweeping away of material by the sheer force of river water itself. No load or material is involved in this process. Some of the water splashes against the river banks and enters into cracks and crevices. This undermines the soft rocks with which it comes in contact. It picks up the loose fragments from its bank and bed and transports them away.

(d) Attrition

This is the wear and tear of the transported materials themselves when they roll and collide with one another. In the process the coarser boulders are broken down into smaller pieces. The angular edges are smoothened and rounded to form pebbles.

(2) TRANSPORTATION

River carries rock particles from one place to another. This activity is known as transportation of load by a river. The load is transported in four ways.
The work of running water and underground water

(a) Traction
The heavier and larger rock fragments like gravel, pebbles etc. are forced by the flow of river to roll along its bed. These fragments can be seen rolling, slipping, bumping and being dragged. This process is known as traction and the load is called traction load.

(b) Saltation
Some of the fragments of the rocks move along the bed of a stream by jumping or bouncing continuously. This process is called saltation.

(c) Suspension
The holding-up of small particles like sand, silt and mud by the water as the stream flows is called suspension.

(d) Solution
Some parts of rock fragments are dissolved in the river water and are thus transported (See fig.5.1)

- The river transports its load in four ways viz. traction, saltation, suspension and solution.
- The transporting power of a river mainly depends upon its velocity, volume and size of particles.

(3) DEPOSITION
When the stream comes down from hills to plain area, its slope becomes gentle. This reduces the energy of the stream. The decrease in energy hampers transportation; as a result part of its load starts settling down. This activity is known as deposition. Deposition takes place either due to decrease in slope or due to fall in the volume or velocity of river water. Deposition takes place usually in plains and low lying areas. When the river joins a lake or sea, the whole of its load is deposited.
The work of running water and underground water

- Deposition takes place either due to decrease in slope or decrease in volume or velocity of water.

**INTEXT QUESTIONS 5.1**

1. Which are the three functions of a river?
   (i) __________________ (ii) __________________ (iii) __________________

2. What name is given to the rock material carried away by a river?
   _______________________________________________________

3. Name the four ways in which river erosion takes place.
   (i) __________________ (ii) __________________ (iii) __________________
   (iv) __________________

4. Name four ways in which a river transports its load.
   (i) __________________ (ii) __________________ (iii) __________________
   (iv) __________________

5. Name two conditions which favour the deposition of river load.
   (i) __________________ (ii) __________________

6. Name the areas where deposition takes place.
   _______________________________________________________

**5.2 DEVELOPMENT OF A RIVER VALLEY**

The erosional and depositional land features produced and modified by the action of running water may be better understood if we note the stages through which a stream passes from its source to its mouth. The source of a river may lie in a mountainous region and the mouth may meet the sea or lake. The whole path followed by a river is called its course or its valley.

The course of a river is divided into three sections:

(i) The upper course or the stage of youth
(ii) The middle course or the stage of maturity
(iii) The lower course or the stage of old age. (See Fig. 5.2)

- Upper, middle and lower are the three courses into which a river valley is divided.

(i) **THE UPPER COURSE**

The upper or mountain course begins from source of the river in hilly or mountainous areas. The river tumbles down the steep slopes and as a result its velocity
The work of running water and underground water and eroding power are at their maximum. Consequently valley deepening assumes its greatest importance at this stage. Normally, weathering also plays its part on the new surfaces exposed along the banks of the stream. The weathered rock material is carried into the stream partly through the action of gravity and partly by rain water flowing into the river. Weathering helps in widening a valley at the top giving it a typical ‘V’ shaped cross section. Such valleys are known as ‘V’ shaped valleys.

![Diagram: Upper, Middle and Lower Courses of River](https://smartprep.in)

**Fig. 5.2 (a) The Upper, Middle and Lower Courses of River**

![Diagram: Graded Long Profile and Cross-section of a River Valley](https://smartprep.in)

**Fig. 5.2(b) The Graded Long Profile and Cross-section of a River Valley from Source to Mouth**
If the bed rock is hard and resistant, the widening of the valley at its top may not take place and the down cutting process of a vigorous river may lead to the formation of a gorge i.e. a river valley with almost vertical sides.

In India, deep gorges have been cut by the Brahmaputra and the Indus in the Himalayas. Deep gorges also develop in limestone regions and in rocks lying in dry climates. The narrow and very deep gorge or the canyon with vertical walls is also known as ‘I’ shaped valley. A canyon is ‘very deep gorge with steep sides running for hundreds of kilometers, e.g. Grand Canyon of the river Colorado in U.S.A. Some of the more outstanding features that are developed in the upper course of a river include rapids, cataracts, cascades and waterfalls.

- The land features carved by a river in its upper course are gorges, canyons, ‘V’ shaped valleys, rapids, cataracts, and waterfalls.

(ii) THE MIDDLE COURSE

In the middle course, lateral corrasion tends to replace vertical corrasion. Active erosion of the banks widens the ‘V’ shaped valley. The volume of water increases with the confluence of many tributaries and this increases the river’s load. Thus work of the river is predominantly transportation with some deposition. Rivers which sweep down from steep mountain valleys to a comparatively level land drop their-loads of coarse sand and gravels as there is sudden decrease in velocity. The load deposited generally assumes a fan like shape, hence it is called an alluvial fan. (See Fig. 5.3)

![Fig. 5.3 Alluvial Fans](image)

Sometimes several fans made by neighbouring streams often unite to form a continuous plain known as a piedmont alluvial plain, so called because it lies at the foot of the mountain.

In this section even minor obstacles force a river to swing in loops to go round the obstacles. These loops are called meanders, a term derived from the winding River Meanderes in Turkey.
Some of the land features formed by a river in its middle course are alluvial fans, and meanders.

(iii) THE LOWER COURSE

The river moving downstream across a broad, level plain is heavy with debris brought down from the upper and middle courses. Vertical corrosion has almost ceased, the lateral corrosion still goes on to erode its banks further. The work of the river is mainly deposition, building up its bed and forming an extensive flood plain. Many tributaries join the river and the volume of water increases, coarse materials are dropped and the fine silt is carried down towards the mouth of the river. Large sheets of material are deposited on the level bed and the river splits into a maze of channels. Such a stream is called a braided stream (See Fig. 5.4)

![Fig. 5.4 Braided Stream](image)

During annual floods large quantities of sediments are spread over the low lying adjacent areas. A layer of sediments is thus deposited during each flood gradually building up a fertile flood plain. A raised ridge of coarse material is formed along each bank of the river. Such ridges are called levees. (See Fig. 5.5)

![Fig. 5.5 Flood Plain and Levees](image)

In the lower course of the river, meanders become much more pronounced. The outer bank or concave bank is so rapidly eroded that the meander becomes almost a complete circle. A time comes when the river cuts through the narrow neck
The work of running water and underground water

of the loop. The meander, now cut off from the main stream, takes the form of an oxbow lake (See Fig. 5.6).

Fig. 5.6 Stages in the Formation of a Oxbow lake

This lake gradually, turning into swamps disappears in course of time. Numerous such partially or fully filled oxbow lakes are marked at short distance from the present course of river like the Ganga.

Upon entering a lake or a sea, the river deposits all the load at its mouth giving rise to the formation of a delta (See Fig. 5.7). Delta is a triangular relief features with its apex pointing up stream and is marked as a fan-shaped area of fine alluvium. The Greek letter (Δ) pronounced delta closely resembles the triangular delta of the river Nile. Some deltas are extremely large. The Ganga-Brahmaputra Delta is the largest delta in the world.

Fig. 5.7 Formation of a Delta
The work of running water and underground water

The following conditions favour the formation of deltas:

1. active vertical and lateral erosion in the upper course of the river to supply large amount of sediments;
2. tideless, sheltered coast;
3. shallow sea, adjoining the delta and
4. no strong current at the river mouth which may wash away the sediments.

Due to the obstruction caused by the deposited alluvium, the river discharge its water through several channels which are called distributaries. Some rivers emptying into sea have no deltas but instead they have the shape of a gradually widening mouth cutting deep inland. Such a mouth is called estuary. The formation of estuaries is due to the scouring action of tides and currents. But in most of the cases the original cause is the subsidence of the earth’s crust in the area of the outlet. The two west flowing rivers of India, the Narmada and the Tapi do not form deltas. They form estuaries when they join the Arabian Sea.

In the lower course land features produced by river are meanders, flood plains, braided steam, oxbow lakes, deltas and estuaries.

INTEXT QUESTIONS 5.2

1. Fill in the blanks:
   (a) The course of river from its source to mouth has been divided into three parts.
      These are (i)___________ (ii)___________ (iii)___________
   (b) A narrow and steep sides valley is called a ________________.

2. Fill in the blanks
   (a) The winding sections or loops of a stream are known as ____________.
   (b) The load deposited by a river at the foot of a mountain while descending from it, is called ____________.

3. How is a piedmont alluvial plain formed?

4. Fill in the blanks
   (a) The meander completely cut off from the main river takes the form of a lake which is known as___________________.
   (b) A number of branches of the main river carrying water to the sea are called _______________________.
   (c) A triangular shaped land feature made by a river at its month is called _________________________.
   (d) Instead of deltas, rivers Narmada and Tapi form _____________.

GEOGRAPHY
5.3 UNDERGROUND WATER

Seepage and water-holding capacity of the rock depend upon its space. If the rock is porous like sandstone, it will allow water to easily pass through it. Such rocks are called permeable rocks. On the other hand, if the rocks are not porous and do not allow water to pass through them, they are called impermeable rocks. However, if there are any cracks or joints in such rocks, water may pass through them.

- The part of rain or snow-melt water which accumulates in the rocks after seeping through the surface is called underground water.
- The rocks through which water can pass easily are called permeable rocks, and the rocks through which water cannot pass through are called impermeable rocks.

Although the amount of underground water varies from one place to another, its role in shaping the surface features of the earth is quite important. Most of its work is confined to subsurface areas though it plays an important role on surface also.

5.4 WATER TABLE

The water table marks the upper surface of the saturated zone of the ground water, where pores are completely full of water. The zones or horizons of permeable and porous rocks which are fully filled with water are called the zones of saturation. The upper level of this zone, below which the rocks are completely saturated with water is called the underground water level or the water table.

- The rocks containing underground water are called aquifers.
- The underground horizon of porous and permeable rocks which is filled with water is called zone of saturation.
- The level of underground water, below which the rocks are fully filled with water is called water table.

5.5 TYPES OF WATER TABLE

The level of the ground water table always fluctuates. It is never the same in any area. The level of the water table is controlled by the nature of land surface, variation in the amount of rainfall and the character of the underlying rocks. Water table is generally higher in areas of high precipitation and also in areas bordering rivers and lakes. Water-table changes according to seasons. It is higher in rainy season and lower during summers. On the basis of the variability, the water-table is of two type: (a) The permanent water table and (b) The temporary water table.

(a) Permanent Water Table

When the water table is stable or static and never falls below a particular level, it
is called the permanent water-table. It is not affected by seasonal change. Wells dug upto this depth provide water in all seasons. They are perennial wells.

![Fig. 5.8 Water Table](image)

(b) **Temporary Water Table**

This is also known as seasonal water table. The level at which the water-table is not stable, keeps changing with season is called temporary water table. It means that during the wet season, the water table will be higher than it is during the dry season. It is the water table of the wet season that is temporary. Wells dug upto this level are not perennial. They dry up during the summer season. (See Fig. 5.8). You might have seen wells drying up during the summer season and becoming filled with water during the rainy season. It is because such wells are dug upto the temporary water-table.

- Nature of land surface, variations in amount of rainfall and the nature of rocks affect the underground water table of any area.
- The level below which the water table never falls is called the permanent water table.
- The water table which changes with seasons is called the temporary or seasonal water table.

### INTEXT QUESTIONS 5.3

1. Fill in the blanks with the appropriate word given in the bracket against each statement.
   
   (a) The water which accumulates in the rocks after seeping through the surface is called____________________(underground water, water-table)

   (b) The rocks filled with underground water are called ________________(Zones of Saturation, aquifers)

2. Name two types of water-table.

   (a)_________________________ (b)_________________________
3. Name three factors affecting water-table.
   (a) __________________ (b) ______________ (c) ______________

5.5 WELLS, TUBEWELLS & ARTESIAN WELLS

You must have seen wells and tubewells. They are man made holes dug into the earth’s surface through which underground water is drawn for drinking purpose and for irrigation. They are either bored mechanically as in the case of tubewells or are dug by man (as in the case of wells) to reach a permanent water table.

A special type of well in which water rises automatically under its own pressure to the surface, either through a natural or a man made hole is called an artesian well. The name artesian has been derived from the province of Artois in France, where the first well of this type was dug. Certain conditions are prerequisite of an artesian well.

(a) **Arrangement of Rocks:** For an artesian well, there should be a layer of permeable rock lying between two impermeable rock layers. In such case, water present in the permeable rock does not escape. (See fig. 5.9)

![Fig 5.9 Artesian Well](image)

(b) **Structure of Rock Strata:** Second condition for the occurrence of artesian wells is that the rock must have a synclinal or tilted structure.

(c) **Intake Area of the Rock:** It is necessary that the permeable rock should be exposed at the ground surface, so that rock can soak rainwater. This intake area should be sufficiently high so that enough hydraulic pressure will be developed to force the water upward in the well.

(d) **Availability of Water:** There should be sufficient amount of precipitation of infiltration of water in the area where the permeable rock is exposed at the surface.
A man-made hole on the earth’s surface through which underground water is obtained is called a well.

A well in which water flows out automatically under its own pressure is called an artesian well.

The necessary conditions required for occurrence of artesian wells are - arrangement of rocks, structure of rock strata, high intake area of the permeable rocks and availability of water.

5.6 SPRINGS & GEYSERS

Springs are surface outflow of ground water through an opening in a rock under hydraulic pressure. In such cases the aquifer is either exposed at the surface or it underlies an impermeable rocks. The amount of water in the aquifer depends upon the amount of rainfall in that area, landform characteristic and the size of the aquifer. (See fig. 5.10)

(a) Hot Spring

Sometimes the water that flows out of the spring is hot. Such springs are called hot springs. They generally occur in areas of active or recent vulcanism. In volcanic regions the underground water gets heated up by coming in contact with hot rocks or steam. Hot springs are found in many parts of India, especially in the Himalaya in Jammu and Kashmir and Himachal Pradesh. They also occur in Uttarakhand, Jharkhand, Haryana and Assam. Manikaran in Kulu Valley, Tatapani near Shimla, Jwalamukhi in Kangra, Sohna in Haryana, Rajgir and Sitakund in Jharkhand and Badrinath in Uttarakhand have hot springs.

(b) Geyser

Springs emitting hot water and steam in forms of fountains or jets at regular inter-
vals are called geysers. The term geyser has been derived from Icelandic word *geysir*. In case of a geyser, hot water is ejected violently because of the pressure created by steam. The water does not come out continuously but it flows out intermittently. The period between two emissions is sometimes regular. The best example of geysers working at a regular interval is the Old Faithful in the Yellowstone National Park of U.S.A which is situated in the Rocky Mountain region. Its regularity is so accurate that tourists correct their watches by it. Geysers are found in Iceland, Yellowstone National Park of U.S.A and the northern part of New Zealand. (See Fig. 5.11)

![Fig. 5.11 Geyser](Image)

- The surface outflow of ground water through an opening in a rock under hydraulic pressure is called a spring.
- They can be hot or cold water springs.
- A geyser is a hot spring in which water is forced out by steam pressure at intervals.

### INTEXT QUESTIONS 5.4

1. Give one word answers for the following questions:
   
   (a) In which province of France was the first artesian well dug?
       ____________________________________________________.
   
   (b) Name the place in Kulu Valley where hot springs are found
       ____________________________________________________.
   
   (c) In which country is Old Faithful geyser located?
       ____________________________________________________.
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(d) What should be the shape of the rock strata for occurrence of the artesian wells?

5.7 LANDFORMS PRODUCED BY UNDERGROUND WATER

Underground water is also an agent of gradation like surface water. It also does the work of erosion, transportation and deposition, which results in formation of a number of picturesque topographical features. Topographical features formed by underground water can be seen particularly, in a highland composed of limestone on a large scale. This distinctive topography formed due to the action of underground water in limestone region is known as Karst topography. ‘Karst’ word comes from the Karst region of Adriatic Sea coast in Croatia (Yugoslavia) where such formations are noticeable. This region is made up of limestone rocks, where underground water is the most active agent of gradation.

- The distinctive topography formed by underground water in limestone region is called Karst topography
- Mechanical weathering and solution of limestone in water help the erosional work of underground water.

The topographical features created by the work of underground water on limestone are of two types.

(a) Topographical features formed on the surface, like sink holes and swallow holes.
(b) Topographical features formed underground like caverns, stalactites and stalagnites.

(i) Sink Holes

A sinkhole is a surface depression in a region of limestone or chalk terrain. Some sinkholes are filled with soil washed from nearby hillsides, while others are steep-sided, dugholes. They develop where the limestone is more susceptible to solution, weathering or where an underground cover near the surface has collapsed.

(ii) Swallow Holes

They are cylindrical in shape lying underneath the sinkholes at some depth. In limestone regions, the surface streams often enter the sinkholes and then disappear underground through swallow holes. It is so, because these holes are connected to the underground caverns on their other side.
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Fig. 5.12 A Sinkholes on the Surface of Limestone Rock
B-Swallow Holes at the bottom of a Funnel Shaped Sinkhole

(iii) Caverns

Caverns are interconnected subterranean cavities in bedrock formed by the corrosive action of circulating underground water on limestone. They are found near Dehradun in Uttarakhand and in Almora in Kumaon Himalayas. The caves of Kotamsar in the tribal district of Bastar in Chhattisgarh are famous caverns of India.

- The funnel-shaped depressions in limestone regions are called sink holes.
- Cylindrical shape tubes lying underneath the sink holes are called swallow holes.
- Underground caves formed due to the solvent action of underground water in limestone region are called caverns.

(iv) Stalactites and Stalagmites

They are the major depositional features formed in the caverns in limestone regions. The water containing limestone in solution, seeps through the roofs of the caverns in the form of a continuous chain of drops. A portion of the water dropping from the ceiling gets evaporated and a small deposit of limestone is left behind on the roof. This process continues and deposit of limestone grows downwards like pillars. These beautiful forms are called stalactites.
When the remain in portion of the water dropping from the roof of the cavern falls on the floor, a part of it is again evaporated and a small deposit of limestone is left behind. This deposit grows upward from the floor of the cavern. These type of depositional features are called stalagmites. As the process grows, both stalactite and stalagmite often join together to form vertical columns in the caverns.

- Solid conical depositional features hanging from the cavern’s roofs are called stalactites.
- Broad conical pillars developing on the floor of the caverns in limestone regions are called stalagmites.

INTEXT QUESTIONS 5.5

1. Answer following questions in one or two words:
   a. Name the cavern located in Chhattisgarh.
      ________________________________________.
   b. In which country is “Karst” region located.
      ________________________________________.
   c. Name three regions of the world where hot spring and geysers are found
      (i)________________(ii)________________(iii)_____________
   d. Name two topographical features formed on the surface through the activity of underground water.
      (i)_________________________(ii)____________________
Among the agents of gradation, the running water is most effective and important. A river has three fold action- (a) erosion (b) transportation (c) deposition. The rock material carried by river water is called its load. The ability of a river to move rock material depends upon- (a) the speed of water (b) the volume of water (c) the land structure and (d) the size, shape and weight of load. The work of river erosion is accomplished in four different ways-corrasion, corrosion, hydraulic action and attrition. The river transports its load in four different ways-by traction, saltation, suspension and solution. The deposition starts in plains and low lying areas. The whole path followed by a river is called its course. The course of a river is divided into three sections-(1) the upper course (2) the middle course (3) the lower course. The upper course lies in mountain. Here vertical cutting is more important. The land features produced are gorges, canyons, rapids, waterfalls. The middle course lies at the junction of mountain and plains. Here the work of river is mainly transportation with some deposition. The land feature produced is meander. The lower course lies in the plain area. Here the work of river is mainly deposition. The land features produced are ox-bow lakes, braided streams, alluvial and flood plains, delta and estuary.

The water which percolates inside the earth is called underground water. The upper limit of underground water is called water-table. The level of water table is not uniform but it varies seasonally. Consequently the water-table is of two types permanent water table and temporary water table. Underground water comes to the surface through wells, tubewells and springs. Wells and tubewells are manmade holes dug into the earth surface through which water is obtained. In addition to these ordinary wells, there is a special type of well in which water flows out automatically under hydraulic pressure. They are called artesian wells. Surface outpour of ground water that from rock opening under its own pressure is called a spring. Sometimes the water flows out of springs is hot, such springs are called hot springs. When the hot springs emits water in the form of a fountain, they are called geysers. Geysers are found mainly in Iceland, Yellowstone National Park, USA and New Zealand.

Underground water does the work of erosion, transportation and deposition which result in number of topographical features. The major depositional features made by underground water are stalactites and stalagmites, which develop in the caverns.

**TERMINAL QUESTIONS**

1. Answer briefly the following questions:
   
   (a) In what different ways does a river transport its load?
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(b) List out factors which affect (1) energy of a stream and (2) carrying capacity of streams.

(c) In what different ways is the work of river erosion accomplished?

2. Distinguish between the following pairs:
   (a) estuary and deltas (b) flood plain and braided stream

3. The following landforms have been formed by rivers. Group them under erosional and depositional features.
   Gorge, V-shaped valley, meander, flood plain, alluvial fan, and canyon.

4. Explain the formation of the following with suitable diagrams:
   (a) Oxbow lake (b) Delta

5. Explain systematically the work of river as an agent of gradation at each of the three stages of its course.

6. Answer the following questions in brief:
   (a) Explain the meaning of the term underground water.
   (b) How do streams in limestone regions suddenly disappear?
   (c) Why is construction of rails and roads difficult in areas of sinkholes.
   (d) Permanent watertable and temporary watertable.
   (e) Sinkhole and swallow hole. (f) Stalactite and stalagmite.
   (g) Permeable rocks and impermeable rocks. (h) Hot spring and geyser.

7. What is meant by ‘Karst’ topography? Name any five topographical features of karst topography and explain any two of these with the help of diagrams.

ANSWERS TO INTEXT QUESTIONS

5.1

1. (i) Erosion (ii) Transportation (iii) deposition
2. Load
4. (i) Traction (ii) Saltation (iii) Suspension (iv) Solution.
5. (i) decrease in slope or in velocity of water (ii) decrease in volume of water.
6. Plains, low laying areas, lakes and seas.

5.2

1. (a) (i) upper (ii) middle (iii) lower course. (b) Gorge
2. (a) Meanders (b) Alluvial fan
3. By deposition of load at the foot of mountains.
4. (a) Oxbow lake (b) Distributaries (c) Delta (d) Estuaries.

5.3
1. (a) Underground water (b) Acquifers,
2. (a) Permanent water table (b) Temporary water-table.
3. (a) Nature of surface (b) Rainfall (c) Nature of rocks.

5.4
1. (a) Arto region (b) Manikaran (c) U.S.A. (d) Synclinal or titled.

5.5
(a.) Kotamsar b. Croatia (Yugoslavia) c. (i) Iceland (ii) Yellowstone National Park, USA (iii) New Zealand
d. (a) Sinkholes (b) Swallow holes.

HINTS TO TERMINAL QUESTIONS
1. (a) The river transports its load in four ways by traction, by saltation, by suspension and by solution.
   (b) (i) Slope, velocity, structure of river bed. (ii) Velocity, volume and size of particles.
   (c) The work of river erosion is accomplished by corrasion, corrosion, hydraulic action and attrition.

2. (a) Estuary- The funnel shaped mouth of river, where tides flow in and out and where fresh water and sea water mix. They are formed by drowning of coastal lowlands by a relative rise of sea level.
   Delta - A more or less triangular and level tract of alluvium formed at the mouth of river and traversed by the distributaries of the river.
   (b) Flood Plain - A plain bordering a river formed as a result of sediments deposited by a river and is generally liable to flooding.
   Braided stream - A river that gets divided into a network of interconnected channels, forming bars and sand island in between.

   Work of Deposition- Meander, Flood plain, Alluvial Fan.

4. (a) Ox-Bow lake- The meanders develop in the middle course of the river. In course of time the strip of land between two loops becomes
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narrower and narrower till the river cuts through this strip and takes a straight course. The former loop or meander is left behind completely cut off from the main channel forming an Ox-bow lake.

(b) Delta- A more or less triangular and level tract of alluvium formed at the mouth of river and traversed by the distributaries of the river.

5. River is the most important agent of gradation. The river has three stages. It remains busy doing the work of gradation in the three stages,

Upper Stage:- Gorge, waterfall, canyons are formed.

Middle Stage: Meanders, alluvial fans are formed.

Lower Stage:- Flood plains, braided stream, ox-bow lake, delta and estuary, are formed by the river.

6. (a) Underground water is that part of the rainwater which percolates through the ground and accumulates below the surface, is called underground water.

(b) A large number of sinkholes and swallow holes are found in limestone regions. The water of the streams enters these openings and the surface flow becomes underground. In this manner the streams in the limestone regions become underground.

(c) Construction of roads and railways is difficult in regions having a large number of sink holes and swallow holes due to which the level of the ground sinks in such regions.

(d) Permanent water table: This is the level of the water under the surface below which the water-table never falls. This water-table is not affected by seasonal change. Wells dug upto this depth are never dry. (See fig. 5.8)

Temporary water-table: In some regions the water-table is not permanent and it keeps changing with seasons. The water-table changing with seasons is called temporary water-table. Wells dug upto this depth become dry during the dry season.

(e) Sink holes: These are funnel-shaped openings in the limestone region. Their depth varies from 3 to 9 metres and the diameter of the mouth is more than one metre. (See Fig 5.12) Construction of roads and railways is difficult in areas having a large number of sink holes.

Swallow holes: They are cylinderical tube-like openings which are connected to the lower part of the sink hole. Rivers of the limestone regions become underground through swallow holes.

(f) Stalactite: A portion of the water dropping from the ceiling gets evaporated and a small deposit of limestone is left behind on the roof. This process continues and deposit of lime stone grows downwards like pillars. These beautiful forms are called stalactites.
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**Stalagmites**: When the remaining portion of the water dropping from the roofs of the cavern falls on the floor a part of it is again evaporated and a small deposit of limestone is left behind. This deposit grows upward from the floor of the cavern. These type of depositional features are called stalagmites.

**(g) Permeable rock**: The rock through which water can percolate are called permeable rocks. **Impermeable rocks**: The rocks through which water cannot percolate are called impermeable rocks.

**(h) Hot springs**: The springs emitting hot or warm water are called hot springs. These springs are found in areas of present or past volcanic activity. In such regions the underground water gets heated up by coming in contact with hot rocks or steam.

**Geyser**: Hot springs emitting hot water and steam at almost regular intervals are called geysers. The water in geysers is ejected with force as in case of a fountain.

7. For Karst topography see following figures 5.12, 5.13 and 5.14

**(i) Sinkholes (ii) Swallow holes (iii) Caverns (iv) Stalactites (v) Stalagmites.**

See description of these figures in Section 5.8.
You have learnt in the previous lesson about the gradational role of running water and underground water. In addition to these two agents, moving ice, wind and sea-waves too are powerful agents of gradation. These three agents too perform the threefold function of erosion, transportation and deposition. In other words, they are removing the weathered material, transporting it from the elevated ground and are depositing the same into low lying areas. This process also tends to ‘grade’ or ‘level off’ all irregularities on the surface of the earth in the areas of their operation. We will learn during the course of this lesson how each of these three agents of gradation functions as well as note the details of topographical features formed by each of them.

**OBJECTIVES**

After studying this lesson, you will be able to:

- define glacier, snow-line, snowfield, continental and valley glaciers;
- explain with the help of diagrams the formation of main erosional and depositional features produced by glaciers;
- differentiate among the various types of moraines;
- explain the features formed by the wind with the help of diagrams;
- explain with the help of diagrams the various relief features formed by sea-waves;
- give examples of features formed by these three agents of gradation preferably from India.

**6.1 SNOW-FIELDS**

In regions where the temperature always remains below freezing point, precipita-
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Changing face of the Earth

Notes

Region permanently covered by snow and ice is called snow-field.
Snowline is the lowest limit of permanent snow. Factors affecting snowline are- latitude, amount of snowfall, direction of winds and slope.

6.2 GLACIER

In region experiencing snowfall, the snow keeps on accumulating in layers one above the other. Its overlying pressure is applied to the underlying snow. It is so great that snow in lower layers becomes granular, hard and compact. The pressure also quickens the melting of some of the snow, which on refreezing starts turning into a granular ice. Again it is the pressure of the overlying layers which makes this solid mass of ice mobile. This great mass of ice moving more under its own weight is called a glacier. Its velocity is very low and it moves from a few centimetres to a few metres in a day.

Types of Glaciers

On the basis of their location or area of origin, glaciers are divided into two types:

(i) continental glaciers and (ii) valley glaciers.

(i) Continental Glaciers

A thick ice sheet covering vast area of land is called a continental glacier. The thickness of ice in such regions goes up to thousands of metres. Glaciers of this type build up at the centre and move outward in all directions. Continental glaciers of today are found mainly in Antarctica and Greenland. The precipitation in these regions occurs in the form of snow. It gets accumulated year by year because of relatively slower rate of its melting.

(ii) Valley Glaciers

When a mass of ice from the high mountainous regions starts moving down into the pre-existing valleys, it is called a valley glacier or a mountain glacier. The shape of the valley glaciers depends on the valley it occupies. Where the valley is broad, the glacier spreads outwards and where the valley is narrow, the glacier contracts.

The longest glacier in India is the Siachen Glacier in Karakoram range which is 72 kilometres long. Gangotri Glacier in Uttarakhand is 25.5 kilometres long. There are many smaller glaciers in other parts of the Himalaya. Their length varies from 5
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to 10 kilometres. The two important rivers of India, the Ganga and Yamuna, originate from Gangotri and Yamunotri glaciers respectively.

- A moving mass of ice and snow is called a glacier. Glaciers are of two types-continental glaciers and valley glaciers.

### INTEXT QUESTIONS 6.1

Answer the following questions briefly:

1. What is the name given to a moving mass of ice and snow?
   - Glacier

2. What is the name given to the areas lying above the snow-line?
   - Snow-line

3. What is the name given to the lowest limit of snow-fields?
   - Snow fields

4. Name two types of glaciers.
   - (a) Continental glaciers
   - (b) Valley glaciers

### 6.3 LANDFORMS PRODUCED BY GLACIER

Like running water and underground water, glacier also does the work of erosion, transportation and deposition. Although the zone of action of glaciers is rather limited, topographical features made by them are frequently found spread over even in areas once affected by glacial action.

(A) **Erosional work of glacier**

As a glacier moves over the land, it drags rock fragments, gravel and sand along with it. These rock fragments become efficient erosive tools. With their help glacier scrapes and scours the surface rocks with which it comes in contact. This action of glacier leaves behind scratches and grooves on rocks.

The landforms created by glacial erosion are:

(i) **Cirque (or Corrie)**

Snow collects at the upper end in a bowl shaped depression, is called cirque. Layers of snow in the process of compaction and recrystallization are called firn. Sometimes the deepest parts of these hollows are occupied by accumulated-water, to form Corrie Lake (or Tarn).
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(ii) ‘U’-shaped Valley

The glacier does not carve a new valley like a river but deepens and widens a preexisting valley by smoothening away the irregularities. In this process the glacier broadens the sides of the valley. The shape of the valley formed in this manner resembles the letter ‘U’. It is therefore called a ‘U’-shaped valley. (See Fig. 6.2). Such a valley is relatively straight, has a flat floor and nearly vertical sides.

(iii) Hanging Valley

Just like tributary streams of river, there are tributary glaciers also which join the main glacier after moving over their mountainous path. These tributary glaciers like the main glaciers carve U-shaped valleys. However, they have less volume of ice than the main glaciers and thus their rate of erosion is less rapid. As a result their valleys are smaller and not as deep as that of the main glacier. Due to this difference in deepening; the valley of the tributary glacier is left at a higher level than that of the main glacier. The valley of the tributary glacier just looks like hanging downwards at the point of its confluence with the main valley. This type of a topographical feature is called a hanging valley. This feature is visible when ice has melted in both the valleys. (See Fig. 6.3 and 6.4). When the ice in the hanging valley melts, a waterfall is formed at the point of confluence of this stream with the main river.
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The main erosional features formed by a valley glacier are (i) Cirque (or Corrie), (ii) U-shaped valley and (iii) hanging valley.

(B) Transportational work of Glacier

Although the glacier moves very slowly, it drags with it large boulders and rock fragments. Glacier gets this material from the mountain slopes, valley sides, valley bottom and from air. This material is called the load of glacier.

(C) Depositional work of Glacier

When the glacier melts or retreats, it deposits its load in different parts. The debris thus deposited are called moraines. Depending upon their location in the valley, moraines are of four types:-(i) terminal moraine, (ii) lateral moraine, (iii) medial moraine and (iv) ground moraine. (See fig. 6.5)
Notes

(i) **Terminal Moraine**: When the glacier melts, the debris are deposited at the end of the valley glacier in the form of a ridge. It is called terminal moraine. Morainic material ranges from fine clay to large angular boulders.

(ii) **Lateral moraine**: The moraine which is deposited on either side of a glacier is called lateral moraine.

(iii) **Medial moraine**: When two glaciers join each other their lateral moraines also join. Moraines thus formed on the confluence of two glaciers are called medial moraines.

(iv) **Ground moraine**: It consists of deposits left behind in areas once covered by glaciers. It is seen only after the glacial ice has disappeared by melting.

---

**Fig. 6.5 A Glacier with Small Tributaries (showing moraines)**

- Morains are accumulation of angular blocks of rocks, boulders, pebbles and clay that has been deposited by melting glacier or ice-sheet at the edges.
- The moraines deposited at the end of the valley glacier is called terminal moraine.
- Moraine deposited on the sides of the glacier is called the lateral moraine.
- Moraine deposited at the confluence of two glaciers is called the medial moraine.
- Moraine deposited at the bottom of the glacier is called ground moraine.

---

**INTEXT QUESTION 6.2**

1. Name three topographical features made by glacial erosion.
   (a) ____________________ (b) ____________________ (c) ____________________
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2. Name one topographical feature made by glacial deposition.

_______________________________________________________

3. Name three functions of glacier.
(a) ___________________ (b) ___________________ (c) ___________________

6.4 LANDFORMS PRODUCED BY THE WIND

Wind action moves mineral particles when they are in a dry state and unprotected by a vegetation cover. These conditions are found in deserts and semiarid regions of the world, as well as on sandy shorelines.

(A) EROSION BY WIND

Wind performs three kinds of erosional work abrasion, attrition and deflation. Loose particles laying on ground surface may be lifted into the air or rolled along the ground by wind action. In the process of wind abrasion, wind drives sand and dust particles against an exposed rock or soil surface. When the wind borne material strike against each other, they are reduced in smaller particles. This process is known as attrition. The removal of loose particles from the ground is termed “deflation”.

Landforms Produced by Wind Erosion

Some of the topographical features made by wind erosion are as follows: (i) Mushroom Rocks (Or Rock Pedestals)

When rocks, consisting of alternate hard and soft layers are subjected to wind abrasion, differential erosion results. The soft layers are easily eroded but the hard layer’s resist erosion. As a result of undercutting near the base (due to greater amount of sand and rock particles being transported close to the ground), the resulting feature resembles a rock pillar shaped like a mushroom. It is aptly called rock pedestal or mushroom rock. Such formations are common in the Sahara Desert, and are also seen near Jodhpur. (See fig. 6.6)

Fig. 6.6 Mushroom Rock
(ii) Wind Eroded Basins

A land form produced by deflation is a shallow depression called a “blowout”. The Quattara depression in Egypt is perhaps the finest example of such a hollow.

Fig. 6.7 Wind Eroded Basin

- Mushroom rocks are formed in the desert regions by means of wind erosion.
- Wind-eroded basins are formed by wind deflation.

(B) TRANSPORTATION BY WIND

Wind is an important agent of transportation in the arid region. The transported material is sometimes deposited in areas very far away from the place from where the dust particles have been picked. Winds blowing from Gobi Desert carry dust to the northern parts of China. In our country also winds blowing from Thar Desert bring dust particles to western Uttar Pradesh and the adjoining parts of Haryana & Punjab. This transported material is deposited in the fertile plains of Uttar Pradesh.

(C) DEPOSITION BY WIND

Under certain conditions, the material transported by wind starts getting deposited at a particular site along its running track. The conditions favouring it are:

(i) When the amount of dust particles present in the air exceed its carrying capacity, a part of the material being transported is deposited. This is the material which is in excess of the transportation capacity of the wind.

(ii) When the speed of the wind is reduced, its carrying capacity is also reduced. The material in suspension is thus deposited.

(iii) When an obstruction comes in the path of the wind, air has to rise above this obstruction. When it rises, the velocity of the wind is reduced and it starts dropping its load. This material is deposited in the form of a mound at the foot of the obstruction.
Landforms produced by Wind Deposition

Some of the topographical features made by wind deposition are as follows:

(i) Sand Dunes

Sand dunes are a special feature of the desert regions. They are of different types and have a variety of shapes. The major factors affecting their formation are (a) amount of sand available (b) direction and force of wind, (c) an obstruction in the path of the wind e.g. a bush, a stone or a dead animal. As long as the wind is strong enough to carry the sand, the sand dunes are mobile and they keep on shifting from one place to another. If vegetation or a line of trees starts growing on the dunes they become fixed. They also become stationary when they are blocked by a hillock. In case there is no such obstruction, sand dunes may bury agricultural land, plains and settlements.

There are two main types of sand dunes:

(a) Barchan

One common type of sand dune is an isolated heap of free sand called a barchan, or crescentic dune. This type of dune has the outline of a crescent, and the points of the crescent are directed downwind. On the upwind side of the crest, the sand slope is gentle and smoothly rounded. They are found in large numbers in the Sahara Desert.

(b) Seif Dunes

These are long, narrow ridges of sand that lie parallel to the direction of the prevailing winds. The winds blow straight along the corridors between the lines of dunes, sweeping the corridors clear of the sand, However, eddies set up in the winds blow towards the sides of the corridors, depositing sand there to form these nar-
row elongated dunes. Seif dunes are common in the western part of the Thar Desert of India.

(c) Loess

In several large areas of the world, the surface is covered by deposits of wind-transported silt that has settled out from dust storms over many thousands of years. This material is known as loess.

Loess tends to break away along vertical cliffs whenever it is exposed by the cutting of a stream or grading of a roadway. It is also very easily eroded by running water and is subject to rapid gullying when the vegetation cover that protects it is broken. The thickest deposits of loess are in northeast China, where a layer over 30m deep is common and a maximum thickness of 100m has been measured. Besides China, deposits of loess occur in Mississippi Valley of North America and north of Central European Upland in Germany, Belgium and France. Loess deposits are found in Australia also.

- Depositional work of wind results in formation of topographical features like sand dunes, Barchan, seif dunes and loess.
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INTEXT QUESTIONS 6.3

(a) In which region is the work of wind more effective?
_______________________________________________________

(b) Name three important works of wind.
(i) __________________ (ii) __________________ (iii) _________________

(c) Which major topographical features are made by wind erosion?
(i) __________________ (ii) __________________

(d) Name three important topographical features made by wind deposition.
(i) __________________ (ii) __________________ (iii) _________________

(e) Where are the maximum deposits of loess found?
_______________________________________________________

6.5 LANDFORMS PRODUCED BY SEA WAVES

We are aware of the fact that the water in the oceans is never at rest. The tides, waves and ocean currents contribute to the restlessness of ocean. Their continuous effect on coast creates a number of relief features. The work of sea waves as an agent of gradation includes erosion, transportation and deposition. A number of topographical features are made through these actions of waves. Such features are found in the coastal regions. Let us study the work of sea waves in some more details.

(A) EROSION BY SEA WAVES

Sea waves have a great erosive force. In their role of an erosional agent they perform four functions. When the sea water loaded with rock fragments and sand attack the coastal rocks it is called abrasion. The rock particles present in the water hit against each other and break into progressively smaller particles. This process is called attrition. Thirdly the broadening of cracks and crevices in the cliffs along the coast due to the attack of the sea waves is called the hydraulic action. The rocks made up of limestone are subjected to solution action by the sea waves. All these processes help in formation of new features on the coastal margins.

- The three major works of sea waves are erosion, transportation and deposition.
- Abrasion, attrition, solution and hydraulic action are the processes which help in erosion by the sea waves.
Landforms Produced by sea Wave Erosion

Waves, like streams erode the coastal rocks with the help of rock fragments present in the water. Due to the continued erosion by waves, the coastline keeps retreating and a number of topographical features are formed in the process. Some of the important features made through sea wave erosion are mentioned here:

(i) Sea Cliff

The maximum impact of the sea waves is observed on the lower part of the coastal rocks and consequently the lower part of the rocks is eroded more rapidly than the upper part. This results in the formation of a hollow under the rock and with the passage of time this excavation in the lower part of the rock keeps on becoming larger.

![Fig. 6.10 A Sea Cliff](image)

The upper part of the rock is thus left projecting out towards the sea. After sometime, this projecting part fall into the sea under its own weight. As a result a vertical wall is left. This vertical wall is called a cliff. In India a number of sea cliffs are found along the Konkan Coast of India.

(ii) Sea Caves

When the upper part of the coastal rock is hard and the lower part is soft, the erosion is not uniform. The lower part of the rock in such circumstances is eroded much faster than the upper part. Due to differential erosion a hollow is created in the lower part of the rock. When the waves pound against this hollow, air present in the hollow gets compressed. When the wave comes out of the hollow, the pressure on air is also released and it expands. Due to continuous compression of the air in the hollow, the rocks are subjected to a great pressure and they break. In this process, the hollows in the lower part of the rock keep on enlarging. With
passage of time they attain the form of caves and are known as sea caves. Formation of caves depends upon the nature of the coastline and the force of the waves.

(iii) Sea Arches

When a part of coast extends to some distance into the sea, sea waves working from opposite directions cut a passage through the soft rocks. In the initial stages, this passage is a narrow hole but it enlarges into a broad arch. These broad door-like features are called sea arches or natural bridges.

(iv) Sea Stacks

When the roof of an arch is broken by erosion or under its own weight or due to any other reason a part of the original rock remains standing as a solitary mass. It may be the rock forming the side of the arch. This type of a feature is called a sea-stack. Stacks are of a number of types depending upon their shape and the nature of the rocks. Sometimes they take the shape of islands but such islands are not permanent. Small underwater stacks are known as stumps.

Wave erosion is responsible for the formation of sea cliffs, sea caves, sea arches and sea stacks.

(B) Transportation by Sea Waves

Sea waves, currents and tides are the main agents of transportation of eroded material in the coastal regions. However, the role of waves is more important in connection with the formation of coastal relief features. The material deposited on the coasts by the rivers and glaciers etc. is removed and transported by the waves. Transportation by sea waves is carried out in two ways:

(i) Removal and transportation, towards the sea, of the material deposited by river etc. on the coast.

(ii) Carrying of material found in the sea to the coastal areas. During this process, the oceanic materials like pearls, conches and other shells are brought to the coast.
Transportation by sea waves is responsible for oceanward transportation of the material deposited on the coast and coastward transportation of the material found in the sea.

(C) Deposition by Sea Waves

Sea waves are helpful in the deposition of the material eroded from the coastal areas. Oceanic currents are also helpful in deposition of the transported material. Deposition of the material along the coast is selective. The larger particles are deposited first therefore they are found near the coast. On the other hand, the finest particles are deposited last and they are deposited generally away from the coast. This selective deposition is sometimes altered or affected by a change in the intensity or force of the waves. Thus it is sometimes possible to find very fine particles deposited near the coast where generally larger particles are deposited.

A number of topographical features are formed due to deposition by waves and currents. Some of these topographical features are discussed here:

(i) Beach

Most of the material eroded and picked up by the waves is deposited near the coast. Due to this deposition, the sea becomes shallow and a part of the coastal area is raised above the water level. This raised portion is almost like a flat plain of a platform formed of gravel and sand. This type of depositional features along the coast is called a beach. Beaches are centres of tourist attraction. Marina Beach of Chennai and Kovalam Beach of Thiruvananthapuram are the famous beaches of India.

(ii) Sand Bar

Sometimes the deposits of sand and gravel laid down by waves and currents form embankment, separating shoreline from the sea. They thus form barriers between the sea and the mainland. Such deposits are called sand bars. They sometime pose difficulties in navigating.
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(iii) Spit

When one end of a bar is attached to the coast and other extends into the sea, it is called a spit. These spits are formed by the accumulation of materials brought by waves like sand and gravel.

(iv) Lagoon

Sometimes due to deposition of waves and currents both the ends of the bar join to enclose a part of the sea water between the coast and the bar. This enclosed part of the sea forms a lake of saline water. This saline water lake is called a lagoon.

![Fig. 6.13 Map showing Famous Lagoons of India](image)

Sometimes the lagoons are formed due to wave erosion also. A lagoon is generally connected with the sea through a narrow passage. The Chilka and Pulicate lakes on the north-eastern coast and lake Vembanad on Kerala coast are examples of lagoon lakes in India.

- Topographical features like beaches, bars, spits and lagoons are formed by the action of waves.

**INTEXT QUESTIONS 6.4**

1. Fill in the blanks

   (a) Cutting of coastal rocks by sea waves is known as their ________ work.

   (b) The four processes contributing to erosional action of sea waves are:

      (i) ________ (ii) ________ (iii) ________ (iv) ________
(c) Sea cliff is a result of ______________ action of sea waves.

2. Name any three relief features made through erosional action of sea waves.
   (i) _______________ (ii) _______________ (iii) _______________

3. Name two important factors on which the formation of the sea caves depends.
   (i) __________________ (ii) __________________

4. Which action of waves is responsible for the formation of spit
   ________________________________________________________________________

5. Classify following relief features made by erosional and depositional action of waves:
   Sea stack, Bars, Sea caves, Sea cliffs, Beaches and Arches.

   Categories:
   (i) Made through erosion (1) __________ (2) __________ (3) __________
   (ii) Made through deposition (1) __________ (2) __________ (3) __________

WHAT YOU HAVE LEARNT

In areas where the temperature always remains below freezing point, precipitation occurs in the form of snow. Therefore, these areas are covered with snow. Such regions are called snow-fields. Snow-fields are found always above the snowline. Snowline is that line above which the snow never melts completely. Moving ice is called a glacier. They are of two types - continental glaciers and valley glaciers. Glaciers do the work of erosion, transportation and deposition through which a number of topographical features are formed. The major topographical features of glacial erosion are the ‘U’-shaped valleys and hanging valleys. The major depositional features of glacial action are the moraines. There are three types of moraines-terminal moraine, lateral moraine and medial moraine. Topographical features made by glaciers are found in areas of high altitude and high latitude.

Wind like running water, moving ice and underground water, is an important agent of gradation. Action of wind is more effective in arid and semi-arid regions. Wind erodes the rocks, transports the broken material and deposits it in different areas. These three actions of wind are known as erosion, transportation and deposition. Erosional work of wind include abrasion, attrition and deflation. One of the major topographical features made by wind erosion is mushroom rock which resembles an umbrella in shape. The transportation work of wind is also extensive, the broken particles of rocks are transported to thousands of kilometres. Deposition of the transported material results in formation of a number of topographical features. The important ones among these are the sandunes and loess.
The Work of Moving Ice, Wind and Sea Waves

The most important agent shaping coastal landform is wave action. The important works of waves are the breaking up of the rocks, removal of broken material and laying down of this material in different parts of the coastal areas. These three actions of waves are called erosion, transportation and deposition. Erosion by waves is achieved through the processes of abrasion, attrition, hydraulic action and solution. Erosion by sea waves results in formation of topographical features like sea cliff, sea caves, arches and stacks. Transportation work of waves makes possible seaward movements of the material accumulated on the coast and coastward movement of the material found in the sea. Depositional work of sea waves is responsible for formation of topographical features like bars, spit, beaches and lagoons.

TERMINAL QUESTIONS

1. Answer the following questions in brief:
   (i) What is snowline?
   (ii) What is a hanging valley? How is it formed?

2. Distinguish between the following:
   (a) Continental glacier and valley glacier. (b) V-shaped valley and U-shaped valley.

3. Name the major relief features formed by glacial erosion and deposition and explain the process of formation of each with the help of diagrams.

4. In which region is the work of wind more effective? Why is it so?

5. Explain the three processes which help in the wind erosion.

6. How is a mushroom rock formed? Explain with the help of a diagram.

7. Where is the greatest deposits of loess found?

8. Which topographical features are formed through erosional action of sea waves? Explain the mode of formation of each.

10. How is a beach formed? Name two important beaches of India.

11. Differentiate between:
   (i) Erosional and depositional work of wind.
   (ii) Solution action and hydraulic action of sea-waves.
   (iii) Lagoon and beach.

GEOGRAPHY
ANSWERS TO INTEXT QUESTIONS

6.1

6.2
1. (a) U-shaped valley (b) Hanging valley (c) Cirque
2. Moraine
3. (a) Erosion, (b) Transportation, (c) Deposition

6.3
(a) Desert and semi-desert regions.
(b) (i) Erosion (ii) Transportation (iii) Deposition
(c) (i) Mushroom rock, (ii) Wind eroded basin
(d) (i) Sand dunes (ii) Barchans or Seifdunes, (iii) Loess
(e) In North China

6.4
1. (a) Erosional (b) (i) Abrasion, (ii) Attrition, (iii) Hydraulic action; (iv) Solution. (c) Erosional
2. (i) Sea cliffs (ii) Sea caves (iii) Sea arches (iv) Sea stack (any three)
3. (i) Nature of the coastline (ii) Force of waves
4. Depositional work.
5. (i) Made through erosion: Sea stacks, cliffs, caves, arches.
   (ii) Made through deposition: Bars, beaches.

HINTS TO TERMINAL QUESTIONS

1. (i) Snowline is an imaginary line above which there is Permanent snow.
   (ii) Refer to section 6.3 (a) (iii) for answer draw the diagram (Fig. 6.4) given on that page.

2. (a) (i) Continental glacier: A large area covered with ice and snow.
   (ii) Valley glacier: is formed when ice and snow start moving from high mountains into some pre-existing valleys. This moving mass of ice and snow is called a valley glacier.
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(b) U-shaped Valley: Due to a steep slope in the higher mountainous regions, the flow of the rivers is very rapid. They erode the bottom of their valleys at a higher rate and this results in the formation of a V-shaped valley. (See figure in the foregoing lesson).

U-shaped valley: Glaciers do not form their valley as the river does. They flow through some old valleys. Such narrow valleys are broadened and deepened by the glaciers to form U-shaped valleys. U-shaped valleys are deep and steep-sided and they are formed through erosion on the valley floor and the valley sides. (See Fig. 6.2).

3. Major relief features formed by glacial erosion are (i) U-shaped valley, (ii) Hanging valley. Major relief features formed by glacial deposition are: (i) Lateral moraines, (ii) Terminal moraines, (iii) Ground moraines, (iv) Medial moraines.

4. In arid or desert regions

Due to partial or total absence of vegetation cover, the wind fins the conditions ideal for blowing over vast areas uninterrupted. Besides mechanical weathering breaks the rocks into small particles which are easily blown away.

5. The three processes are abrasion, attrition and deflation. (For details Refer to Section 6.4 (A).

6. Mushroom rock is formed by wind erosion. (For details and see Section 12.6 (i).

7. Greatest expanse of loess deposits is found in North China. Where a layer over 30M is common and a maximum thickness of 1000M has been measured.

8. The major topographical features made through wave erosion are sea cliffs, sea caves, sea arches and sea stacks. (For details of their mode of formation refer to section 6.5 (A).

9. Beaches are formed through depositional work of : Sea waves. Two famous beaches of India are Marina Beach of Chennai and Kovalam Beach of Thiruvananthapuram. (For details of mode of formation see Section 6.5 (C) (i).

10. (i) Breaking lip and frictional reduction of rocks by wind is called erosion and the process of laying down of wind-borne material is called deposition. (For details refer to section 6.4 (A) and (C).
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(ii) The term hydraulic action refers to the process of broadening of the rock joints and cracks by the pressure exerted by air entrapped in the coastal “rocks. The term solution refers to the action of water on the soluble rocks like limestone. Such rocks are dissolved by water and thus eroded. (For detail refer to Section 6.5).

(iii) Lagoon and beach are both formed through depositional action of waves. A beach is a raised portion on the sea coast made through deposition of sand and gravel. A lagoon is the enclosed part of the sea separated from the open sea by an enlarged bar. (For details refer to 6.5 (C) (i) and (iv).
You have learnt in the previous lesson that the landforms found on the earth’s surface are the result of interplay between internal and external forces. The soft rocks are easily worn down by these forces. While the relatively harder rocks are not so easily worn down. Therefore, rocks have a great influence on the landforms developed in an area. The internal forces are perpetually elevating the earth’s surface and the external forces about which you will study in the next lessons are constantly wearing down such elevations to make the surface level. This is how various landforms are formed by constant action of agents of gradation. These landforms are not only the physical features of the earth’s surface but also the basis of human civilization. The major landforms found on the earth’s surface are mountains, plateaus and plains. In this lesson, we will study the major landforms of the earth and their economic importance for us.

After studying this lesson you will be able to:

- differentiate among the three major landforms found on the earth’s surface;
- explain the process of formation of various landforms with the help of illustrations;
- classify mountains on the basis of their mode of formation;
- discuss the usefulness of mountains to man;
- list different types of plateaus and describe their economic significance;
Major Landforms and their Economic Significance

- enumerate major types of plains and explain their influence on human life;
- locate major mountains, plateaus and plains on the outline map of the world.

7.1 MOUNTAINS

Mountain, plateau and plain are broad by present day land features of the earth’s surface produced by the deformation of its crust. Among them, mountains are the most awe-inspiring landform. About 27% of the earth’s surface is covered by the mountains. Generally, they are uplifted portions of the earth’s surface which are much higher in contrast to the surrounding areas. But all uplifted or elevated areas are not mountains. In fact height and slope together give rise to a particular form of land which we identify as a landform. For example, the elevated portion in Tibet, which is about 4500 metres high above sea level, is called a plateau and not a mountain.

It may also be remembered that the formation of a mountain range takes millions of years. During these years, the internal forces of the earth uplifting the land are fighting against erosion wearing it down. In order to form one Mt. Everest, internal forces must push up the land faster than the external forces constantly eroding it. Therefore, mountains are those uplifted portions of the earth’s surface which have steep slopes and small summit area rising more than thousand metres above the sea level. Mountains have the maximum difference of height between their high and low portions.

- The uplifted portions of the earth’s surface with steep slopes and small summit area rising above 1000 metres and formed over a period of million of years are called mountains.

7.2 CLASSIFICATION OF MOUNTAINS

On the basis of their mode of formation, the mountains have been classified as:

(a) Fold Mountains
(b) Block Mountains
(c) Volcanic Mountains
(d) Residual Mountains

(a) Fold Mountains

We have studied in the last lesson how folds are formed in the rock strata by the internal earth movements. Mountain range mainly consisting of uplifted folded sedimentary rocks are called fold mountains. When these rocks are subjected to horizontal compressional forces for millions of years, they get
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bent into up and down folds. This leads to the formation of anticlines and synclines. Such earth movements occur from time to time and lift the folds to a considerable height which result in the formation of fold mountains.

- The mountains which have been formed by the uplift of mainly the folded sedimentary rock strata under compressional forces are called fold mountains.

![Fig. 7.1 Distribution of Important Fold Mountains of the World](image)

The Himalayas in Asia, the Alps in Europe, the Rockies in North America and the Andes in South America are the most prominent fold mountains of the world, (See fig. 7.1). Since these mountain ranges were formed during the most recent mountain building period, they are known as young fold mountains. Some of these mountain ranges, for example, Himalayas, are still rising.

(b) Block Mountains

Block mountains are also formed by the internal earth movements. When the forces of tension act on the rocks, they create faults in them. When the land between the two almost parallel faults is raised above the adjoining areas, it forms a block mountain. It may also occur when land on the outer side of the faults slips down leaving a raised block between them. The rocks composing the fault levels may be flatlying or even folded. Block mountain is also called horst (see fig. 7.2). The Vosges in France, Black Forest Mountains in Germany and Sierra Nevada in North America are the typical examples of block mountains.

![Fig. 7.2 Block Mountain or Horst](image)
Notes

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- The mountain formed by the uplift of land between faults or by the subsidence of land outside the faults is known as block mountain.

(c) Volcanic Mountains

We have learnt in the previous lesson that the interior of the earth is extremely hot. Due to high temperature deep inside the earth rocks turn into a molten magma. When this molten rock material is ejected to the earth’s surface during volcanic eruption, it accumulates around the vent and may take the form of a cone. The height of the cone increases with each eruption and it takes the form of a mountain. As these mountains are formed by the accumulation of volcanic material, they are known as volcanic mountains or mountains of accumulation (see fig.7.3). Mount Mauna Loa in Hawaii Islands, Mount Popa in Myanmar, Vesuvius in Italy, Cotopaxi in Equador and Fuji Yama in Japan are examples of volcanic mountains.

(d) Residual Mountains

The weathering and different agents of erosion – rivers, winds, glaciers etc. are constantly acting on the earth’s crust. As soon as an elevated mountain range appears on the earth’s surface, the agents of gradation begin their work of leveling it down. To a large extent, the process of wearing down depends on the shape and structure of the rocks. After thousands of years, soft rocks are worn down into sand and the hard rocks are left standing up in the area that has been reduced in height. These are called residual mountains (fig.7.4). Hills like the Nilgiris, the Parasnath, the Rajmahal and the Aravalis in India are examples of residual mountains.
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Fig. 7.4 Residual Mountains

- The elevated regions that have escaped weathering and erosion and appear in the form of mountains are called residual mountains.
- On the basis of their mode of formation, the mountains can be classified as Fold Mountains, Block Mountains, Volcanic Mountains and Residual Mountains.

7.3 THE ECONOMIC SIGNIFICANCE OF MOUNTAINS

Mountains are useful to us in the following ways:

(a) **Storehouse of Resources**

Mountains are the storehouse of natural resources. Large resources of minerals are found in mountains. The Appalachian range in the United States is well-known for coal and limestone deposits. We get timber, lac, medicinal herbs and wood for making pulp from the forests of the mountains. Tea and coffee plantations and some fruits orchards have been developed on mountain and hill slopes.

(b) **Generation of Hydro-electricity**

Hydro-electricity is generated from the waters of perennial rivers in the mountain regions. The mountainous countries like Japan, Italy and Switzerland, which suffer from the shortage of coal have developed hydro-electricity.

(c) **Abundant Sources of Water**

Perennial rivers rising in the snow fed or heavily rain fed mountains are the important source of water. They help in promoting the irrigation and provide water for many other uses.

(d) **Formation of Fertile Plains**

The rivers that originate in the high mountain region bring silt alongwith water to the lower valleys. This helps in the formation of fertile plains.
The great alluvial plain of northern India has been formed by the rivers Ganga, Sutlej and the Brahmaputra.

(e) **Natural Political Frontiers**

The mountain ranges do act as natural political frontiers between countries and protect them from invasions to some extent. The Himalaya have formed a political frontier between India and China.

(f) **Effect on Climate**

Mountainous areas have lower temperatures. They serve as climatic divide between two adjoining regions. The Himalaya for example form a barrier to the movement of cold winds from Central Asia towards the Indian subcontinent. They also force the South West Monsoons to ascend and cause rainfall on their southern slopes.

(g) **Tourist Centres**

The pleasant climate and the beautiful scenery of the mountains have led to their development as centres of tourist attraction. The tourist and hotel industries get an additional encouragement in such regions. Shimla, Nainital, Mussorie and Srinagar are some of the important hill stations of India which attract tourists all over the world.

**INTEXT QUESTIONS 7.1**

1. Name the three major landforms found on the earth’s surface.
   
   (i) ___________ (ii) ___________ (iii) ___________

2. Answer in brief
   
   (a) From which rock type have the fold mountains been formed?
   
   __________________________________________

   (b) By which forces are the fold mountains formed?
   
   __________________________________________

   (c) Name the four important hill stations of India.
   
   (i) ___________ (ii) ___________ (iii) ___________ (iv) ___________

3. Write the type of mountain in the brackets:
   
   (a) The Black forest (________
   
   (b) The Nilgiris (________
   
   (c) The Fuji Yama (________
   
   (d) The Andes (________
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7.4 PLATEAUS

The plateaus cover about 18% of the earth’s surface. This landform has a large elevated area on its top unlike a mountain and has nearly even surface out there. Very often rivers or streams cut out deep valleys and gorges in a plateau region. In place of its original smooth topography, it then changes into a dissected plateau. A plateau, however, remains much higher above the sea level of the nearby areas. Though normally 600 metres above sea level, there are plateau of Tibet and Bolivia, more than 3600 metres above sea level.

A plateau is an elevated area of more or less level land on its top. It has a large area on its top and steep slope on its side.

7.5 CLASSIFICATION OF PLATEAUS

On the basis of their geographical location and structure of rocks, the plateaus can be classified as:

(a) Intermontane Plateaus
(b) Piedmont Plateaus
(c) Continental Plateaus

(a) Intermontane Plateau

The plateau which are bordering the fold mountain range or are partly or fully enclosed within them are the intermontane plateaus (Fig 7.5). Vertical movements raise this extensive landforms of nearly horizontal rocks to thousands of metres above sea level. The extensive and over 4500 metres high plateau of Tibet is one such example. It is surrounded by folded mountains like Himalaya, Karakoram, Kunlun, Tien Shah on its two sides. The plateau of Colorado is another well known example, over one km high into which rivers have cut the Grand Canyon and a series of gorges. The plateau of Mexico, Bolivia and Iran are all other examples of this type.
(b) Piedmont Plateau

The plateaus that are situated at the foot of the mountains and are bounded on other sides by a plain or an ocean are called piedmont plateau Fig. 7.6. The plateau of Malwa in India, those of Patagonia facing the Atlantic ocean and the Appalachian situated between the Appalachian Mountain and the Atlantic Coastal Plain in U.S.A are their examples. In their case, the areas once high have now been reduced by various agents of erosion. For this reason, these are also called the plateaus of denudation.

![Fig. 7.6 Piedmont Plateau](image)

(c) Continental plateau

These are formed either by an extensive continental uplift or by the spread of horizontal basic lava sheets completely covering the original topography to a great depth. The volcanic lava covered plateau of Maharashtra in India, Snake River Plateau in North West USA are the examples of this type. These are also, called the plateau of accumulation.

All continental plateaus show an abrupt elevation in contrast to the nearby lowland or the sea (fig.7.7). As compared to other, these plateaus, cover a vast area like the Great Indian Plateau and those of Arabia, Spain, Greenland, Africa and Australia. They may be tilted on one side without any disturbance in the horizontal nature of underlying rock strata as in the case of Great Indian plateau.

![Fig. 7.7 Continental Plateau](image)
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- The plateau which are bordering or are enclosed within high mountain ranges are called intermontane plateau.
- The plateaus formed by the uplift of large areas or by the gradual spread and accumulation of basic lava sheets are called continental plateau.
- The plateaus which are situated at the foot of mountains and are bounded by a plain or an ocean on the other side are called piedmont plateaus.

Due to continuous erosion of their surface, we observe the prevalence of a patchy or the slow development of agriculture and building of roads on the plateaus. This factor also explains why the plateaus are sparsely populated. Nevertheless plateaus are extremely useful to mankind in the following ways:

1. **Storehouse of Minerals**

   Most of the minerals in the world are found in the plateaus. Besides, the extraction of minerals is relatively easier on plateaus. These minerals are indispensable as raw material for our industries. We get gold from the Plateau of Western Australia; copper, diamonds and gold from the Plateaus of Africa and coal, iron, manganese and mica from the Chota Nagpur Plateau in India.

2. **Generation of Hydel-power**

   Rivers falling down the edges of plateaus form water-falls. These water-falls provide ideal sites for generating hydel-power.

3. **Cool Climate.**

   The higher parts of the plateaus even in tropical and sub-tropical regions have cool climate. Hence they have attracted Europeans to settle there and develop their economy e.g. South and East Africa.

4. **Useful for Animal-rearing and Agriculture**

   Plateaus have large grassland areas suitable for animal-rearing specially sheep, goat and cattle. They provide a variety of products such as wool, milk, meat and hides and skin. The lava plateaus as compared to all other plateau are richer in agriculture since their soil is very fertile.

   - Plateaus are useful because of the presence and easier way of extracting minerals and favouring generation of hydro-power. Their suitable climate and sometimes fertile soils are helpful for developing animal-rearing and agriculture.
(a) Name the three types of plateaus.
   (i) ___________ (ii) ___________ (iii) ___________

(b) Name three natural resources for which plateaus are well known
   (i) ___________ (ii) ___________ (iii) ___________

(c) Write against each of the following the type of plateaus to which it belongs:
   (i) The plateau of Patagonia _______________________________
   (ii) The plateau of Bolivia _________________________________
   (iii) The Decean plateau __________________________________

Plains are the most important landforms found on the earth’s surface. A low-lying relatively flat or slightly rolling land surface with very gentle slope and minimum local relief is called a plain. Plains occupy about 55% of the earth’s surface. Most of the plains have been formed by the deposition of sediments brought down by rivers. Besides rivers, some plains have also been formed by the action of wind, moving ice and tectonic activity. Plains have an average height of less than 200 metres.

- A low-lying relatively flat or slightly rolling land surface with very gentle slope and minimum local relief is called a plain.

Plains can be classified into the following types:

(a) Structural plains,
(b) Erosional plains and
(c) Depositional plains:

(a) **Structural plains**

These plains are mainly formed by the uplift of a part of the sea-floor or continental shelf. These are located on the borders of almost all the major continents. The south eastern plain of the United States formed
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by the uplift of a part of the Gulf of Mexico is an example of this type of plain. The structural plains may also be formed by the subsidence of areas. One such plain is the central low-lands of Australia.

(b) Erosional Plains

These plains are formed by the continuous and a long time erosion of all sorts of upland. The surface of such plains is hardly smooth. These are therefore also called peneplains which means almost a plain. The Canadian shield and the West Siberian plain are examples of erosional plains.

- The plains formed by uplift or subsidence of an area are called structural plains.
- The plains formed by the continuous long term erosion of uplands are called erosional plains.

(c) Depositional plains

Fragments of soil, regolith, and bedrock that are removed from the parent rock mass are transported and deposited elsewhere to make on entirely different set of surface features—the depositional landforms. When plains are formed by river deposits, they are called riverine or alluvial plains. The Indo Gangetic plain of the Indian sub-continent, the Hwang-Ho Plain of North China, the Lombardy Plain of the Po river in Italy and the Ganga-Brahmaputra Delta Plain in Bangladesh are examples of alluvial plains.

The deposition of sediments in a lake gives rise to a lacustrine plain or a lake plain. The Valley of Kashmir and that of Manipur are examples of two most prominent lacustrine plains in India.

When plains are formed by glacial deposits they are called glacial or drift plains. Plains of Canada and North-Western Europe are examples of glacial plains.

When wind is the major agent of deposition, they are called loess plains. Loess plains of North- Western China are formed by the deposits of loess-air-borne fine dust particles.

- depositional plains are formed by the deposition of sediments brought down by rivers, glaciers and winds.
- depositional plains are sub-divided into alluvial, lacustrine, glacial and loess plains.
Notes

**Changing face of the Earth**

**GEOGRAPHY**

The plains have influenced the human life in the following ways:

1. **Fertile Soil**

   The plains generally have deep and fertile soil. Since the plains have a flat surface, the means of irrigation are easily developed. Both these factors have made the plains agriculturally so important that they are often called ‘food baskets of the world’.

2. **Growth of Industries**

   The rich agricultural resources especially of alluvial plains have helped in the growth of agro-based industries. This has given employment to millions of people and has registered a marked increase in the national production and per capita income. Since the plains are thickly populated, plenty of labour is available for the intensive cultivation and for supplying work force for industries.

3. **Expansion of Means of Transport**

   Since the plains have an even surface it favours the building of roads, airports and laying down of railway lines.

4. **Centres of civilization**

   The plains have been the centres of many modern and ancient civilizations. The major river valley civilizations of the world have flourished in the plains only. Hence, they are aptly referred to as the cradles of civilization. For example, there are the civilization of the Indus and the Nile Valley.

5. **Setting-up of Cities and Towns**

   Easy means of transport on land, the growth of agriculture and industries in plains have resulted in the setting-up and expansion of cities and towns. The most developed trade-centres and ports of the world are found in the plains only. Rome, Tokyo, Calcutta, Yangon (Rangoon), Varanasi, Paris and other famous cities are situated in the plains. As much as 80% of the world’s population lives in the plains.

   - Plains are useful to man due to their fertile soils, growth of industries, development of transport, setting up of cities & towns and making them attractive as cradles of human civilisation.

---

(a) Name the three major types of plains.

(i) ____________ (ii) ____________ (iii) ____________
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(b) To which category do the following plains belong?

(i) Lombardy Plain of Italy ________________
(ii) The Plain of North-Western China ________________
(iii) The Plain of Northern Canada ________________

2. Name two civilizations that flourished in the river valleys.

(i) __________________________(ii) ________________________

3. Give two examples of lacustrine plains?

(i) ________________________ (ii)____________________________

The major landforms found on the earth’s surface are the mountains, the plateaus and the plains. Besides the structure of rocks, the external and internal forces acting on the earth’s surface also play a significant role in the development of these landforms. The landforms on the earth’s surface have influenced human life in different ways. Fertile plains have been formed by the rivers originating in the mountains. These rivers are our perennial source of water for irrigation and other purposes. The plateaus are often described as the storehouse of minerals. Many of our major industries are dependent on the constant supply of these minerals. Besides this, the density of population is also influenced by the landforms. The plains including some of the valleys located in the mountain are teeming with people. Compared to the plains, the mountains and the plateaus have an uneven surface that is why they are generally sparsely populated.

TERMINAL QUESTIONS

1. Name the four types of mountains found in the world and describe the formation of each type.

2. Describe how plateaus are useful to man.

3. Why are the plains called ‘cradles of civilization’?

4. Describe the significance of mountains.

5. Distinguish between the following:

   (i) The intermontane plateau and the continental plateau.

   (ii) The block mountain and the volcanic mountain.
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(iii) The structural plain and the depositional plain.

6. Locate and label the following on the outline map of the world.
   (a) Rockies and Alps mountain ranges;
   (b) Patagonia and Tibetan plateaus;
   (c) Central low land of Australia and Hwang-Ho plains.

1. (a) Mountain (b) Plateau (c) Plain
2. (a) Sedimentary rocks (b) Horizontal compressional force (c) (i) Shimla (ii) Nainital (iii) Mussoorie (iv) Sri nagar.
3. (a) Block mountain (b) Residual mountain (c) Volcanic mountain (d) Fold mountain.

7.2
(a) (i) Intermontane plateau (ii) Piedmont plateau (iii) Continental plateau
(b) (i) Mineral resources, (ii) water & soils, (iii) grassland
(c) (i) Piedmont plateau (ii) Intermontane plateau (iii) continental plateau.

7.3
1. (a) (i) Structural, (ii) Erosional and (iii) Depositional
   (b) (i) Alluvial plain, (ii) Loess plain and (iii) Erosional plain
2. (i) The Indus valley civilization (ii) The Nile valley
3. (i) Valley of Kashmir (ii) Manipur plain

HINTS TO TERMINAL QUESTIONS
1. See para 7.2 - classification of Mountains. Give examples of each type of mountain and illustrate your answer with diagram.
2. See para 7.6
3. Expand on the following points-availability of fertile soil, development of means of transport, growth of industries, development of trading centre. Give examples of different civilization which flourished on plains.
4. See para 7.3.
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5. (i) See para 7.5 (a) and (c)
   (ii) See para 7.2 (b) and (c)
   (iii) See para 7.8 (a) and (c)

6. See Maps.
Water is important for life on the earth. It is required for all life processes, such as, cell growth, protein formation, photosynthesis and, absorption of material by plants and animals. There are some living organisms, which can survive without air but none can survive without water. All the water present on the earth makes up the hydrosphere. The water in its liquid state as in rivers, lakes, wells, springs, seas and oceans; in its solid state, in the form of ice and snow, though in its gaseous state the water vapour is a constituent of atmosphere yet it also forms a part of the hydrosphere. Oceans are the largest water bodies in the hydrosphere. In this lesson we will study about ocean basins, their relief, causes and effects of circulation of ocean waters and importance of oceans for man.

**OBJECTIVES**

After studying this lesson, you will be able to:

- identify various oceans and continents on the world map;
- differentiate the various submarine relief features;
- analyze the important factors determining the distribution of temperature both horizontally and vertically in oceans;
- locate the areas of high and low salinity on the world map and give reasons for the variation in the distribution of salinity in ocean waters;
- state the three types of ocean movements - waves, tides and currents;
- explain the formation of waves;
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- give various factors responsible for the occurrence of tides;
- establish relationship between the planetary winds and circulation of ocean currents;
- explain with suitable examples the importance of oceans to mankind with special reference to the significance of continental shelves for human beings.

8.1 OCEAN BASINS

Our earth is the only planet in the solar system which has water in abundance, hence, it is often called a ‘watery Planet’. About 71% of the earth’s surface is covered by water.

Oceans form a single, large, continuous body of water encircling all the landmass of the earth. They account for four-fifth of the Southern Hemisphere and three fifth of the Northern Hemisphere. They contain 97.2 percent of the world’s total water.

There are four principal oceans in the world which are separated largely on the basis of their geographical locations. These are the Pacific Ocean, the Indian ocean, the Atlantic Ocean and the Arctic Ocean. All the other seas, inland seas or the arms of the oceans, are counted within these four main oceans.

8.2 THE RELIEF OF THE OCEAN BASINS

The ocean water conceals a considerable variety of landscape very similar to its counterpart on the continents. There are mountains, basins, plateaus, ridges, canyons and trenches beneath the ocean water too. These relief features found on the ocean floor are called submarine relief. The Ocean basins are broadly divided into four major sub-divisions. They are:

(a) Continental shelf;
(b) Continental slope;
(c) Abyssal plains and
(d) The ocean deeps.

(a) Continental shelf;
(b) Continental slope;
(c) Abyssal plains and
(d) The ocean deeps.

Fig 8.2 The Relief of the Ocean Basins

(a) Continental Shelf

There is no clear or well-defined line separating oceans from continents. In fact, continents do not end abruptly at shoreline. They slope seaward from the coast to a point where the slope becomes very steep. The shallow submerged extension of continent is called the continental shelf. The depth of this shallow sea water over the continental shelf ranges between 120 to 370 metres. The width of the continental shelf varies greatly ranging between a few kilometres to more than 100 kilometres. This variation can be seen even in the context of Indian peninsula. The continental shelf off the eastern coast of India is much wider than that of the western coast. Similar variations are seen all over the world. Off the coast of West Europe, it extends to 320 kilometres from the Cape of Land’s End. Off the coast of Florida the shelf is 240 kilometres wide. They are much narrower or absent in some continents, particularly where fold mountains run parallel or close to the coast as along the eastern Pacific Ocean.

Most of the continental shelves represent land which has been inundated by a rise in sea level. Many regard their formation due to the erosional work of waves or due to the extension of land by the deposition of river borne material on the off-shore terraces. Off the coast regions which were once covered by ice sheets, they may have developed due to glacial deposits.
The continental shelves are of great importance to man. The shallow water over the shelf enables sunlight to penetrate through the water to the bottom and encourages growth of microscopic plants and animals called planktons. These planktons are the food for fishes. Continental shelves are the source of fishes, mineral including sand and gravel. A large quantity of the world’s petroleum and natural gas is obtained from these shelves. The Bombay High and the recent discovery of petroleum in the Godavari basin are examples of on shore drilling on the continental shelf. Coral reefs and lipoclastic materials are also common on continental shelves.

One of the striking features of the continental shelf is the presence of submarine canyons which extend to the continental slope. These canyons are ‘steepsided valleys’ cut into the floor of the seas. They are very similar to the gorges found on the continents. Godavari Canyon in front of the Godavari river mouth is 502 metres deep.

---

**Fig 8.3 Submarine Canyon**

One of the reasons for the formation of submarine canyon is underwater landslide. The sediments collected on the continental shelves get dislodged by a storm or an earthquake. The force of these moving sediments erode the slopes as they come down and as a result submarine canyons are carved out. The continental shelf is generally considered to be territorial water extent of the nations to which it adjoins.

- Continental shelf is the submerged portion of the continent which gradually slope seawards from the shore line.
- Submarine canyon is a deep valley cut into a continental shelf and extends to continental slope.

(b) **Continental Slope**

The continuously sloping portion of the continental margin, seaward of
the continental shelf and extending down to the deep sea floor of the abyssal plain, is known as continental slope. It is characterised by gradients of 2.5 degrees. It extends between the depth of 180 to 3600 metres. In some places, for example, off the shore of Philippines, the continental slope extends to a great depth.

Continental slopes, mainly due to their steepness and increasing distance from the land have very little deposits of sediments on them. Sea life is also far less here than on the shelf.

Along the base of the continental slope is a deposit of sediments. This belt of sedimentary deposits form the continental rise. In some regions the rise is very narrow but in others it may extend up to 600 km in width.

- Continental slope is the steeply sloping part of the sea floor which marks the boundary between the sea floor and the continental shelf.
- The belt of sediments deposited along the base of the continental slope is called continental rise.

(c) Abyssal Plain

Abyssal plains are extremely flat and featureless plains of the deep-ocean floor. In fact, the abyssal plains are likely the most level areas on the earth. Abyssal plains covering a major portion of ocean floor between the depth of 3000m to 6000m. They were once regarded as featureless plains but modern devices have shown that they are as irregular as the continental plain or surface. They have extensive submarine plateaus, hills, guyots and seamounts.

The floor of the abyssal plain is covered by sediments. The plains close to the continents are covered mostly by sediments brought down from the land. But those seas which favour, an abundant growth of organisms have a thick layer of sediments, formed from the remains of living things.
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These sediments are called oozes. Some of the open seas do not support enough life to produce ooze on the floor. They are covered with a type of sediment called red clay which is of volcanic origin or made up of tiny particles brought by wind and rivers.

(i) **Submarine Ridges**

The lofty mountain systems which exist on the continents is also represented beneath the ocean waters. These oceanic mountains are known as submarine ridges. They are linear belts occurring near the middle of the oceans and are also called mid-oceanic ridges. All the mid oceanic ridges constitute a world-wide system which is interconnected from ocean to ocean. These ridges are intersected by faults. The oceanic ridge is the site of frequent earthquakes. Volcanism is common in ocean ridges and it produces many relief features.

The Mid-Atlantic Ridge is the largest continuous submerged mountain ridge which runs from north to south in the Atlantic-Ocean. It is in the shape of S. At some places, the peaks, rise above the surface of water in the form of islands. Many of the islands are volcanic in origin. The East Pacific Ridge and Carlsberg Ridge are some of the important submarine ridges. (see fig 8.5)

![Fig 8.5 The World wide System of Submarine Ridges and Trenches](image)

(ii) **Seamounts and Guyots**

Scattered over the entire sea floor are thousands of submerged volcanoes with sharp tops called seamounts. Sometimes they rise above the sea as isolated Islands. Hawaii and Tahiti Islands are the exposed tops of volcanoes. Volcano rising above the ocean floor whose top has been flattened by erosion and is covered by water is called guyot.
The ocean deeps are the deepest part of the ocean. They are long, narrow, steep sided and flat-floored depressions on the ocean floor. They are generally called submarine trenches. These trenches are not always located in the middle of the ocean basins, as may be generally expected but are situated very close or parallel to the continents bordered by fold mountains. They are usually found adjacent to the areas of volcanic and earthquake activity. Great earthquakes and tsunamis are born in them. They occur in all the major oceans. The Pacific Ocean has the largest number of trenches. The Mariana Trench in the Pacific Ocean is the deepest known part of the oceans. This trench is so deep that if we place the highest mountain of the world - the Mt. Everest in it, even this shall have a few kilometers of water above its summit.

- Abyssal plains are undulating plains of enormous extent which have many irregularities such as submarine plateaus, hills, guyots and seamounts.
- Long, narrow steep sided and flat floored depressions in the oceans are known as ocean deeps.

**INTEXT QUESTIONS 8.1**

1. Fill in the blanks:
   (i) The four oceans are
   (a) _______ (b) _______ (c) _______ (d) _______
   (ii) The four major subdivisions of ocean basin are
   (a) _______ (b) _______ (c) _______ (d) _______
Ocean: Submarine Relief and Water Circulation

(iii) The submerged portion of the continent is called ________________________________________

(iv) The two main types of sediments deposited in the abyssal plains are (a) __________________ (b) __________________

(v) A long narrow, steep-sided depression on the ocean floor is called ________________________________________

(vi) A submerged volcano with sharp top is called ____________________.

(vii) _____________ trench in the Pacific Ocean is the deepest known part of the ocean.

2. Tick (✓) the correct ending.

(i) The boundary between the continental shelf and ocean floor is always marked by
   (a) continental slope (b) abyssal plain (c) trench (d) seamount.

(ii) The best fishing ground in the world are located in
   (a) continental shelves (b) abyssal plain (c) submarine trenches (d) ocean deeps.

3. Write True against the correct statements and False against the Wrong.

   (i) A submerged volcano with a flat top is called seamount
   (ii) Oozes are formed by non-living things.
   (iii) Submarine ridge is continuous -chain of mountains.

8.3 PROPERTIES OF OCEAN WATERS

The temperature and salinity are two important aspects of the ocean waters which affect their movements. Therefore, the temperature, salinity and density of the ocean water have special significance in the study of circulation of ocean waters.

(i) TEMPERATURE OF OCEAN WATERS

The temperature of the surface water of the oceans varies in much the same way as that of the land surface. This is because insolation is responsible for the varying quantities of heat which are received at different latitudes and in different seasons. Generally, the temperature is higher near the equator and gradually decreases towards the poles. The mean annual temperatures of about 27°C or higher, are common in tropical seas but there is a general decrease towards the poles where the mean temperature of around 1.8°C are
The domain of the water on the Earth

The decrease of temperature of surface water towards the poles or increase towards the equator is not uniform because drifting warm water from the tropical seas may move into higher latitudes or vice versa and gives a local increase or decrease of temperature. Upwellings of deep, cold water also reduce locally the surface temperature of tropical and subtropical sea waters.

The high temperatures of waters are found in enclosed seas in the tropics e.g. the Red Sea. The Arctic and Antarctic waters are so cold that their surface remains permanently frozen down to a depth of several metres. In the summer months, parts of the ice break off as icebergs which dilute the water and lower the surface temperature of surrounding ice free seas.

There is also variation in the vertical distribution of temperature. Temperature decreases with increase in depth. This is because the surface of the sea water receives the largest amount of insolation. As the rays penetrate the water, their intensity is reduced by scattering, reflection and diffusion. However, the rate of decrease in the temperature is not equal at all depth. Upto a depth of about 100 metres, the temperature of water is about the same as that of the surface, while it falls from 15°C to about 2°C between the surface and a depth of 1,800 metres. The decrease between 1,800 and 4,000 metres is from 2°C to about 1.6°C.

The main process of heating the ocean waters are

1. by absorption of heat from the sun
2. by convection of heat through the ocean bottom from the interior of the earth.

The cooling processes are:

1. by loss of heat to the atmosphere,
2. by evaporation

(ii) SALINITY OF THE OCEAN WATERS

One of the most striking characteristics of the ocean water is its salinity or saltiness. When we speak of salinity we have in mind not only common salt or sodium chloride but a great variety of other salts as well. The dominant salts among these are sodium chloride & Magnesium Chloride with 77.7% & 10.9% respectively. Due to the free movement of ocean water, the proportion of different salts remain remarkably constant in all oceans and even to great depth. But the degree of concentration of the salt solution in oceans does vary appreciably in different seas.

The salinity of the ocean water is produced by a large number of dissolved chemical compounds. Salinity is defined as the weight in grammes of solid material left after the evaporation of 1000 grammes of sea water. If the weight
of solid material is 35 grammes (and it is usually very near this figure), the salinity would be shown 35% (35 per thousands). Salinity is expressed in this way rather than as percentage.

In the Baltic Sea, fresh water enters it from the surrounding land and reduce the salinity to 7% and it may fall in this sea as low as 2%. But great evaporation combined with a very dry climate in the Red Sea region gives the water of this sea a high salinity of 41% to 42%. In enclose sea, which are areas of inland drainage such as the Caspian Sea, the salinity is very high, 18% in the Dead Sea of Jordan. The salinity may by as high as 25%.

The variation of salinity in different seas and oceans is affected by

(i) The rate of evaporation,
(ii) The amount of fresh water added by streams and icebergs,
(iii) Mixing of the ocean waters.

INTEXT QUESTIONS 8.2

(1) Define the term salinity

_______________________________________________________

(2) When 1000gm of water from the Great Salt Lake is evaporated, 250gm of salt remains. What is the salinity of the Great Salt Lake?

_______________________________________________________

(3) Fill in the blanks.

(a) Solar radiation is __________ in equatorial region on in the polar region.

(b) The average salinity of sea water is ________________

(c) Enclosed seas are the areas of ____________ salinity.

8.4 MOVEMENTS OF OCEAN WATERS

The waters of oceans are never still. The oceans actually exhibit three major types of movements - waves, tides and currents.

(I) WAVES

Waves are oscillatory movements that result in the rise and fall of water surface. Infact, the movement of each water particle in a wave is circular. The movement of the waves is just like the wind blowing across a wheat
field and causing wave like ripples to roll across its surface. The wheat stalk returns to its original position after the passage of each wave of wind. Similarly water also returns to its original position after transmitting a wave.

A wave has two major parts. The raised part is called the *crest*. Between the two crests are low areas called *troughs*. The vertical distance between trough and crest is called wave height. The horizontal distance between two crests or two troughs is called wave length. The time it takes for two crests to pass a given point is called wave period. Fast moving waves have short period while slow moving waves have long period (see fig 8.7).

![Fig. 8.7 Part of a Wave](image)

The size and force of a sea wave depends on three factors:

(i) Velocity of the wind,

(ii) The length of time the wind blows and

(iii) Distance that the wind has travelled across the open sea. This is called a fetch.

Waves are an important agent of erosion. When waves are associated with storms or volcanic eruption, they are very violent and cause damage on coastal areas. They are also a source of energy and efforts are being made to harness their energy.

- Waves are the to and for movements of ocean water in which water particles move roughly in a circular path. They rise up in a crest, advance, descend and retreat in the trough as the wave passes.

(II) TIDES

Along a coast all over the world, we observe the sea water moving both upwards and downwards at rates varying from place to place. Such a variation in sea level occurs from hour to hour and from day to day. At the time of a
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rising sea level, the incoming tide towards the land is spoken of as a flow tide or a flood tide. At the time of a falling sea level after a few hours, we speak of the tide water going out or withdrawn, is an ebb tide (low tide). The flood tide is a high tide and the ebb tide is a low tide. Tides are really the largest waves keeping the ocean water restless. Twice a day regularly at constant intervals, a tide flows in and twice a day it ebbs away. Twice a month, flow tides are higher and the ebb tides are lower than the average. Also twice a month flow tides are lower and the ebb tides are higher than the average.

However the regular interval between two high tides or between two low tides is 12 hours and 25 minutes and not exactly 12 hours. Each day (in 24 hours) the high tide arrives about 51 minutes later than on the previous day. It is so because each day the rising and setting of the moon also falls behind by 51 minutes. It takes 24 hours and 50 minutes for the rotating earth to bring the same meridian vertically below the moon every day. The timings of the tides at a place on a coast will be clear to you from the following examples.

| High Tide | 06.00 AM |
| Low Tide  | 12.13 PM |
| High Tide | 06.25 PM |
| Low Tide  | 12.38 AM |
| High Tide | 06.51 AM next day |

The factors responsible for bringing about such a variation in the regulation and the size of tides are:

1. The location of the sun, the moon and the earth in relation to each other which is rarely in a straight line.
2. The distances of the sun and the moon from the earth are not constant.
3. Our globe is not entirely covered with water.
4. The outline or shape of the coast may help or hinder the tides.

Still the tides follow each other with a great punctuality at any given coast. What are the forces that generate the tides? The earth attracts and is also attracted by the sun, the moon and by other planetary bodies. It is called the gravitational force and it operates between the sun, moon and the earth. It sets the ocean waters in motion producing a tidal current. Tides are the proof of such a gravitational pull.

The moon and the sun both exert their gravitational force on the earth. The Oceans, Submarine Relief And Circulation sun which is bigger in mass than the moon is also at a greater distance from the earth than the moon. Therefore,
the gravitational attraction of the moon is more effective on the earth than the gravitational attraction of the sun. Since the water is liquid and mobile, its bulging in the direction facing the moon is easily noticed, yet a lower tidal bulge also develops on the other side of the earth farther from the moon because of moon’s least attraction. (see fig 8.8)

- The rise and fall of the ocean water at a particular place are called tides.
- Interval between two high tides or low tides is exactly 12 hours 25 minutes.
- Tides are produced as a result of gravitational pull of the moon and the Sun on the earth.

(a) SPRING AND NEAP TIDES

The moon, as it is closer to the earth, exerts twice the gravitational pull of the sun on the earth. When the sun and the moon are in a line as on a new moon (Amavasya) or a full moon day (Purnima) both of them pull together at the same time in the same direction. This combined pull produces an extra large tide. It is called a spring tide see fig 6.9(1). In its first quarter (Asthmi Shukla Paksha) and the third quarters (Asthmi-Krishna Paksha) the gravitational force of the two heavenly bodies is at right angle. At this time, the two pulls are opposing each other and are not acting in the same direction. In other words they cancel or neutralize each other’s effect. It produces a weak tide which is called a neap tide see fig.8.9(2).
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(b) EFFECT OF TIDES

The phenomenon of tides, which is so universal has been of immense value to man for ages. Tides act as link between the port and the open sea. Some of the major ports of the world, such as London port on the river Thames and Kolkata port on river Hugli are located on the rivers away from the sea coast. The tidal current clear away the river sediments and slows down the growth of delta. It increases the depth of water which help ships to move safely to the ports. It also acts as a source for producing electricity.

- Tides make the rivers navigable for ocean going ships, clear sediments, retard formation of delta and are a source of producing electricity.

INTEXT QUESTIONS 8.3

1. Choose the correct alternative for the following statements:
   (i) The source of most waves on the sea surface is_______________.
       (a) winds (b) tides (c) earthquakes (d) density difference
   (ii) The length of time for one crest of a wave to follow another crest past is called the wave _____________
        (a) height (b) length (c) period (d) frequency
   (iii) The time between a high tide and a low tide is about _________
        (a) 6 hours 13 minutes (b) 12 hours (c) 24 hours (d) 24 hours, 50 min

2. Define tide?

3. Define wave length?

4. If the first high tide occurred at 9.00 a.m on one day, when will the first high tide most likely to occur the next day?

(III) CURRENTS

The ocean current are horizontal flow of a mass of waters in a fairly defined direction over great distances. They are like stream of water flowing through the main body of the ocean in a regular pattern. The average speed of current
The domain of the water on the Earth is between 3.2 km to 10 kms per hour. Ocean currents with higher speed are called stream and currents with lower speed are called drift.

Ocean currents can be broadly divided into two:

1. Those currents which flow from equatorial regions towards poles have a higher surface temperature and are called warm current.
2. Those currents which flow from polar regions towards equator have a lower surface temperature and are called cold currents.

The origin and the nature of circulation of the ocean currents depend on the following factors:

(i) **Differences in Density**

The sea water’s density varies from place to place according to its temperature and proportion of salinity. The higher the temperature of water, the lesser will be the density. Hence the less dense water of the equator moves towards the poles while the cold and dense waters of the poles move towards the equator. Thus cold currents always move from the poles to the equator while the warm currents move from equator towards the poles.

Currents are also produced by changes in the salinity of ocean waters. If the salinity of the water is more, the density of the water increases, and the water sinks. Hence water with lower salinity flows on the surface of the high salinity water while an under current of high salinity flows towards the less dense water. The currents caused by difference in salinity are found between the Atlantic ocean with lower salinity and the Mediterranean Sea with higher salinity.

- The higher the temperature of water, lower is its density.
- The higher the salinity of water, higher is its density.

(ii) **The Earth’s Rotation**

We have studied in an earlier lesson that the earth’s rotation deflects air to its right in the northern hemisphere and to its left in the southern hemisphere. Similarly, ocean water is also affected by Coriolis force and follows the Ferrel’s Law. So all the ocean currents follow clockwise direction in the northern hemisphere and anticlockwise direction in the southern hemisphere.

(iii) **The Planetary Winds**

The planetary winds like the trade winds and westerlies, drive the ocean water in a steady flow in front of them. If we compare the world map of planetary wind system, with that of the ocean currents it will be clear that currents follow the main direction of the planetary wind system. In low latitudes or in the region of the trade winds the ocean currents change their direction according to the change in the direction of summer and winter monsoon winds.
8.5 CURRENTS OF THE ATLANTIC OCEAN

To the north and south of equator there are two westward moving currents i.e., the north and south equatorial currents. Between these two equatorial currents is the Counter Equatorial Current which flows from west to east. (Locate it in the fig 8.10). This counter current replaces the water removed from the eastern side of the oceans by North and South Equatorial Currents.

The South Equatorial Current bifurcates into two branches near the Cape De Sao Roque in Brazil. Its northern branch joins the North Equatorial Current. This combined current enters the Caribbean Sea and the Gulf of Mexico, while the remaining current passes along the eastern side of the West Indies as the Antilles Current. The part of the current which enters the Gulf of Mexico, comes out from the Florida strait and joins the Antilles Current. This combined current moves along the south eastern coast of U.S.A.. It is known as Florida Current upto cape of Hatteras. Beyond the Cape Hatteras, upto the Grand Banks, off New Foundland, it is called the Gulf Stream. From the Grand Banks, the Gulf Stream is deflected eastwards under the combined influence of the westerlies and the rotation of the earth. It crosses the Atlantic Ocean as North Atlantic Drift.

The North Atlantic Drift bifurcates into two branches on reaching the eastern part of the ocean. The northern branch continues as North Atlantic Drift; reaches the British Isles from where it flows along the coast of Norway as the Norwegian Current and enters the Arctic Ocean. The southern branch flows between Spain and Azores Island as the cold Canaries Current. The Canaries Current finally joins the North Equatorial Current and completes...
the circuit in the North Atlantic Ocean. Within this circuit lies the Sargasso Sea which is full of large quantities of seaweeds called sargassum, a brown algae.

Apart from the clockwise circulation of the currents in the North Atlantic Ocean, there are also two cold currents - the East Greenland Current and the Labrador Current which flow from the Arctic Ocean into the Atlantic Ocean. The Labrador Current flows along the eastern coast of Canada and meets the warm Gulf Stream. (locate it on the fig 8.10) The confluence of these two currents, one cold and the other hot, produces fog around Newfoundland and makes it the most important fishing ground of the world. East Greenland current flows between Iceland and Greenland and cools the North Atlantic Drift at the point of their confluence.

We have seen earlier that South Equatorial Current splits into two branches near Cape De Sao Roque (Brazil). The northern branch joins the North Equatorial Current, whereas the southern branch turns south and flows along the eastern coast of South America as Brazil Current. At about 35° south latitude the influence of the westerlies and the rotation of the earth propel the current eastward to merge with the West Wind Drift.

Near the Cape of Good Hope, the South Atlantic Current is diverted northward as the cold Benguela Current. It finally joins the South Equatorial Currents thus completing the circuit. Another cold current, known as the Falkland Current, flows along the South eastern coast of south America from south to north.

8.6 CURRENTS OF THE PACIFIC OCEAN

It may be observed that the same broad circulatory systems, clockwise in the Northern Hemisphere and anti-clockwise in the Southern Hemisphere, are present in the Pacific ocean also.
In the Equatorial belt of the Pacific Ocean, two streams of equatorial currents flow across the ocean from the Central American Coast. Between these two - the North Equatorial Current and the South Equatorial Current flows a Counter Equatorial current moves west to east. The North Equatorial Current turns northwards and flows along the Philippines Islands, Taiwan and Japan to form the warm Kuro Shio or Kuro Siwo current. From the southeast coast of Japan, the current comes under the influence of westerlies and flows right across the ocean as North Pacific Current (see fig 8.11). After reaching the west coast of North America, it bifurcates into two branches. The northern branch flows anti clockwise along the coast of British Columbia and Alaska and is known as the Alaska Current. The warm waters of this current help to keep the Alaska coast ice free in winter. The other branch of the North Pacific Current moves southward along the coast of California as the Cold Californian Current. It eventually joins the North Equatorial Current to complete its circuit. In the northern part of the Pacific Ocean two cold currents also flow. These are the Oya Siwo Current and Okhotsk Current. The cold Oya Siwo Current flows along the coast of the Kamchatka Peninsula. Another cold current, Okhotsk Current flows past Sakhalin to merge with the Oya Siwo Current near Hokkaido Island. It later merges with Kuro Siwo Current and sinks beneath the warm waters of the North Pacific Currents. (locate it in figure 8.11).

In the South Pacific Ocean, the South Equatorial Current flows towards west and turns southwards as the East Australian Current. It then meets near Tasmania the cold South Pacific Current which flows from west to east. On reaching the South Western Coasts of South America, it turns north wards as the cold Peru Current. It then meets the South Equatorial Current and completes the circuit. The cold waters of the Peru Current are partly responsible for making the coast of northern Chile and western Peru with very scanty rainfall.

8.7 CURRENTS OF THE INDIAN OCEAN

The pattern of circulation of currents in the Indian Ocean differs from the general pattern of circulation in the Atlantic Ocean and the Pacific Ocean. This is because Indian Ocean is blocked by the continental masses in the north. The general pattern of circulation in the southern section of the Indian Ocean is anti clockwise as that of other oceans. But in the northern section there is a clear reversal of currents in winter and summer. These are completely under the influence of the seasonal changes of the monsoon winds. So there is a clear reversal of currents in the winter and summer season i.e/south-westwards during the north-east Monsoon, north-eastwards during the south-west Monsoon and variable during transition season.

During winters Sri Lanka divides the currents of the Arabian sea from those of the Bay of Bengal. The North Equatorial Current flows westward just south of Sri Lanka with distinct counter equatorial current flows between it
and the South Equatorial Current. (See fig. 8.12) At this time in the northern section, the whole of Bay of Bengal and Arabian sea is under the influence of North East Monsoon. The North East Monsoon drives the water of Bay of Bengal and Arabian Sea west wards to circulate in an anti clockwise direction. This current is known as North East Monsoon Drift.

**Fig 8.12 The Currents of the Indian Ocean (Winter)**

In summers, the northern section comes under the influences of South West Monsoon. There is an easterly movement of water in the Bay of Bengal and Arabian Sea and produces a clockwise circulation. This current is known as South West Monsoon Drift (see fig.8.13). In general the summers currents are more regular than those of winter.

**Fig 8.13 The Currents of the Indian Ocean (Summer)**

In the southern Indian Ocean, the South Equatorial Current, strengthened by its corresponding current of the Pacific Ocean, flows from east to west. It turns south-wards along the Coast of Mozambique in Africa. A part of this current which flows between the mainland and the Madagascar Island is known as warm Mozambique Current. After the confluence of these two
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currents, it is called Aghulas Current. It then turn eastwards and merges with
the West Wind Drift.

The West Wind Drift flows across the ocean in west east direction in the
higher latitudes to reach the southern tip of Australia. A branch of this stream
turns north to flow along the western coast of Australia as cold West Australian
Current. West Australian Current later joins the South Equatorial Current to
complete the circuit.

8.8 EFFECTS OF OCEAN CURRENTS

(a) Influence on climate

Oceans currents closely influence the distribution of temperature, pressure,
winds and precipitation, which directly or indirectly influence the economy
and society of the people, especially those living in the coastal regions. Some
of the important effects of oceans currents are as follows:

Currents move from warm temperature areas to colder temperature areas
and vice versa. As they move from one place to another they partly attempt
to modify the temperature. The temperature of a mass of water affects the
temperature of the air above it. Therefore, the ocean current that moves from
the equatorial region to the colder latitudes raises the temperature of the air
in the areas into which it moves. For example, warm North Atlantic Drift
which flows northwards to West European coast helps to keep the coast of
Great Britain and Norway free of ice in winter too. The effect of the ocean
current becomes more clear if you compare the winter conditions of the British
Isles with that of the North East Coast of Canada situated on the same latitudes.
Since the North East Coast of Canada comes under the influence of cold
Labrador current, it remains ice bound during the winter time.

When cold and warm currents meet they produce mist and fog. For example,
near New Foundland warm Gulf Stream meets Labrador Current and produces
fog. They also create conditions for storms. Hurricanes in New Found land
and Typhoons in Japan are perhaps the result of the meeting of warm and
cold currents.

(b) Influence on marine Life

Temperature has a great influence on marine life. It determines the type of
flora and fauna. The areas where warm and cold currents meet are among the
most important fishing grounds of the world. The oceanic movement in the
form of currents helps in the dispersal of marine life.

(c) Influence on Trade

Ocean currents influence the trade. The ports and harbours of higher latitudes
which are affected by warm currents are ice free and open for trade all the
year round. For example, the ports of North Western Europe remain open throughout the year while port of Quebec in Canada gets frozen in winters.

**INTEXT QUESTIONS 8.4**

1. Study the map given below. Each current in the map is shown by a number. Write the name of the corresponding ocean current against the number given below. Also complete the key of the map by writing appropriate words.

2. The warm current which flows off the east coast of South East Africa is called the
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(i) Benguela Current
(ii) Mozambique Current
(iii) Canaries Current
(iv) West Wind Drift.

3. Which one of the following statement is not true?
   (i) Ocean currents sometimes cause fog.
   (ii) The distribution of fishes is often influenced by ocean currents.
   (iii) Ocean current can influence coastal temperature.
   (iv) Warm water wells up along a coast from which an ocean current moves.

8.9 IMPORTANCE OF OCEAN FOR HUMANS

We are well aware that oceans cover about 71% the earth’s surface. They form a major part of our environment and have an overwhelming influence on humans and his activities. In this section we will be studying the importance of oceans in different spheres of human life.

(a) Ocean as modifiers of climate

The most important part played by the oceans is as modifiers of climate.

(i) The ocean stores a large quantity of heat, hence it is often called “the saving bank for the solar energy, receiving deposits in season of excessive insolation and paying them back in seasons of want”. The extensive deep waters of oceans gain as well as loose heat more slowly than the land when both are subjected to the same amount of insolation. The contrast in the temperature of the ocean and land explains the difference in the temperature of coastal and interior region.

(ii) The oceans supply water vapour to the atmosphere and thus are the basic source of all precipitation on earth. They are also the vital source of fresh water on earth.

(iii) Ocean currents are important regulators of temperature on the earth’s surface. They help in exchange of heat between low and high latitudes and are essential in sustaining the global energy balance. On the local scale, the warm ocean currents bring a moderating influence to coasts in higher latitudes; cool currents reduce the heat of tropical deserts along narrow coastal belts.

(iv) The influence of oceans on climate becomes more clear if we consider the distribution of pressure and prevailing wind system over the sea
The domain of the water on the Earth surface. The oceans surface has six or more permanent centres of high pressure. These high pressure areas give birth to the planetary wind system over the earth. These planetary winds determine the amount of rainfall and its distribution over the earth’s surface. The westerlies give rainfall on the West European Coast after collecting moisture from the warm North Atlantic Drift.

(b) Oceans and Resources

The oceans have always been a great source of food and other products of value to man. The animals and plants of the sea constitute a vast resource from which man can derive food, fertilizers for agriculture and raw material for industry. Fish and other marine animals form a rich source of food and nutrition for man. With the progress of human society and the increasing population, man’s dependence on sea for other products has increased. Fishes now make up more than 10 per cent of the total animal protein that human consume.

(c) Oceans and Mineral Resources

Oceans are the store house of a large number of useful metallic and non-metallic minerals. Foremost among the minerals are the petroleum deposits of the continental shelves. In the energy hungry world, they are the most sought after resources. Vast deposits of petroleum have been found in many places such as in the North Sea, off the coast of South California and Texas, in the Mediterranean Sea, Persian Gulf, Bombay High in the Arabian Sea.

The common salt or sodium chloride is extracted from sea water. Apart from salt, magnesium and bromine have long been extracted from sea water. The mineral wealth of the seas also include metals. All the metallic elements are present in the seawaters in some degree. However waters and sediments of ocean are heavily saturated with such metals as zinc, copper, lead, silver and gold, especially in the volcanic region of the oceanic ridge. The technology to exploit these minerals has not yet developed.

The most significant are mineral nodules found on the deep sea floor. The important ones are phosphorites and manganese nodules.

(d) Ocean and Energy

The energy resources of the oceans are of various types - tidal power, geothermal energy and energy from the ocean temperature.

Tidal energy was in use even in the 12th Century. Water wheels driven by the tides were used for grinding grain. Today, efforts are being made to harness the energy to run electric generators. There are difficulties in the use of tidal power because of the irregularities of tides. However, a few tidal power stations are working in Russia, France and China.
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(e) Ocean Transportation and Trade

Ocean were originally considered as barriers but today they act as natural link among continents and nations of the world. They provide natural highways at low cost for international trade. They facilitate movement of bulky goods. The water is buoyant and needs less motive power. Oceans are a great boon to international trade.

INTEXT QUESTIONS 8.5

1. Which one of the following statements is not true?
   (a) Oceans control the distribution of pressure in the upper atmosphere.
   (b) Oceans receive large amount of solar energy in seasons of excessive insulation and pay them back in season of short supply.
   (c) Oceans currents help to redistribute heat over thousands of kilometres.
   (d) Oceans provide natural highways but are a big hindrance to international trade.
   (e) energy due to the rise and fall of the sea water is called geothermal energy.

WHAT YOU HAVE LEARNT

All living organisms on the earth depend on water. About 71 % of the earth’s surface is covered by water. The earth is the only known planet in the solar system with abundant water. The oceans are the single largest continuous body of water encircling land. The oceans contain 97.2% of the world’s water. There are four oceans - the Pacific oceans, the Atlantic oceans, the Indian ocean and the Arctic ocean. The ocean floor which once was considered to be flat has variety of features such as continental shelf; continental slope, abyssal plains and the deeps.

Pacific ocean is the largest ocean. It comprises of thousands of islands. The greater part of the ocean comprises of the deep seas. Mariana trench in the Pacific Ocean is the deepest known part of the ocean with a depth of 11022 metres. The Atlantic Ocean is almost half the size of the Pacific Ocean. The world’s widest shelves like Dogger Bank and Grand Bank are found here. The largest continuous Mid Atlantic Ridge is the important feature of the Atlantic ocean. Indian ocean is smaller than the other two ocean.
The temperature of the surface water of the oceans varies from one part of the ocean to the other. It is generally high near the equator and low near the poles. There is variation in the vertical distribution of temperature too.

Temperature decreases with the increase in depth. Salinity is defined as the weight in grammes of solid material left after the evaporation of 1000 grammes of sea water. The salinity of the ocean water is caused by a large number of dissolved chemical compounds. The salinity is not uniform everywhere in the ocean. Equatorial and Polar water are less saline than the tropical seas. Ocean waters are in constant motion. There are three type of movements in the oceans waters - waves, tides and currents. Waves are ‘caused by winds. They move roughly in circular path. Tides are the periodic change in the elevation of the oceans surface at a particular place. They are produced as a result of gravitational attraction of the moon and the centrifugal force produced due to rotation of earth. Currents are distinct and generally horizontal flow of a mass of water in a fairly defined’ direction. Currents are formed due to the density of water rotation of the earth and planetary winds. These currents form a clockwise pattern in the northern hemisphere and move in anti clockwise pattern in the southern hemisphere. The currents of the Indian ocean are influenced by Monsoon winds.

Oceans are of great importance to man. They influence the climate of the earth’s surface ‘and provide rich source of marine food and minerals. They are also helpful in international trade by providing free highways.

TERMINAL QUESTIONS

1. Describe the important relief features of the ocean floor with the help of a diagram.

2. Distinguish between the following terms:
   (a) Continental shelf and continental slope.
   (b) Submarine trench and submarine Ridge.

3. Describe the difference between a seamount and a guyot.

4. Explain the importance of continental shelf to humans.

5. Write short notes on:
   (a) Submarine canyons
   (b) Continental rise

6. Define the term salinity and how is it expressed?

7. Why does temperature of ocean decrease with depth?
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8. What are tides? How are they caused?

9. Distinguish between spring tide and neap tide with the help of a diagram.

10. Give reasons to account for the following.
    (a) Spring tides occur on new moon and full moon.
    (b) In the lower latitudes the eastern sides of the land masses are warmer than the western sides.
    (c) In the higher latitudes the eastern sides of the landmasses are cooler than the western side.

11. Describe the circulation of ocean currents In the Atlantic Ocean with the help of a diagram. Compare it with that of the currents of the Pacific Ocean.

12. Write a short essay to show the importance of oceans for man.

ANSWERS TO INTEXT QUESTIONS

8.1

1. (i) (a) The Pacific Ocean (b) The Atlantic Ocean (c) The Indian Ocean (d) The Arctic Ocean.
   (ii) (a) The continental shelf (b) The continental slope (c) Abyssal plains (d) and the deeps.
   (iii) The continental shelf
   (iv) (a) ooze (b) red clay (v) submarine trench
   (vi) seamount
   (vii) The Mariana

2. (i) (a) continental slope
   (ii) (b) continental shelves

3. (i) False (ii) False (iii) True

8.2

1. Salinity is the weight in grammes of solid material left after the evaporation of 1000 grammes of sea water.

2. 250%c

3. (a) maximum, minimum (b) 35%/ (c) high.
8.3
1. (a) winds, (ii) period, (iii) 6 hours 13 minutes
2. Periodic charge in the elevation of the ocean surface at a particular place.
3. The horizontal distance between two crests or two troughs.
4. 9.51 A.M

8.4
<table>
<thead>
<tr>
<th>Warm currents</th>
<th>Cold currents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Okhotsk Current</td>
<td>2. North Pacific Current</td>
</tr>
<tr>
<td>5. Counter Equatorial Current</td>
<td>6. South Equatorial Current</td>
</tr>
<tr>
<td>7. East Australian Current</td>
<td>8. West Wind Drift</td>
</tr>
<tr>
<td>11. West Wind Drift</td>
<td>12. Brazil Current</td>
</tr>
<tr>
<td>17. East Greenland Current</td>
<td>18. Labrador Current</td>
</tr>
<tr>
<td>19. Agulhas Current</td>
<td>20. West Australian Current</td>
</tr>
<tr>
<td>2. Mozambique Current</td>
<td>3. (iv)</td>
</tr>
</tbody>
</table>

8.5
1. (a), (d), (e)

HINTS TO TERMINAL QUESTIONS
1. Refer to section to 8.2
2. Refer to section 8.2(a) and (b)
   Refer to section 8.2(d) and (c) (i)
3. Refer to section 8.2(c) (ii)
4. Refer to 8.2(a)
5. See under continental shelf and continental slope.
6. See para 8.3 (ii)
7. See para 8.3 (ii)
Ocean: Submarine Relief and Water Circulation

8. See para 8.4 II
9. See para 8.4 II(a)
10. (a) See para 8.4 II(a)
    (b) In the equatorial region the warm ocean currents flow from east to west direction carrying with them warm water, in the process warming the coastal regions. Whereas the western coast are affected by cold currents. Give examples with your explanation.
    (c) In the higher latitudes the eastern sides are generally washed by cold current and western coast by warm current. Give examples with your explanation.
11. Refer to section 8.5 and 8.6
12. Refer to section 8.9
ATMOSPHERE COMPOSITION AND STRUCTURE

Earth is a unique planet because the life is found only on this planet. The air has a special place among the conditions necessary for life. The air is a mixture of several gases. The air encompasses the earth from all sides. The air surrounding the Earth is called the atmosphere. The atmosphere is an integral part of our Earth. It is connected with the earth due to the gravitational force of the earth. It helps in stopping the ultra violet rays harmful for the life and maintain the suitable temperature necessary for life.

The air is essential for the survival of all forms of life on the earth. You cannot imagine any kind of life in the absence of it. The atmosphere is like a large protective cover. Besides many gases, water vapour and dust particles are also found in the atmosphere. Due to these all kinds of changes take place in the atmosphere you will study in this lesson. The composition and structure of the atmosphere and the cyclic process of main gases.

OBJECTIVES

After studying this lesson, you will be able to :-

- explain the composition of atmosphere.
- tell the characteristics of different layers of the atmosphere.
- explain the importance of atmosphere.
- explain the cyclic process of main gases of the atmosphere – nitrogen, oxygen and Carbon dioxide.
- describe the importance of cyclic process of important gases of the atmosphere such as nitrogen, oxygen and carbon dioxide.
Atmosphere Composition and Structure

9.1 COMPOSITION OF ATMOSPHERE

The atmosphere is made up of different types of gases, water vapour and dust particles. The composition of the atmosphere is not static. It changes according to the time and place.

(A) Gases of the atmosphere:

The atmosphere is the mixture of different types of gases, including water vapour and dust particles. Nitrogen and Oxygen are the two main gases of the atmosphere. 99 percent part of it is made up of these two gases. Other gases like organ, carbon dioxide, hydrogen, nion, helium etc. form the remaining part of atmosphere. The details of different gases of the atmosphere are given in the table No. 9.1 and Fig. No. 9.1

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Gas</th>
<th>Amount (in percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A.</strong></td>
<td><strong>Main</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Nitrogen</td>
<td>78.1</td>
</tr>
<tr>
<td>2.</td>
<td>Oxygen</td>
<td>20.9</td>
</tr>
<tr>
<td><strong>B.</strong></td>
<td><strong>Secondary</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Organ</td>
<td>0.9</td>
</tr>
<tr>
<td>2.</td>
<td>Carbon Dioxide</td>
<td>0.03</td>
</tr>
<tr>
<td>3.</td>
<td>Hydrogen</td>
<td>0.01</td>
</tr>
<tr>
<td>4.</td>
<td>Nion</td>
<td>0.0018</td>
</tr>
<tr>
<td>5.</td>
<td>Helium</td>
<td>0.0005</td>
</tr>
<tr>
<td>6.</td>
<td>Ozone</td>
<td>0.00006</td>
</tr>
<tr>
<td>7.</td>
<td>Others</td>
<td>99%</td>
</tr>
</tbody>
</table>

Fig. 9.1 Composition of Atmosphere
Ozone Gas

The amount of ozone gas in the atmosphere is very little. It is limited to the ozone layer but it is very important. It protects the living beings by absorbing the ultra-violet rays of the sun. If there was no ozone gas in the atmosphere, there would not have been existence of living beings and plants on the earth surface.

(B) Water vapour

Gaseous form of water present in the atmosphere is called water vapour. Water vapour present in the atmosphere has made life possible on the earth. Water vapour is the source of all kinds of precipitation. Its maximum amount in the atmosphere could be up to 4 percent. Maximum amount of water vapour is found in hot-wet regions and its least amount is found in the dry regions. Generally, the amount of water vapour goes on decreasing from low latitudes to high latitudes.

In the same way, its amount goes on decreasing with increasing altitude. Water vapour reaches in the atmosphere through evaporation and transpiration. Evaporation takes place in the oceans, seas, rivers, ponds and lakes while transpiration takes place from the plants, trees and living beings.

(c) Dust Particles

Dust particles are generally found in the lower layers of the atmosphere. These particles are found in the form of sand, smoke and oceanic salt. Sand particle have important place in the atmosphere. These dust particles help in the condensation of water vapour. During condensation water vapour gets condensed in the form of droplets around these dust particles. Due to this process the clouds are formed and precipitation is made possible.

Importance of the Atmosphere:

(i) Oxygen is very important for the living beings.

(ii) Carbon dioxide is very useful for the plants.

(iii) Dust particles present in the atmosphere create suitable conditions for the precipitation.

(iv) The amount of water vapour in the atmosphere goes on changing and directly affects the plants and living beings.

(v) Ozone protects all kinds of life on the earth from the harmful ultra violet rays of the sun.

INTEXT QUESTIONS 9.1

(i) Which are the two main gases of the atmosphere?

(a) ______________________ (b) ___________________________
Atmosphere Composition and Structure

(ii) In which region the maximum amount of water vapour is found?

(iii) What is the main function of ozone gas?

9.2 STRUCTURE OF THE ATMOSPHERE

The atmosphere is an integral part of the earth. It surrounds the earth from all sides. Generally it extends up to about 1600 kilometres from the earth's surface. 97 percent of the total amount of weight of the atmosphere is limited up to the height of about 30 kilometres. The atmosphere can be divided into five layers according to the diversity of temperature and density.

(a) Troposphere  
(b) Stratosphere  
(c) Mesosphere  
(d) Ionosphere  
(e) Exosphere

![Fig. 9.2 Structure of the atmosphere](http://smartprep.in)

(a) TROPOSPHERE :-

(i) This is the lowest layer of the atmosphere.

(ii) The height of this layer is about 18 kms on the equator and 8 kms on the poles. The main reason of higher height at the equator is due to presence of hot convection currents that push the gases upward.
Atmosphere Composition and Structure

The domain of Air on the Earth

Notes

This is the most important layer of the atmosphere because all kinds of weather changes take place only in this layer. Due to these changes development of living world take place on the earth. The air never remains static in this layer. Therefore this layer is called changing sphere or troposphere.

The environmental temperature decreases with increasing height of atmosphere. It decreases at the rate of 1°C at the height of 165 metre. This is called Normal lapse rate.

The upper limit of the troposphere is called tropopause. This is a transitional zone. In this zone characteristics of both the troposphere and ionosphere are found.

(b) STRATOSPHERE

(i) This layer is above the troposphere.
(ii) This layer is spread upto the height of 50 kms from the Earth’s surface. Its average extent 40 kms.
(iii) The temperature remains almost the same in the lower part of this layer upto the height of 20 kms. After this the temperature increases slowly with the increase in the height. The temperature increases due to the presence of ozone gas in the upper part of this layer.
(iv) Weather related incidents do not take place in this layer. The air blows horizontally here. Therefore this layer is considered ideal for flying of aircrafts.

(c) MESOSPHERE

(i) It is the third layer of the atmosphere spreading over stratosphere.
(ii) It spreads upto the height of 80 kms. from the surface of the earth. It’s extent is 30 kms.
(iii) Temperature goes on decreasing and drops upto – 100°C.
(iv) ‘Meteors’ or falling stars occur in this layer.

(d) IONOSPHERE

(i) This is the fourth layer of the atmosphere. It is located above the mesosphere.
(ii) This layer spreads upto the height of 400 kms. from the surface of the earth. The width of this layer is about 300 kms.
(iii) The temperature starts increasing again with increasing height in this layer.
(iv) Electrically charged currents flows in the air in this sphere. Radio waves are reflected back on the earth from this sphere and due to this radio broadcasting has become possible.

(e) EXOSPHERE

(i) This is the last layer of the atmosphere located above ionosphere and extends to beyond 400 km above the earth.
(ii) Gases are very sparse in this sphere due to the lack of gravitational force. Therefore, the density of air is very less here.
Atmosphere Composition and Structure

- Change of weather take place only in troposphere.
- Change of weather conditions do not take place in stratosphere. This is an ideal layer for flying aeroplanes.
- Ions are found in abundance in ionosphere. Ionosphere reflects back the radio waves to the earth and make possible the communication system.
- Density of air is the least in the exosphere.

INTEXT QUESTIONS 9.2

1. Define tropopause.

2. Why is there a difference in the height of troposphere?

3. In which two spheres the temperature increases with the height?

4. From which sphere are the radio waves reflected?

5. In which layer of the atmosphere, the density of the air is the least?

6. In which layer of the atmosphere is the ozone gas found?

9.3 CYCLIC PROCESS OF THE ATMOSPHERIC GASES

The cycle of main gases found in the atmosphere is given below:

(a) Carbon cycle
(b) Oxygen cycle
(c) Carbon dioxide cycle

(a) CARBON CYCLE

1. The element of carbon is present in the atmosphere in the form of carbon dioxide. The source of carbon for all living beings is atmosphere.

2. Green plants receive carbon dioxide from the atmosphere which is used for making food with the help of the sunlight. This is called photosynthesis. By this process the plants create ‘carbohydrates’ in the form of food. Carbohydrates thus, produced by plants are used as a food by all living beings.
3. Carbon dioxide gets dissolved in the water bodies and gets collected in the form of lime on the earth. After dissolution of lime stone, carbon dioxide again reaches in the atmosphere. This process is called carbonization. In this way carbon dioxide goes on moving between the atmosphere and water-bodies of the earth.

4. Carbon dioxide produced by breathing of plants and animals, disintegration of plants and animals and by burning fossil fuels like coal, petroleum and natural gas again returns back to the atmosphere.

In this way, the process of receiving of carbon-dioxide from the atmosphere and going back to it from the surface of the earth keeps on going continuously. It keeps the balance between the carbon and biosphere.

(b) OXYGEN CYCLE

1. The amount of oxygen in the atmosphere is about 21% and all living beings use oxygen present in the atmosphere for breathing.

2. For the burning of fuels like wood, coal, gas etc. oxygen is essential and carbon dioxide gas is produced by their burning.

3. The main sources of oxygen in the atmosphere are plants and trees. Higher the number of trees and plants, the availability of oxygen will be more.

4. Oxygen produced through photosynthesis by the green plants goes back to the atmosphere. In this way the process of oxygen cycle goes on continuously.
(c) NITROGEN CYCLE

Nitrogen is an important element for life. The amount of nitrogen gas in the atmosphere is 78%. The main source of nitrogen are nitrates present in the soil. From the atmosphere, nitrogen enters into bio components through the biological and industrial processes. Nitrogen compounds from the plants are transferred to the animals through food chain. The process of transformation of nitrogen gas of the atmosphere into nitrogen components is called nitrogen Fixation. Bacteria’s decompose dried plants and dead animals. It produces nitrogen gas which goes back into the atmosphere. In this way the cycle of nitrogen gas is completed.
The domain of Air on the Earth

Notes

- The main source of carbon is carbon dio-oxide gas found in the atmosphere.
- The main source of oxygen in the atmosphere are plants and trees.
- Oxygen is used for breathing and for burning fuels.
- Nitrogen is very essential for life on the earth. The main source of nitrogen in the plants are nitrates present in this soil.

INTEXT QUESTIONS 9.3

(i) What is the main source of carbon?
_______________________________________________________

(ii) What is the main source of oxygen?
_______________________________________________________

(iii) What is the percentage of nitrogen in the atmosphere?
_______________________________________________________

WHAT YOU HAVE LEARNT

The atmosphere is made up of different kinds of gases which surrounds the earth. Two important gases nitrogen and oxygen together are found on the 99% part of the atmosphere. The atmosphere is composed of troposphere, stratosphere, mesosphere, ionosphere and exosphere. All weather related incidents take place in the troposphere whereas stratosphere is considered to be ideal for flying of aeroplanes. Radio waves are reflected back on the earth from the ionosphere. This has made possible the radio broadcast.

The element of carbon in the atmosphere is found in the form of carbon dio-oxide gas. The main sources of carbon are petroleum, wood, coal and gases. The main sources of oxygen in the atmosphere are plants and trees. Oxygen is very important for breathing and for the burning of fuels. The main source of nitrogen for the plants is nitrate present in the soil. Nitrogen gas is produced by decomposition of plants and animals and goes back to the atmosphere.

TERMINAL QUESTIONS

(1) Which is called atmosphere?
(2) Distinguish between troposphere and stratosphere.
(3) State the importance of ozone gas.
(4) Explain the cycle process of nitrogen gas.
(5) Explain the oxygen cycle with the help of a diagram.
Atmosphere Composition and Structure

(6) Describe the structure of the atmosphere with the help of a diagram.

(7) Write notes on the following.
   (i) Carbon cycle.
   (ii) Importance of atmospheric is gases.
   (iii) Water vapour.
   (iv) Dust particles.

ANSWERS TO INTEXT QUESTIONS

9.1
   (i) Nitrogen and Oxygen
   (ii) Hot-wet region
   (iii) Absorption of harmful ultra-violet rays of the sun.

9.2
   (i) See para 9.1(a)
   (ii) See para 9.2(a)
   (iii) See para 9.3(c)
   (iv) Ionosphere
   (v) Exosphere
   (vi) Stratosphere

9.3
   (i) Fossil fuels – Coal, petroleum and natural gas
   (ii) Plants and trees
   (iii) 78 percent

HINTS TO TERMINAL QUESTIONS

1. See 9.1
2. See 9.2 (a and b)
3. See ozone gas under 9.1(A)
4. See 9.3(c)
5. See 9.3(b)
6. See 9.2
7. (i) See 9.3(a)
   (ii) See 9.1
   (iii) See 9.1(b)
   (iv) See 9.1(c)
In the previous lesson we have studied that the air surrounding the earth is called the atmosphere. The atmosphere is made up of different types of gasses, water vapour and dust particles. Atmosphere is essential for survival of plant and animal life. They also require optimum temperature to keep themselves warm and grow. Have you ever thought what is the source of heat and energy received on the surface of the earth? Why does earth’s surface get warm during the day and cool down during the night? Let us find answer to all these and other related questions in this lesson.

OBJECTIVES

After studying this lesson, you will be able to:

- explain the importance of insolation and establish relationship between angle of incidence of sun’s rays and the intensity of heat received from them at a place;
- explain the different processes involved in heating and cooling of the atmosphere (conduction, convection, radiation and advection);
- explain the heat budget with the help of a diagram;
- differentiate between solar radiation and terrestrial radiation;
- explain the causes of global warming and its effects;
- explain the various factors affecting the horizontal distribution of temperature;
- explain with the help of map, the main characteristics of temperature distribution in the world in the month of January and July;
- explain the conditions in which inversion of temperature occurs.
10.1 INSOLATION (Solar Radiation)

The sun is the primary source of energy on the earth. This energy is radiated in all directions into space through short waves. This is known as solar radiation.

Only two billionths or (two units of energy out of 1,00,00,00,000 units of energy radiated by the sun) of the total solar radiation reaches the earth’s surface. This small proportion of solar radiation is of great importance, as it is the only major source of energy on the earth for most of the physical and biological phenomena.

Incoming solar radiation through short waves is termed as insolation. The amount of insolation received on the earth’s surface is far less than that is radiated from the sun because of the small size of the earth and its distance from the sun. Moreover water vapour, dust particles, ozone and other gases present in the atmosphere absorb a small amount of insolation.

- Sun is the primary source of energy on earth.
- Insolation is the incoming solar radiation.

(a) Factors influencing Insolation

The amount of insolation received on the earth’s surface is not uniform everywhere. It varies from place to place and from time to time. The tropical zone receive the maximum annual insolation. It gradually decreases towards the poles. Insolation is more in summers and less in winters.

The following factors influence the amount of insolation received.

(i) The angle of incidence.
(ii) Duration of the day. (daily sunlight period)
(iii) Transparency of the atmosphere.

(i) The Angle of Incidence: Since the earth is round, the sun’s rays strike the surface at different angles at different places. The angle formed by the sun’s ray with the tangent of the earth’s circle at a point is called angle of incidence. It influences the insolation in two ways. First, when the sun is almost overhead, the rays of the sun are vertical. The angle of incidence is large hence, they are concentrated in a smaller area, giving more amount of insolation at that place. If the sun’s rays are oblique, angle of incidence is small and sun’s rays have to heat up a greater area, resulting in less amount of insolation received there. Secondly, the sun’s rays with small angle, traverse more of the atmosphere, than rays striking at a large angle. Longer the path of sun’s rays, greater is the amount of reflection and absorption of heat by atmosphere. As a result the intensity of insolation at a place is less. (see fig. 10.1)
(ii) **Duration of the day**: Duration of the day varies from place to place and season to season. It decides the amount of insolation received on earth’s surface. The longer the duration of the day, the greater is the amount of insolation received. Conversely, shorter the duration of the day leads to receipt of less insolation.

(iii) **Transparency of the atmosphere**: Transparency of the atmosphere also determines the amount of insolation reaching the earth’s surface. The transparency depends upon cloud cover, its thickness, dust particles and water vapour, as they reflect, absorb or transmit insolation. Thick clouds hinder the insolation to reach the earth while clear sky helps it to reach the surface. Water vapour absorb insolation, resulting in less amount of insolation reaching the surface.

- Amount of insolation at a place depends upon angle of incidence, duration of the day and transparency of the atmosphere.

(b) **Heating and cooling of the Atmosphere**

Sun is the ultimate source of atmospheric heat and energy, but its effect is not direct. For example, as we climb a mountain or ascend in the atmosphere, temperature become steadily lower, rather than higher, as we might expect. This is because the mechanism of heating the atmosphere in not simple. There are four heating processes directly responsible for heating the atmosphere. They are: (i) Radiation (ii) Conduction (iii) Convection and (iv) Advection.

(i) **Radiation**: Radiation is the process by which solar energy reaches the earth and the earth loses energy to outer space. When the source of heat transmits heat directly to an object through heat waves, it is known as radiation process. In this process, heat travels through the empty space. The vast amount of heat energy coming to and leaving the earth is in the form of radiation. The following facts about radiation are worth noting.
Insolation and Temperature

(i) All objects whether hot or cold emit radiant energy continuously.
(ii) Hotter objects radiate more energy per unit area than colder objects.
(iii) Temperature of an object determines the waves length of radiation. Temperature and wave length are inversely related. Hotter the object shorter is the length of the wave.
(iv) Insolation reaches the earth’s surface in short waves and heat is radiated from the earth in long waves.

You will be amused to know that atmosphere is transparent to short waves and opaque to long waves. Hence energy leaving the earth’s surface i.e. terrestrial radiation heats up the atmosphere more than the incoming solar radiation i.e. insolation.

(ii) Conduction: When two objects of unequal temperature come in contact with each other, heat energy flow from the warmer object to the cooler object and this process of heat transfer is known as conduction. The flow continues till temperature of both the objects becomes equal or the contact is broken. The conduction in the atmosphere occurs at zone of contact between the atmosphere and the earth’s surface. However, this is a minor method of heat transfer in terms of warming the atmosphere since it only affects the air close to the earth’s surface.

(iii) Convection: Transfer of heat by movement of a mass or substance from one place to another, generally vertical, is called convection. The air of the lower layers of the atmosphere get heated either by the earth’s radiation or by conduction. The heating of the air leads to its expansion. Its density decreases and it moves upwards. Continuous ascent of heated air creates vacuum in the lower layers of the atmosphere. As a consequence, cooler air comes down to fill the vacuum, leading to convection. The cyclic movement associated with the convectional process in the atmosphere transfer heat from the lower layer to the upper layer and heats up the atmosphere.

(iv) Advection: Winds carry the temperature of one place to another. The temperature of a place will rise if it lies on the path of winds coming from warmer regions. The temperature will fall if the place lies on the path of the winds blowing from cold regions. This process of horizontal transport of heat by winds is known as advection.

INTEXT QUESTION 10.1

1. Answer the following questions in one or two words:
   (a) By which process heat energy travels from the sun to the earth?
(b) What part of solar radiation is received by the earth’s surface?

(c) Name the process in which heat is transferred by winds.

(d) Name the three factors influencing the amount of insolation received at a place.

(i) ___________  (ii) ___________  (iii) ___________

2. Select correct alternative for each of the following and mark (√) on it.

(a) Insolation comes to the earth’s surface in

(i) short waves, (ii) long waves, (iii) both of them, (iv) none of them

(b) Atmosphere is heated by

(i) insolation, (ii) heat radiation from the earth, (iii) both of them, (iv) none of them.

(c) Even after the sunset the air near the earth’s surface continues to receive heat by-

(i) insolation, (ii) terrestrial radiation, (iii) conduction, (iv) convection

10.2 HEAT BUDGET

The insolation is made up of energy transmitted directly through the atmosphere and scattered energy. Insolation is the amount of solar radiation that reaches the earth’s surface through shortwaves. The earth also radiates heat energy like all other hot object. This is known as terrestrial radiation. The annual mean temperature on the surface of the earth is always constant. It has been possible because of the balance between insolation and terrestrial radiation. This balance is termed as a heat budget of the earth.

![Heat Budget Diagram]

Fig. 10.2: Heat Budget (balance between insolation and terrestrial radiation)
Let us suppose that the total heat (incoming solar radiation) received at the top of the atmosphere is 100 units (see fig. 10.2) Roughly 35 units of it are reflected back into space even before reaching the surface of the earth. Out of these 35 units, 6 units are reflected back to space from the top of the atmosphere, 27 units reflected by clouds and 2 units from the snow and ice covered surfaces.

Out of the remaining 65 units (100-35), only 51 units reach the earth’s surface and 14 units are absorbed by the various gases, dust particles and water vapour of the atmosphere.

The earth in turn radiates back 51 units in the form of terrestrial radiation. Out of these 51 units of terrestrial radiation, 34 units are absorbed by the atmosphere and the remaining 17 units directly go to space. The atmosphere also radiates 48 units (14 units of incoming radiation and 34 units of outgoing radiation absorbed by it) back to space. Thus 65 units of solar radiation entering the atmosphere are reflected back into the space. This account of incoming and outgoing radiation always maintains the balance of heat on the surface of the earth.

- Heat budget is the balance between insolation (incoming solar radiation) and terrestrial radiation.

Although the earth as a whole, maintains balance between incoming solar radiation and outgoing terrestrial radiation. But this is not true what we observe at different latitudes. As previously discussed, the amount of insolation received is directly related to latitudes. In the tropical region the amount of insolation is higher than the amount of terrestrial radiation. Hence it is a region of surplus heat. In the polar regions the heat gain is less than the heat loss. Hence it is a region of deficit heat. Thus the insolation creates an imbalance of heat at different latitudes (see Fig. 10.3 This is being nullified to some extent by winds and ocean currents, which transfer heat from surplus heat regions to deficit heat regions. This is commonly known as latitudinal heat balance.
10.3 GLOBAL WARMING

Global warming is one of the major environmental problem our earth is facing. Scientist see its close association with depletion of Stratospheric ozone layer and increase in atmospheric carbon dioxide.

As you know that the upper portion of the stratosphere contains a layer of ozone gas. Ozone is capable of absorbing a large amount of sun’s ultraviolet radiation thus preventing it from reaching the earth’s surface. Scientist have realised that the thickness of the ozone layer is reducing. This is disturbing the balance of gases in the atmosphere and increasing the amount of ultraviolet radiation reaching the earth. Ultraviolet radiation is responsible for increasing the global temperature of the earth’s surface besides it can severely burn human being’s skin, increase the incidence of skin cancer, destroy certain microscopic forms of life and damage plants. There is a gradual increase in the carbon dioxide content of the atmosphere. It is estimated that the carbon dioxide content of the atmosphere has increased 25 per cent in the last hundred years. Carbon dioxide allows insolation to pass through but absorbs terrestrial radiation. Increase of carbon dioxide in the atmosphere has the effect of raising the atmospheric temperature. It is estimated that the temperature of atmosphere has increased by about 0.5°C in the last 1000 years. Large scale deforestation, fossil fuel burning, burning of garbages, combustion processes in factories and volcanic eruptions are some of the factors responsible for the increase of carbon dioxide in the atmosphere.

If the depletion of ozone layer and the increase in the carbon dioxide content continue, the time would come when the temperature of the atmosphere will rise to the extent that it would melt polar ice caps, increasing the sea level and causing submergence of coastal regions and islands. The phenomenon of world wide increase of atmospheric temperature due to depletion of ozone layer and the increase of carbon dioxide content is known as global warming.

- Latitudinal heat balance is the transfer of heat from lower to higher latitudes by winds and ocean currents to counter the imbalance created by insolation at different latitudes.
- Global warming is the world - wide increase of atmospheric temperature due to depletion of ozone layer and in the increase of carbon dioxide content.

INTEXT QUESTIONS 10.2

1. Define the following terms:
   (a) Heat Budget:

   (b) Latitudinal Heat Balance:
Insolation and Temperature

(c) Global Warming

2. Answer the following questions very briefly:

(a) What percentage of insolation is received by the earth?

(b) What part of the incoming solar radiation is reflected back to space from the top of the atmosphere?

(c) Name the regions of surplus heat

(d) Which is the region of deficit heat?

10.4 TEMPERATURE AND ITS DISTRIBUTION

Temperature indicates the relative degree of heat of a substance. Heat is the energy which make things or objects hot, while temperature measures the intensity of heat. Although quite distinct from each other, yet heat and temperature are closely related because gain or loss of heat is necessary to raise or lower the temperature. The celsius scale, named after the swedish astronomer. Anders Celsius, is accepted internationally by Scientists for reporting air temperature. The historical temperature records of several English-speaking countries include values on the Fahrenheit scale, Fahrenheit temperatures may be converted to their celsius equivalents by the formula

\[ C = \frac{5}{9}(F - 32) \]

Moreover, difference in temperature determines the direction of flow of heat. This we can understand by studying temperature distribution.

Distribution of temperature varies both horizontally and vertically. Let us study it under:

(a) The horizontal distribution of temperature

(b) The vertical distribution of temperature

(a) **Horizontal Distribution of Temperature**

Distribution of temperature across the latitudes over the surface of the earth is called its horizontal distribution. On maps, the horizontal distribution of
Insolation and Temperature

The domain of air on the Earth

the temperature is commonly shown by “Isotherms”, lines connecting points that have equal temperatures. An isotherm is made of two words ‘iso’ and ‘therm’, ‘iso’ means equal and ‘therm’ means” temperature. If you study an isotherm map you will find that the distribution of temperature is uneven.

The factors responsible for the uneven distribution of temperature are as follows:

(i) Latitude
(ii) Land and Sea Contrast
(iii) Relief and Altitude
(iv) Ocean Currents
(v) Winds
(vi) Vegetation Cover
(vii) Nature of the soil
(viii) Slope and Aspect

(i) Latitude: You have already studied under ‘insolation’ that the angle of incidence goes on decreasing from equator towards poles (fig. 10.1). Higher the angle of incidence, higher is the temperature. Lower angle of incidence leads to the lowering of temperature. It is because of this that higher temperatures are found in tropical regions and they generally decrease at a considerable rate towards the poles. Temperature is below freezing point near the poles almost throughout the year.

(ii) Land and Sea Contrast: Land and sea contrast affects temperature to a great extent. Land gets heated more rapidly and to a greater degree than water during sunshine. It also cools down more rapidly than water during night. Hence, temperature is relatively higher on land during day time and it is higher in water during night. In the same way there are seasonal contrasts in temperature. During summer the air above land has higher temperature than the oceans. But the air above oceans gets higher temperature than landmasses in winter.

Not withstanding the great contrast between land and water surfaces, there are differences in the rate of heating of different land surfaces. A snow covered land as in polar areas warms very slowly because of the large amount of reflection of solar energy. A vegetation covered land does not get excessively heated because a great amount of insolation is used in evaporating water from the plants.

(iii) Relief and Altitude: Relief features such as mountains, plateaus and plains control the temperature by way of modifying its distribution.
Insolation and Temperature

Mountains act as barriers against the movement of winds. The Himalayan ranges prevent cold winds of Central Asia from entering India, during winter. Because of this Kolkata is not as cold as Guangzhou (Canton) in winter though both are situated almost on the same latitude. (fig. 10.4).

As we move upwards from sea level, we experience gradual decrease in temperature. Temperature decreases at an average rate of $6^\circ C$ per 1000 m. altitude. It is known as normal lapse rate. The air at lower elevations is warmer than that of higher elevations because it is closest to the heated surface of the earth. As a result mountains are cooler than the plains even during summers (see fig.10.4). It is worth remembering that the rate of decrease of temperature with altitude varies with time of day, season and location.

![Fig. 10.4 Effect of Altitude on Temperature](image)

Quito and Guayaquil are two cities of Ecuador (South America) situated near the equator and relatively close to each other. Quito is at 2800 metres high from mean sea level while Guayaquil is just at 12 metres altitude. However because of difference in altitude. Quito experiences annual mean temperature of $13.3^\circ C$ while in Guayaquil it is $25.5^\circ C$.

(iv) **Ocean Currents:** Ocean currents are of two types - warm and cold. Warm currents make the coasts along which they flow warmer, while cold currents reduce the temperature of the coasts along which they flow. The North-Western European Coasts do not freeze in winter due to the effect of North Atlantic Drift (a warm current), while the Quebec on the coast of Canada is frozen due to the Cold Labrador Current flowing along it, though the Quebec is situated in lower latitudes than the North-West European Coast (see fig.10.5).
(iii) **Winds**: Winds also affect temperature because they transport heat from one region to the other, about which you have already studied under advection.

(vi) **Vegetation Cover**: Soil devoid of vegetation cover receives heat more rapidly than the soil under vegetation cover. Because vegetation cover absorbs much of sun’s heat and then prevents quick radiation from the earth whereas the former radiates it more rapidly. Hence the temperature variations in dense forested areas are lower than those in desert areas. For example, the annual range of temperature in equatorial regions is about 5°C while in hot deserts, it is as high as 38°C.

(vii) **Nature of the Soil**: Colour, texture and structure of soils modify temperature to a great degree. Black, yellow, and clayey soils absorb more heat than sandy soils. Likewise, heat radiates more rapidly from sandy soils than from black, yellow, and clayey soils. Hence temperature contrasts are relatively less in black soil areas than those of sandy soils.

(viii) **Slope and Aspect**: Angle of the slope and its direction control the receipt of insolation. The angle of incidence of sun’s rays is greater along a gentler slope and smaller along a steeper slope. The ray in both the cases carry an equal amount of solar energy. Greater concentration of solar energy per unit area along gentler slope raises the temperature while its lesser concentration along steeper slopes lowers the temperature. For such reasons, the southern slopes of the Himalaya are warmer than the northern ones. At the same time, the slopes, in terms of aspect, exposed to the sun receive more insolation and are warmer than those which are away from the direct rays of the sun. The northern slopes of the Himalaya for example, not facing the sun are exposed to cold northerly winds and are obviously colder. On the other hand, the southern slopes of the Himalaya are sun-facing and are also shelter from the northerly cold winds, which are warmer. Hence we observe...
Insolation and Temperature

settlements and cultivation largely on the southern slopes of the Himalaya while the northern slopes are more under forest area.

- Latitude, land and sea contrast, relief and altitude, oceans currents, winds, vegetation cover, nature of soil, slope and aspect control the distribution of temperature in the world.

The horizontal distribution of temperature over the globe can be studied easily from the maps of January and July months, since the seasonal extremes of high and low temperature are most obvious in both northern and southern hemispheres during these months.

(I) Horizontal Distribution of Temperature in January

In January, the sun shines vertically overhead near the Tropic of Capricorn. Hence it is summer in southern hemisphere and winter in northern hemisphere. High temperature is found over the landmasses mainly in three regions of the southern hemisphere. These regions are North-west Argentina, East, Central Africa, and, Central Australia. Isotherm of 30°C closes them. In northern hemisphere landmass arc cooler than oceans. During this time North-east Asia experiences lowest temperatures. (see fig. 10.6)

As the air is warmer over oceans than over landmasses in the northern hemisphere, the Isotherms bend towards poles when they cross the oceans. In southern hemisphere, the position of the isotherms is just reverse. They bend towards poles when they cross the landmasses and towards equator when they cross oceans.

Large expanse of water exists in southern hemisphere. Hence, isotherms are regular and widely spaced in the southern hemisphere. While they are irregular and closely spaced in northern hemisphere due to large expanse of landmasses. For these reasons no extreme seasonal contrasts between land and water are found in middle and higher latitudes in the southern hemisphere as they exist north of equator.

Fig. 10.6 Horizontal Distribution of Temperature (January)
(II) Horizontal Distribution of Temperature in July

During this period the sun shines vertically overhead near the Tropic of Cancer. Hence, high temperatures are found in the entire northern hemisphere. Isotherm of 30°C passes between 10° N and 40° N latitudes. The regions having this temperature include South Western USA, the Sahara, the Arabia, Iraq, Iran, Afghanistan, desert region of India and China. However, lowest temperature of 0°C is also noticed in the Northern Hemisphere during summer in the central part of Greenland (see fig. 10.7).

During summer in the northern hemisphere, isotherms bend equatorward while crossing oceans and polewards while crossing landmasses. In southern Hemisphere the position of isotherms is just opposite.

Isotherms are wide spaced over oceans while they are closely spaced over landmasses.

A comparison between the January and July isotherm maps reveals the following important characteristics.

The latitudinal shifting of highest temperature as a result of migration of the vertical rays of the sun.

The occurrence of highest values in the low latitudes and the lowest value in the high latitudes is due to the decreasing insolation from equator to the poles.

In northern hemisphere the isotherms on leaving the land usually bend rather sharply towards poles in winter and towards the equator in the summer. This behaviour of the isotherms is due to the differential heating and cooling of landmasses. The continents are hotter in the summer and colder in the winter than the oceans.

Fig. 10.7 Horizontal Distribution of Temperature (July)
Insolation and Temperature

Difference between the average temperatures of warmest and the coldest months is known as annual range of temperature. Annual range of temperature is larger in the interior parts of the continents in middle and high latitudes of the northern hemisphere. Verkhoyansk in Siberia records 66°C the highest annual range of temperature in the world. Its lowest average winter temperature is -50°C. Hence it is aptly called ‘cold pole’ of the earth.

- The difference between average temperature of the warmest and the coolest months is known as annual range of temperature.

INTEXT QUESTIONS 10.3

1. Select the correct alternative and mark tick (✓) on it:
   (a) Terrestrial radiation is the amount of heat radiated by the
       (i) earth, (ii) sun, (iii) atmosphere, (iv) hydrosphere
   (b) Quito has lower temperature than that of Guayanquil because Quito is situated at
       (i) higher latitude, (ii) higher altitude, (iii) lower latitude, (iv) lower altitude.
   (c) Verkhoyansk has very high annual range of temperature because it is located
       (i) in the equatorial region, (ii) on the sea coast, (iii) in the interior parts of Asia (iv) on mountain

2. Give a geographical term for each of the following statements:
   (a) The process of horizontal transport of heat by winds.
   (b) Imaginery lines on a map joining the places of equal temperature, reduced to sea level.
   (c) Difference between the mean temperatures of the hottest and that of the coldest month.

(b) Vertical Distribution of Temperature

The permanent snow on high mountains, even in the tropics, indicate the decrease of temperature with altitude. Observations reveals that there is a fairly regular decrease in temperature with an increase in altitude. The average
rate of temperature decrease upward in the troposphere is about 6°C per km, extending to the tropopause. This vertical gradient of temperature is commonly referred to as the standard atmosphere or normal lapse rate, but it varies with height, season, latitude and other factors. Indeed the actual lapse rate of temperature does not always show a decrease with altitude.

(c) Inversion of Temperature

Long winter night, clear sky, dry air and absence of winds leads to quick radiation of heat from the earth’s surface, as well as from the lower layers of the atmosphere. This results in the cooling of the air near the earth’s surface. The upper layers which lose their heat not so quickly are comparatively warm. Hence the normal condition in which temperature decreases with increasing height, is reversed. The cooler air is nearer the earth and the warmer air is aloft. In other words, temperature increases with increasing height temporarily or locally. This phenomena is termed as inversion of temperature. Sometimes the cold and dense air remains near the surface for number of days. So the phenomenon of inversion of temperature is also seen for days together.

The phenomenon of inversion of temperature is especially observed in intermontane valleys. During winters the mountain slopes cool very rapidly due to the quick radiation of heat. The air resting above them also becomes cold and its density increases. Hence, it moves down the slopes and settles down in the valleys. This air pushes the comparatively warmer air of valleys upwards and leads to the phenomenon of inversion of temperature. Sometimes the temperature falls below freezing point in the valleys leading even to the occurrence of frost. In contrast, the higher slopes remain comparatively warmer.

That is why mulberry planters of the Suwa Basin of Japan and the apple growers of Himachal Pardesh avoid the lower slopes of the mountains to escape winters frost. If you have been to any hill station you would have seen that most of the holiday resorts and the houses of affluent persons are built on the upper slopes.

- Temperature usually decreases with increasing altitude.
- The normal lapse rate is 6°C per 1000m metres ascend.
- The phenomenon in which temperature increases with increasing altitude temporarily and locally under certain conditions is known as inversion of temperature.

INTEXT QUESTIONS 10.4

1. Select the correct alternative for each of the following and mark tick ( ) on it:
Insolation and Temperature

(a) Temperatures decrease with increase in -
   (i) altitude, (ii) depth, (iii) pressure, (iv) both altitude and depth

(b) The normal lapse rate is 6°C per
   (i) 561 metres, (ii) 1000 m, (iii) 651 metres (iv) 156 metres

(c) The phenomenon in which temperature increases with increasing altitude is known as
   (i) temperature anomaly, (ii) inversion of temperature, (iii) lapse rate, (iv) insolation

2. Tick (✓) the true statements and cross (x) on the false ones
   (a) Cold air is light.
   (b) Cold air is dense.
   (c) Clear sky dry air and absence of winds causes rapid radiation leading to the phenomenon of inversion of temperature.
   (d) Inversion of temperature occurs very frequently in plain
   (e) Apple growers of the Himachal Pradesh avoid lower slopes
   (f) The cool and dense air sliding down the mountain slopes pushes the comparatively warm and light air of valleys of words.
   (g) Inversion of temperature occurs locally and temporarily.

WHAT YOU HAVE LEARNT

Sun is the primary source of energy on earth. Sun’s energy reaching the earth in short waves is called insolation. The amount of insolation depends upon angle of incidence, duration of the day and transparency of the atmosphere. The processes involved in the heating and cooling of the atmosphere are radiation, conduction, convection and advection. Radiation predominates other three processes. Terrestrial radiation is the amount of heat radiated back from the earth. There is a balance between the receipt of insolation and the terrestrial radiation on earth’s surface. It is known as heat budget. Global warming is the world wide increase of atmospheric temperature due to depletion of ozone layer and increase in carbon dioxide.

Temperature measures the intensity of heat. Distribution of temperature varies both horizontally and vertically. Certain factors control its distribution. They are latitude, land and water contrast, winds, ocean currents, altitude and aspect of slope. Horizontal distribution of temperature is shown on a map with the help of isotherms, the imaginary lines joining places of equal temperature.
Temperature also decreases with increasing altitude. The rate at which it decreases in normal conditions is known as normal lapse of temperature. It is 6°C per 1000m of height. The phenomenon of inversion of temperature occurs when temperature increases with increase in height: It is generally local and temporary in character.

**TERMINAL QUESTIONS**

1. Answer the following questions at the most in one sentence:
   (a) What is meant by normal lapse rate?
   (b) What is insolation?
   (c) Define terrestrial radiation.
   (d) At which rate does temperature decrease with increase in altitude?

2. Write in about 50 words on each of the following
   (a) Distribution of temperature in the world in January
   (b) Heat Budget
   (c) Comparison between January & July isotherms.
   (d) Latitudinal heat balance.

3. Describe the factors that influence the horizontal distribution of temperature.

4. Mark and label the following on an outline map of world.
   (a) 30°C isotherm in July
   (b) Verkhoyansk
   (c) The Sahara
   (d) Borneo island

5. Why do different parallel of latitude receive different amount of insolation?

6. Draw a diagram to explain the heat budget of the earth.

**ANSWER TO INTEXT QUESTIONS**

10.1

1. (a) Radiation (b) Two billionths part (c) Advection (d) (i) Angle of incidence, (ii) Duration of the day and (iii) Transparency of the atmosphere
Insolation and Temperature

2. (a) short waves (b) heat radiation from the earth (c) terrestrial radiation

10.2
1. (a) see 10.2 (b) see 10.2 (c) see 10.3
2. (a) 51% (b) 6% (c) Tropical Region (d) Polar region

10.3
1. (a) earth (b) higher altitude (c) in the interior parts of Asia
3. (a) Advection (b) Isotherms (c) Annual range of temperature

10.4
1. (a) altitude (b) 1000 metres (c) inversion of temperature
2. (a) False, (b) True, (c) True, (d) False’, (e) True, (f) True, (g) True

HINTS TO TERMINAL QUESTIONS
1. (a) The normal rate at which temperature decreases with increase in altitude.
   (b) The portion of solar radiation that reaches the surface of the earth.
   (c) Heat radiated from the earth’s surface.
   (d) 6°C at every 1000 metres altitude.
2. (a) Please refer to para to 10.4 (a) (I)
   (b) Please refer to para 10.2
   (c) Please refer to para 10.4 (a) (II)
   (d) Please refer to para 10.2 (a)
3. Please refer to para 10.4 (a)
4. Please see maps of this lesson
5. Please see para 10.1 (i)
6. Please see Fig. 10.2
PRESSURE AND WINDS

We do not ordinarily think of air as having too much weight. But air has weight and it exerts pressure. Let us take an empty bicycle tube and weight it. Now fill tube with air and weight it again. You will find that the weight of the air filled tube is more than when it was empty. If you go on filling air in the tube a situation comes when the tube bursts. The bursting of the tube occurs due to increase in air pressure in the tube. Similarly, the air around us exerts pressure. But we do not feel the weight of the atmosphere because we have air inside us which exerts an equal outward pressure that balances the inward pressure of the atmosphere. Atmospheric pressure is important to us because it is related to winds and it helps to determined, weather conditions of a place. In this lesson you will study air pressure, its distribution, winds and their types.

OBJECTIVES

After studying this lesson, you will be able to:

- give reasons for the decrease of air pressure with increase in altitude;
- describe with examples the effect of low air pressure at high altitude on the daily life of man;
- explain the relationship between the spacing of isobar and pressure gradient;
- establish relationship between the temperature and the existence of equatorial low pressure and the polar high pressure;
- give reason for the existence of sub-tropical high pressure and sub-polar low pressure belts;
- explain the distribution of atmospheric pressure with the help of isobar maps of the world for the months of January and July;
Pressure and Winds

- establish the relationship between pressure gradient and speed of winds
- explain the influence of coriolis effect on the direction of winds of both the hemispheres;
- draw diagram showing pressure belts and planetary winds;
- distinguish between (a) planetary and monsoon winds (b) land and sea breezes (c) valley and mountain breezes and (d) cyclones and anticyclones:
- describe the characteristics of Important local winds

11.1 MEASUREMENT OF AIR PRESSURE

The atmosphere is held on the earth by the gravitational pull of the earth. A column of air exerts weight in terms of pressure on the surface of the earth. The weight of the column of air at a given place and time is called air pressure or atmospheric pressure. Atmospheric pressure is measured by an instrument called barometer. Now a days Fortin’s barometer and Aneroid barometer I are commonly used for measuring air pressure.

Atmospheric pressure is measured as force per unit area. The unit used for measuring pressure is called millibar. Its abbreviation is ‘mb’. One millibar is equal to the force of one gram per square centimetre approximately. A pressure of 1000 millibars is equal to the weight of 1.053 kilograms per square centimetre at sea level. It is equal to the weight of a column of mercury which is 76 centimetre high. The international standard pressure unit is the “pascal”, a force of one Newton per square meter. In practice atmospheric pressure is expressed in kilopascals, (one kpa equals 1000 Pa).

- The weight of a column of air at a given place and time is called air pressure.
- Barometer is the instrument which measures air or atmospheric pressure.
- The unit of measurement of atmospheric pressure is millibar (kilopascals).
- One millibar is equal to the force of nearly one gram per square centimetre.

The mean atmospheric pressure at sea level is 1013.25 millibars. However the actual pressure at a given place and at a given time fluctuates and it generally ranges between 950 and 1050 millibars

11.2 DISTRIBUTION OF AIR PRESSURE

Distribution of atmospheric pressure on the surface of the earth is not uniform. It varies both vertically and horizontally.
(a) Vertical Distribution

Air is a mixture of various gases. It is highly compressible. As it compresses, its density increases. The higher the density of air, the greater is the air pressure and vice versa. The mass of air above in the column of air compresses the air under it hence its lower layers are more dense than the upper layers; As a result, the lower layers of the atmosphere have higher density, hence, exert more pressure. Conversely, the higher layers are less compressed and, hence, they have low density and low pressure. The columnar distribution of atmospheric pressure is known as vertical distribution of pressure. Air pressure decreases with increase in altitude but it does not always decrease at the same rate. Dense components of atmosphere are found in its lowest parts near the mean sea level. Temperature of the air, amount of water vapour present in the air and gravitational pull of the earth determine the air pressure of a given place and at a given time. Since these factors are variable with change in height, there is a variation in the rate of decrease in air pressure with increase in altitude. The normal rate of decrease in air pressure is 34 millibars per every 300 metres increase in altitude; (see figure 11.1). The effects of low pressure are more clearly experienced by the people living in the hilly areas as compared to those who live in plains. In high mountainous areas rice takes more time to cook because low pressure reduces the boiling point of water. Breathing problem such as faintness and nose bleedings are also faced by many trekkers from outside in such areas because of low pressure conditions in which the air is thin and it has low amount of oxygen content.

(b) Horizontal Distribution

The distribution of atmospheric pressure over the globe is known as horizontal distribution of pressure. It is shown on maps with the help of isobars. An isobar is a line connecting points that have equal values of pressure. Isobars are analogous to the contour lines on a relief map. The spacing of isobars expresses the rate and direction of change in air pressure. This change in air pressure is referred to pressure gradient. Pressure gradient is the ratio between
Pressure and Winds

Pressure difference and the actual horizontal distance between two points. Close spacing of isobars expresses steep pressure gradient while wide spacing indicates gentle pressure gradient (see fig. 11.5)

The horizontal distribution of atmospheric pressure is not uniform in the world. It varies from time to time at a given place; it varies from place to place over short distances. The factors responsible for variation in the horizontal distribution of pressure are as follows:

(i) Air temperature
(ii) The earth’s rotation
(iii) Presence of water vapour

(i) Air Temperature: In the previous lesson, we have studied that the earth is not heated uniformly because of unequal distribution of insolation, differential heating and cooling of land and water surfaces. Generally there is an inverse relationship between air temperature and air pressure. The higher the air temperature, the lower is the air pressure. The fundamental rule about gases is that when they are heated, they become less dense and expand in volume and rise. Hence, air pressure is low in equatorial regions and it is higher in polar regions. Along the equator lies a belt of low pressure known as the “equatorial low or doldrums”. Low air pressure in equatorial regions is due to the fact that hot air ascends there with gradual decrease in temperature causing thinness of air on the surface. In polar region, cold air is very dense hence it descends and pressure increases. From this we might expect, a gradual increase in average temperature thords equator. However, actual readings taken on the earth’s surface at different places indicate that pressure does not increase latitudinally in a regular fashion from equator to the poles. Instead, there are regions of high pressure in subtropics and regions of low pressure in the subpolar areas.

(ii) The Earth’s Rotation: The earth’s rotation generates centrifugal force. This results in the deflection of air from its original place, causing decrease of pressure. It is believed that the low pressure belts of the sub polar regions and the high pressure belts of the sub-tropical regions are created as a result of the earth’s rotation. The earth’s rotation also causes convergence and divergence of moving air. Areas of convergence experience low pressure while those of divergence have high pressure (see fig. 11.7).

(iii) Pressure of Water Vapour: Air with higher quantity of water vapour has lower pressure and that with lower quantity of water vapour has higher pressure. In winter the continents are relatively cool and tend to develop high pressure centres; in summer they stay warmer than the
The domain of Air on the Earth

oceans and tend to be dominated by low pressure, conversely, the oceans are associated with low pressure in winter and high pressure in summer.

- An isobar is a line connecting points that have equal values of pressure.
- Pressure gradient is the ratio between pressure difference and horizontal distance between two points.
- On an average air pressure decreases by 34 millibars per 300 metres increase in height.

INTEXT QUESTIONS 11.1

1. Name the three factors which influence horizontal distribution of air pressure:
   (a) ____________________ (b) ________________ (c) ____________________

2. Name the two instruments used to measure air pressure:
   (a) ____________________ (b) ____________________

3. What is the mean atmospheric pressure at sea level?
   ____________________________________________

4. Select the best alternative for each and mark tick (✓) on it:
   (a) A pressure of 1000 millibars is equal to the weight of a column of mercury having height of
      (i) 65 cm; (ii) 70 cm; (iii) 76 cm; (iv) 80 cm
   (b) Areas where moving air converge have
      (i) high pressure; (ii) low pressure; (iii) both high and low pressure
      (iv) no pressure at all
   (c) Air with lower quantity of water vapour has (i) higher pressure (ii) lower pressure; (iii) no pressure (iv) none of the above

11.3 PRESSURE BELT

The horizontal distribution of air pressure across the latitudes is characterized by high or low pressure belts. This is however, a theoretical model because pressure belts are not always found as such on the earth. We will see it later how the real condition departs from the idealized model and examine why these differences occur.

These pressure belts are: (i) The Equatorial Low Pressure Belt; (ii) The Sub
Pressure and Winds

tropic High Pressure Belts; (iii) The Sub-polar Low Pressure Betts; (iv) The Polar High Pressure Belts (see fig. 11.2)

(i) The Equatorial Low Pressure Belt

The sun shines almost vertically on the equator throughout the year. As a result the air gets warm and rises over the equatorial region and produce equatorial low pressure. This belt extends from equator to 10\(^\circ\)N and 10\(^\circ\)S latitudes. Due to excessive heating horizontal movement of air is absent here and only conventional currents are there. Therefore this belt is called doldrums (the zone of calm) due to virtual absence of surface winds. These are the regions of convergence because the winds flowing from sub tropical high pressure belts converge here. This belt is also known as-Inter Tropical Convergence Zone (ITCZ).

(ii) The Sub-tropical High Pressure Belts

The sub-tropical high pressure belts extend from the tropics to about 35\(^\circ\) latitudes in both the Hemispheres. In the northern hemisphere it is called as the North sub-tropical high pressure belt and in the southern hemisphere it is known as the South sub-tropical high pressure belt. The existence of these pressure belts is due to the fact that the up rising air of the equatorial region is deflected towards poles due to the earth’s rotation. After becoming cold and heavy, it descends in these regions and get piled up. This results in high pressure. Calm conditions with feeble and variable winds are found here. In olden days vessels with cargo of horses passing through these belts found difficulty in sailing under these calm conditions. They used to throw the horses in the sea in order to make the vessels lighter. Henceforth these belts...
or latitudes are also called ‘horse latitudes’. These are the regions of divergence because winds from these areas blow towards equatorial and sub-polar low pressure belts.

(iii) The Sub-polar low Pressure Belts

The sub-polar low pressure belts extend between 45°N and the Arctic Circle in the northern hemisphere and between 45°S and the Antarctic Circle in the southern hemisphere. They are known as the North sub-polar low and the South sub-polar low pressure belts respectively. Winds coming from the sub-tropical and the polar high belts converge here to produce cyclonic storms or low pressure conditions. This zone of convergence is also known as polar front.

(iv) The Polar High Pressure Belts

In polar regions, sun never shines vertically. Sun rays are always slanting here resulting in low temperatures. Because of low temperature, air compresses and its density increases. Hence, high pressure is found here. In northern hemisphere the belt is called the North polar high pressure belt while it is known as the South polar high pressure belt in the southern hemisphere. Winds from these belts blow towards sub-polar low pressure belts.

This system of pressure belts that we have just studied is a generalised picture. In reality, the location of these pressure belts is not permanent. They shift northward in July and southward in January, following the changing position of the sun’s direct rays as they migrate between the Tropics of Cancer and Capricorn. The thermal equator (commonly known as the belt of highest temperature) also shifts northwards and southwards of the equator. With the shifting of thermal equator northwards in summer and southwards in winter, there is also a slight shift in pressure belts towards north and south of their annual average location.

- Sub-tropical high pressure belts are also called horse latitudes.
- Subsidence and piling of air in sub-tropical belts cause high pressure.
- Convergence of subtropical and polar winds result in the formation of cyclones in the sub-polar regions.
- High pressure belts are dry while low pressure belts are humid.
- With the movement of sun northwards and southwards thermal equator also shifts northwards and southwards.
- Pressure belts also shift northwards and southwards with the shift of thermal equator.
Pressure and Winds

11.4 SEASONAL DISTRIBUTION OF PRESSURE

The variation of pressure from place to place and from season to season over the earth plays an important role in affecting the weather and climate. Therefore we study pressure distribution through isobar maps. While drawing isobar maps, the pressures of all places are reduced to sea level to avoid the effect of altitude on air pressure.

(i) January Conditions

In January, with the southward apparent movement of the Sun, the equatorial low pressure belt shifts a little south of the mean equatorial position (see fig. 11.3). Areas of lowest pressure occur in South America, Southern Africa and Australia. This is because the land tends to get hotter rapidly than water. Sub-tropical high pressure cells are centered over the ocean in the southern hemisphere. The belt of high pressure is interrupted by the continental land masses where the temperature is much higher. They are well developed in eastern part of the ocean where cold ocean currents dominate.

![Fig. 11.3 Distribution of Air Pressure (January)](image)

In the northern hemisphere, ridges of high pressure occur in the sub-tropical latitudes over the continent. A well developed high pressure cell occurs in the interior parts of Eurasia. This is due to the fact that land cools more rapidly than oceans. Its temperatures are lower in winter than the surrounding seas. In the southern hemisphere, the sub-polar low pressure belt circles the earth as a real belt of low pressure and is not divided into cells, because there is virtually no landmass. In northern hemisphere two cells of low pressure namely Iceland low and Aleutian low develop over the North Atlantic and the North Pacific oceans respectively.

(ii) July Conditions

In July, the equatorial low pressure belt shifts a little north of the mean
equatorial position because of the northward apparent movement of the Sun. All the pressure belts shift northwards in July. (see fig. 11.4)

![Fig. 11.4 Distribution of Air Pressure (July)](image)

The Aleutian and Icelandic lows disappear from the oceans while the landmasses, which developed high pressure during winter months, have extensive low pressure cells now. In Asia, a low pressure develops. The subtropical highs of the northern hemisphere are more developed over the oceans - Pacific and Atlantic. In the southern hemisphere, the sub-tropical high pressure belt is continuous. Sub-polar low forms a continuous belt in the southern hemisphere while in northern hemisphere, there is only a faint oceanic low.

**INTEXT QUESTION 11.2**

1. Complete each of the following with suitable endings:
   
   (a) The belt of highest temperature is known as ___________
   
   (b) In drawing isobar maps the factor eliminated is that of ___________
   
   (c) Higher the density of air, higher is its ___________
   
   (d) Higher the temperature of air, lower is its ___________

2. Select the best alternatives for each of the following:

   (a) Earth’s rotation causes:
       
       (i) deflection of air from its original direction. (ii) convergence of air. (iii) both deflection and convergence of air. (iv) none of the above.
Pressure and Winds

(b) Equatorial Low Pressure Belt extends between:
   (i) 45° N and S Arctic and Antarctic Circles. (ii) 10° N and 10° S latitudes. (iii) tropics and 35° N and S latitudes. (iv) none of them.

(c) ‘Horse latitudes’ are those latitudes which lie within:
   (i) equatorial low pressure belt. (ii) sub- tropical high pressure belts. (iii) sub-polar low pressure belts. (iv) polar high pressure regions.

(d) Belts of high pressure are:
   (i) unstable and dry. (ii) unstable and humid. (iii) both of the above. (iv) none of the above.

11.5 WINDS

We have just studied that air pressure is unevenly distributed. Air attempts to balance the uneven distribution of pressure. Hence, it moves from high pressure areas to low pressure areas. Horizontal movement of air in response to difference in pressure is termed as wind while vertical or nearly vertical moving air is called air current. Both winds and air currents form the system of circulation in the atmosphere.

(i) Pressure Gradient and Winds

There is a close relationship between the pressure and the wind speed. The greater the difference in air pressure between the two points, the steeper is the pressure gradient and greater is the speed of the wind. The gentler the pressure gradient slower is the speed of the wind. (see fig. 11.5).
(ii) The Coriolis Effect and Wind

Winds do not cross the isobars at right angles as the pressure gradient directs them. They get deflected from their original paths. One of the most potent influences on wind direction is the deflection caused by the earth’s rotation on its axis. Demonstrated by Gaspaved de Coriolis in 1844 and known as the Coriolis effect or coriolis force. Coriolis force tend to deflect the winds from their original direction. In northern hemisphere winds are deflected towards their right, and in the southern hemisphere towards their left (see fig. 11.6) This is known as Farrel’s law. The Coriolis force is absent along the equator but increases progressively towards the poles.

![Fig. 11.6 Deflection of Winds by Coriolis Force](image)

11.6 TYPE OF WINDS

For ages man has observed that in some areas of the earth the winds blow predominantly from one direction throughout the year; in other areas the wind direction changes with the season and in still others the winds are so variable that no pattern is discernible. Despite these difference, the winds are generalized under three categories.

(a) planetary winds or permanent winds
(b) periodic winds and
(c) local winds

(a) Planetary Winds

Planetary or permanent winds blow from high pressure belts to low pressure belts in the same direction throughout the year. They blow over vast area of
Pressure and Winds

continents and oceans. They are easterly and westerlies and polar easterlies. (see fig. 11.7)

(i) The Easterlies

The winds that blow from sub-tropical high pressure areas towards equatorial low pressure areas called trade or easterly winds: The word trade has been derived from the German word ‘trade’ which means track. To blow trade means ‘to blow steadily and constantly in the same direction’. Because of the Coriolis effect the northern trade winds move away from the sub-tropical high in north-east direction. In southern hemisphere the trade winds diverge out of the sub-tropical high towards the equatorial low from the south-east direction As the trade winds tend to blow mainly from the east, they are also known as the Tropical easterlies. (see fig. 11.7)

(ii) The Westerlies

The winds that move poleward from the sub-tropical high pressure in the northern hemisphere are detected to the right and thus blow from the south west. These in the southern hemisphere are deflected to the left and blow from the north-west. Thus, these winds are called westerlise (see fig. 11.7)

(iii) Polar Easterlies

Polar easterlies blow from polar regions towards sub-polar low pressure regions. Their direction in the northern hemisphere is from north-east to south-west and from south-east to north-west in the southern hemisphere.

Fig 11.7 : Planetary Winds
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In northern hemisphere winds, are deflected towards their right and in the southern hemisphere towards their left. This is known as Ferrel’s law.

INTEXT QUESTIONS 11.3

1. Name Planetary winds:
   (a) ____________________ (b) ____________________ (c) ____________________

2. What is Ferrel’s law?

3. Choose the correct alternative for each of the following:
   (a) Winds blow from high pressure to
       (i) low pressure, (ii) high pressure, (iii) both low and high pressures
       (iv) none of them.
   (b) Winds are deflected from their original path due to
       (i) Coriolis effect, (ii) pressure gradient, (iii) their speed, (iv) high pressure
   (c) Winds are caused primarily by
       (i) Coriolis effect, (ii) pressure difference (iii) rotation of the earth,
       (iv) humidity difference.
   (d) The Coriolis force at the equator is
       (i) maximum, (ii) medium, (iii) nil, (iv) none of the above.

(b) Periodic Winds

The direction of these winds changes with the change of seasons. Monsoon winds are the most important periodic winds.

Monsoon Winds

The word ‘Monsoon’ has been derived from the Arabic word ‘Mausim’ meaning season. The winds that reverse their direction with the change of seasons are called monsoon winds. During summer the monsoon winds blow from sea towards land and during winter from land towards seas. Traditionally these winds were explained as land and sea breezes on a large scale. But this explanation does not hold good now. Now a days the monsoon is generally accepted as seasonal modification of the general planetary wind system. The Asiatic monsoon is the result of interaction of both planetary wind system
Pressure and Winds

and regional factors, both at the surface and in the upper troposphere (see fig. 11.8)

![Monsoon Winds Map](image)

**Fig. 11.8 The Monsoon Winds**

India, Pakistan, Bangladesh, Myanmar (Burma), Sri Lanka, the Arabian Sea, the Bay of Bengal, South-east Asia, North Australia, China and Japan are important regions where monsoon winds are prevalent.

- Winds which reverse their direction with the change of seasons are called monsoons.

**c) Local Winds**

Till now we were discussing the major winds of the earth’s surface, which are vital for understanding the climatic regions. But we are all aware that there are winds that affect local weather. Local winds usually affect small areas and are confined to the lower levels of the troposphere. Some of the local winds are given below:

**i) Land and Sea Breezes**

Land and sea breezes are prevalent on the narrow strips along the coasts or a lake. It is a diurnal (daily) cycle, in which the differential heating of land and water produces low and high pressures. During the day when landmass gets heated more quickly than the adjoining sea or large lake; air expands and rises. This process produces a local low pressure area on land. Sea breeze then develops, blowing from the water (high pressure) towards the land (low pressure). The sea breeze begins to develop shortly before noon and generally reaches its greatest intensity during mid-day to late afternoon. These cool winds have a significant moderating influence in coastal area.
At night, the land and the air above it cools more quickly than the nearby water body. As a result, land has high pressure while the sea has comparatively a low pressure area. Gentle wind begins to blow from land (high pressure) towards sea (low pressure). This is known as land breeze (see fig. 11.9)

**(ii) The Mountain and Valley Breezes**

Another combination of local winds that undergoes a daily reversal consists of the mountain and valley breezes. On a warm sunny day the mountain slopes are heated more than the valley floor.

Hence, the pressure is low over the slopes while it is comparatively high in the valleys below. As a result gentle wind begins to blow from valley towards slopes and it assumes the name of valley breeze (see fig. 11.10).

After sunset, the rapid radiation takes place on the mountain slopes. Here, high pressure develops more rapidly than on the valley floor. Cold arid heavy air of mountain slopes starts moving down towards the valley floor. This is known as the mountain breeze (see fig. 11.10).
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The valley and mountain breezes are also named as anabatic and katabatic breezes respectively.

(iii) Hot Winds

Loo, Foehn and Chinook are important hot winds of local category.

(1) Loo

Loo are hot and dry winds, which blow very strongly over the northern plains of India and Pakistan in the months of May and June. Their direction is from west to east and they are usually experienced in the afternoons. Their temperature varies between 45°C to 50°C.

(2) Foehn

Foehn is strong, dusty, dry and warm local wind which develops on the leeward side of the Alps mountain ranges. Regional pressure gradient forces the air to ascend and cross the barrier. Ascending air sometimes causes precipitation on the windward side of the mountains. After crossing the mountain crest, the Foehn winds starts descending on the leeward side or northern slopes of the mountain as warm and dry wind. The temperature of the winds vary from 15°C to 20°C which help in melting snow. Thus making pasture land ready for animal grazing and help the grapes to ripe early.

(3) Chinook

Chinook is the name of hot and dry local wind which moves down the eastern slopes of the Rockies in U.S.A. and Canada. The literal meaning of chinook is ‘snow eater’ as they help in melting the snow earlier. They keep the grasslands clear of snow. Hence they are very helpful to ranchers.

(iv) Cold Winds

The local cold winds originate in the snow-capped mountains during winter and move down the slopes towards the valleys. They are known by different names in different areas.

(1) Mistral

Mistral are most common local cold winds. They originate on the Alps and move over France towards the Mediterranean Sea through the Rhone valley. They are very cold, dry and high velocity winds. They bring down temperature below freezing point in areas of their influence. People in these areas protect their orchards and gardens by growing thick hedges and build their houses facing the Mediterranean sea.
1. Choose the correct alternative for each of the following:
   (a) Foehn winds are
       (i) wet and dry (ii) cold, (iii) both wet and cold, (iv) none of them.
   (b) Chinooks are similar to
       (i) Foehn, (ii) Mistral, (iii) both of them, (iv) none of them.

2. Where from the Foehn wind originates.

3. Name the local wind which originate on the snow capped rockies and move down the eastern slopes.

4. Write hot or cold against each of the following
   (a) Loo ______________
   (b) Mistral ______________
   (c) Chinok ______________

11.7 TROPICAL AND TEMPERATE CYCLONES

(1) Air Mass
An air mass is an extensive portion of the atmosphere having uniform characteristics of temperature, pressure and moisture which are relatively homogeneous horizontally.

An air mass develops when the air over a vast and relatively uniform land or ocean surface remains stationary for long time to acquire the temperature or moisture from the surface. The major source regions of the air masses are the high latitude polar or low latitude tropical regions having such homogeneous conditions. Air masses, therefore, are of two kinds-polar and tropical air masses. Polar air mass is cold and tropical air mass is warm. When cold air mass and warm air mass blow against each other, the boundary line of convergence separating the two air masses is termed as front. When the warm air mass, moves upward over the cold air mass the front formed in such a situation is called warm front. On the contrary, when the cold air mass advances faster and undercuts the warm air mass and forces the warm air upwards, the front so formed is called cold front. The frontal surface of cold front is steeper than that of a warm front (see fig 12.5). A prevailing air mass in any region - polar, tropical, maritime or continental largely controls the regions general weather.
Pressure and Winds

(2) Cyclones

Typical cyclones are elliptical arrangement of isobars having low pressure at the centre with a convergence of winds within them. The wind direction in the cyclones is anti clockwise in the northern hemisphere and clockwise in the southern hemisphere. Cyclones are of two types - the temperate or mid latitude cyclones and the tropical or low latitude cyclones (see fig. 11.11).

(a) Temperate Cyclones

Temperate cyclones are formed along a front in mid-latitudes between 35° and 65° N and S. They blow from west to east and are more pronounced in winter season.

Atlantic Ocean and North West Europe are major regions of temperate cyclones. They are generally extensive having a thickness of 9 to 11 kilometers and with 1040-1920 km short and long diameters respectively. Each such cyclone alternates with a high pressure anticyclone. The weather associated with the cyclone is drizzling rain and of cloudy nature for number of days. The anticyclone weather is sunny, calm and of cold waves.

(b) Tropical Cyclones

Tropical cyclones are formed along the zone of confluence of north-east and south-east trade winds. This zone is known as the Inter Tropical Convergence Zone (ITCZ). Cyclones generally occur in Mexico, South-Western and North Pacific Ocean, North Indian Ocean and South Pacific Ocean. These cyclones differ from temperate cyclones in many ways. There are no clear warm and cold fronts as temperature seldom differs in Inter Tropical Convergence Zone. They do not have well-defined pattern of winds and are energised by convectional currents within them. Generally, these are shallow depressions and the velocity of winds is weak. These are not accompanied by anticyclones. The arrangement of isobars is almost circular. These are not extensive and have the diameters of 160-640km. However, a few of them become very violent and cause destruction in the regions of their influence. They are called hurricanes in the Carribean Sea, typhoons in the China, Japan and philippines,

Fig. 11.11 : Movement of Wind associated with Cyclones and Anticyclone in Northern and Southern Hemisphere
Tropical cyclones often cause destruction on the coasts. You would have heard cyclones striking Indian coasts in summer and autumn months. They cause heavy loss of life and property in these regions. The steeper pressure gradient causing strong high velocity winds and torrential rainfall bursting upon a restricted area combine to create destructive storms. However about 8 to 48 km. area around their centre called the eye of these stormy cyclones remains calm and rainless. If this eye is detected, it is possible for the modern science to stop further development of these strong cyclones and thus protecting us from them.

- An air mass is a large body of air having uniform temperature and moisture contents.
- The boundary line separating two air masses is termed as front.
- Temperate cyclones are prevalent in mid-latitudes while tropical cyclones develop in tropical regions.

**INTEXT QUESTIONS 11.5**

1. What is air mass?
Pressure and Winds

2. Which type of cyclones cause heavy loss to life and property?

________________________________________________________________________

3. In which latitudes temperate cyclones develop?

________________________________________________________________________

WHAT YOU HAVE LEARNT

Atmospheric pressure is the weight of the column of air at a given place and time. It is measured by an instrument called barometer. Unit of measurement of pressure is millibar. The distribution of atmospheric pressure varies both vertically and horizontally. It is shown on the maps through isobars which are the imaginary lines joining the places having equal air pressure. In high latitudes, atmospheric pressure is more than the pressure at low latitudes. The zonal character of horizontal pressure is commonly known as pressure belts. There are four pressure belts spread over the earth. They are equatorial low pressure belt, sub-tropical high pressure belts, sub-polar low pressure belts and the polar highs. Thermal factor causes difference in pressure. Pressure belts are not fixed, they shift northwards in summer and southwards in winter with the apparent movement of the sun. Pressure gradient is the difference in horizontal pressure between regions of high pressure and region of low pressure. The difference in air pressure causes movement of air called wind. There are wind systems that blow regularly on a daily pattern. Examples include the land and sea breezes, the mountain and valley breezes and winds warmed as a result of compression. There is a close relationship between pressure gradient and wind speed. Due to Coriolis force, winds deflect from their original course. In Northern Hemisphere they deflect towards their right and in Southern Hemisphere towards their left. This is known as the Ferrel’s law. Winds are grouped under planetary, Periodic and local winds. Planetary winds blow in the same direction throughout the year, while the other types of winds get modified due to certain reasons. Monsoon are seasonal winds while local winds below generally on diurnal basis. Air masses are horizontal large bodies of air which have uniform temperatures and moisture contents. The boundary line between two different air masses is called a front. Air masses and front cause temperate cyclones in mid-latitudes. Another type of cyclones are tropical cyclones which originate on tropical oceans and influence the coastal areas. Sometimes they turn violent and cause heavy loss to life and property.

TERMINAL QUESTIONS

1. Answer the following questions in about 30 words each.
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(a) What is an atmospheric pressure?
(b) How is atmospheric pressure measured?
(c) What are the following?
   (i) Millibars
   (ii) Isobars.
(d) What is the effect of altitude on air pressure?

2. Distinguish between the following in 50 words each:
(a) Air current and wind.
(b) Planetary winds and periodic winds.
(c) Foehn and Mistral.
(d) Katabatic and Anabatic Breezes.

3. Give reasons for the following in 100 words:
(a) Low pressure is prevalent in sub-polar regions
(b) Sea breezes blow during day time.
(c) Winds change their direction in both the hemisphere.

4. Define the following:
(a) Air mass (b) front

5. What are temperate cyclones? How do they differ from tropical cyclones?

6. What is the role of coriolis force in the deflection of winds?

7. Explain the following terms:
(a) Horse latitudes (b) Doldrums

8. On an outline map of the world mark and label the following.
(a) Prominent areas of low pressure in January.
(b) Prominent areas of high pressure in July in Northern Hemisphere

ANSWER TO INTEXT QUESTIONS

11.1

1. (a) Air temperature (b) The earth’s rotation (c) Presence of water vapour
2. (a) Fortin’s barometer (b) Aneriod barometer
3. 1013.25 Millibar
4. (a) 76 cm (b) low pressure (c) Higher pressure
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11.2
1. (a) thermal equator (b) altitude
   (c) the air pressure (d) pressure/density
2. (a) (i), (b) (ii), (c) (ii), (d) (iv).

11.3
1. (a) Trade winds (b) Westerlies
   (c) Polar easterlies
2. Winds or moving bodies turn towards their right in the northern hemisphere and towards their left in the Southern hemisphere. It is known as Ferrule’s law.
3. (a) (i), (b) (i), (c) (ii), (d) (iii)

11.4
1. (a) (iv) (b) (i)
2. On the leeward side of the Alps Mountains.
3. Chinook
4. (a) Hot, (b) cold, (c) Hot

11.5
1. A large body of air which has uniform temperature and moisture contents is called air mass.
2. Tropical and polar
3. Mid latitudes

HINTS TO TERMINAL QUESTIONS
1. (a) The weight of the air column at a place at a given time.
   (b) Air pressure is measured by an instrument called barometer.
      (i) The unit used for measuring air pressure. It is approximately equal to the force of one gram per square centimeter.
      (ii) Isobars are lines connecting points that have equal values Pressure.
   (d) Pressure decreases with increase in attitude.
2. (a) please refer to para 11.5
   (b) please refer to para 11.6 (a) and (b)
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(c) please refer to para 11.6 (c) (iii) (2) and (iv) (1)
(d) please refer to para 11.6 (c) (ii)

3. (a) please refer to para 11.3 (iii)
   (b) please refer to para 11.6 (c) (i)
   (c) please refer to para 11.5 (ii)

4. (a) Air mass: a large body of air having uniformity of temperature, pressure and moisture.
   (b) Front: the boundary line of convergence separating two different air masses.

5. Please refer to para 11.7 (2) (a) and (b)

6. Please refer to para 11.5 (ii)

7. (a) Horse latitudes is the region of sub-tropical high pressure belts of Northern hemisphere.
   (b) Doldrums are the regions of calm in equatorial areas where winds are negligible and ascending air current are prominent.

8. Please see maps 11.3 and 11.4
HUMIDITY AND PRECIPITATION

In our previous lesson while discussing the composition of the atmosphere, we noted that water vapour, though a minor component, is a very important constituent of the atmosphere. In this lesson, we will study the role of water vapour in producing day to day weather changes.

OBJECTIVES

After studying this lesson, you will be able to:

• distinguish between absolute and relative humidity;
• establish relationship between temperature (absolute and relative humidity);
• infer conditions in which the relative humidity of a given sample of air increases or decreases;
• distinguish between saturated and unsaturated air;
• identify the factors affecting the rate of evaporation;
• explain the latent heat and its importance;
• describe the various forms of condensation;
• explain conditions conducive to precipitation;
• distinguish among the three types of precipitation (rainfall) with the help of diagrams;
• describe the salient features of distribution of precipitation in the world with reference to regional and seasonal variations;
• identify factors affecting rainfall distribution.
Humidity and Precipitation

12.1 WATER VAPOUR IN THE ATMOSPHERE

Water vapour is a highly variable component of the atmosphere. Its proportion varies from zero to four percent by volume of the atmosphere. Water can exist in the air in all the three states of matter i.e. solid (ice-crystals), liquid (droplets of water) and gaseous (water vapour). Most commonly water exists in air as tasteless, colourless, transparent gas known as water vapour. The presence of water in the atmosphere has made life possible on the earth. Let us examine its significance for life on the earth.

(i) We have noted in the lesson 10, that water vapour in the atmosphere absorbs a significant portion of both incoming solar energy and outgoing earth radiation. In this way, it prevents great losses of heat from the earth’s surface and helps to maintain suitable temperatures on the earth.

(ii) The amount of water vapour present in the air affects the “rate of evaporation.

(iii) The amount of water vapour present in a volume of air decides the quality of latent heat or energy stored in it for producing atmospheric changes;

(iv) The amount of water vapour present in the air of a place or in a region indicates the potential capacity of that air for precipitation.

(v) The amount of water vapour present in the air also affects standing crops favourably. On the other hand hot dry winds damage standing crops as in the case of rabi crops of North-Western India.

(vi) Air, poor in water vapour content, makes our body skin dry and rough. It is because of this fact that we use cream to protect our faces from dry air of cold winters or hot summers.

- The water vapour present in the atmosphere absorbs radiation, controls the rate of evaporation, releases latent heat for weather changes, decides the potentiality for precipitation, affects standing crops and our body skin, hence is of great significance.

12.2 HUMIDITY

How does water changes into water vapour? The heat energy radiated from the sun changes water into water vapour. This invisible water vapour present in gaseous form in the atmosphere at any time and place is termed as humidity. In other words, we can say that the term humidity refers to the amount of water vapour present in a given air. It indicates the degree of dampness or wetness of the air. Humidity of the air is mainly expressed in the following two ways:
Humidity and Precipitation

(i) Absolute humidity

Absolute humidity is the ratio of the mass of water vapour actually in the air to a unit mass of air, including the water vapour. It is expressed in gram per cubic metre of air. For example, if the absolute humidity of air is 10 grams it means that one cubic metre of that air holds 10 grams of moisture in the form of water vapour. Absolute humidity is variable and changes from place to place and with change in time.

The ability of an air to hold water vapour depends entirely on its temperature. The capacity of holding water vapour of an air increases with the increase in its temperature. For example, at 10°C, one cubic metre of an air can hold 11.4 grams of water vapour. If the temperature of the same air increases to 21°C, the same volume of air can hold 22.2 grams of water vapour. The Figure 12.1 shows the relationship between temperature and the maximum amount of water vapour that an air can hold at a given temperature. A cursory glance at this figure indicates how the water holding capacity of the air increases with increase in temperature. Change in temperature and pressure conditions of an air results in the change of its volume and consequently there is change in its absolute humidity. Hence, there is a need of some more reliable measure of humidity.

Fig 12.1 Maximum Absolute Humidity for a Wide Range of Temperature

(ii) Relative Humidity

Relative humidity is the most important and reliable measure of atmospheric moisture. It is the ratio of the amount of water vapor actually in a volume occupied by air to the amount the space could contain at saturation.
Relative humidity = \frac{\text{Vapour pressure in the air}}{\text{Saturation vapour pressure}}.

From Figure 12.1, it is quite clear that air can hold a definite maximum quantity of water vapour at a given temperature. When this situation is attained, we say the air is fully saturated. The temperature at which a given sample of air becomes fully saturated is called the dew point or saturation point. The relative humidity of an air at saturation point is hundred percent. Since the concept of relative humidity is very important in understanding this lesson let us illustrate it with the help of an example. It is clear in Fig 12.1 that an air can hold 22.2 grams of water vapour at 21°C temperature. If this air is holding 11.1 grams of water vapour at the same temperature i.e. 21°C, the relative humidity of the air will be 11.1/22.2x100 or 50 percent. And, if the same air is actually holding 22.2 grams of water vapour at 21°C, the relative humidity of air will be 22.2/22.2x100 or 100 percent. The air become saturated when its relative humidity is cent percent. If the relative humidity of air is less than 100 percent, the air is said to be unsaturated.

The relative humidity increases when the temperature of the air goes down or when more moist air is added to it. The relative humidity decreases when the temperature of the air increases or when less moist air is added to it.

In order to make it clear that relative humidity is a better measurement of water vapour in atmosphere than absolute humidity, yet another example can be cited. Suppose, there is a tumbler containing 250 grams of water, one cannot tell how much portion of the tumbler is filled with water till one knows its maximum water containing capacity. When one comes to know that the tumbler can contain maximum of 500 grams of water, one can immediately tell that the tumbler is half filled with water. Likewise, when one measures relative humidity of an air, one not only needs to know about its actual water vapour content but also its total capacity to contain water vapour at that temperature. So, now you can understand why relative humidity is more useful in making predictions about atmospheric conditions.

- Absolute humidity is the actual amount of water vapour present in grams per cubic metres of a given air.
- Relative humidity is the ratio of actual water vapour content to the maximum moisture holding capacity of an air at a given temperature and it is expressed in percentage (RH.=A.H/Max. capacity X 100)
- The temperature at which a given sample of air becomes fully saturated is called dew point or saturation point.
1. Name the three forms in which water can exist in the atmosphere.
   (a) _______________  (b) _______________  and (c) _______________

2. Give a geographical term for each of the following:
   (a) The amount of water vapour present in the atmosphere.
   _____________________________________________________
   (b) The weight of actual water vapour present per volume of air.
   _____________________________________________________
   (c) The ratio of the amount of the water vapour actually is a volume occupied by air to the amount the space could contain of saturation.
   _____________________________________________________
   (d) The air that contains moisture to its full capacity is called
   _____________________________________________________
   (e) The temperature at which a sample of air becomes saturated.
   _____________________________________________________

12.3 EVAPORATION

Evaporation is the process of which water changes from its liquid state to gaseous form. This process takes place at all places, at all times and at all temperatures except at dew point or when the air is saturated. The rate of evaporation is affected by several factors. Important among them are as under:

(i) **Accessibility of water bodies**

The rate of evaporation is higher over the oceans than on the continents.

(ii) **Temperature**

We know that hot air holds more moisture than cold air. So, when the temperature of an air is high, it is capable of holding more moisture in its body than at a low temperature. It is because of this that the rate of evaporation is more in summers than in winters. That is why wet clothes dry faster in summers than in winters.

(iii) **Air moisture**

If the relative humidity of a sample of air is high, it is capable of holding
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less moisture. On the other hand if the relative humidity is less, it can take more moisture. Hence, the rate of evaporation will be high. Aridity or dryness of the air also increases the rate of evaporation. During rainy days, wet clothes take more time to dry owing to the high percentage of moisture content in the air, than on dry days.

(iv) Wind

Wind also affects the rate of evaporation. If there is no wind, the air which overlies a water surface will get saturated through evaporation. This evaporation will cease once saturation point is reached. However, if there is wind, it will blow that saturated or nearly saturated air away from the evaporating surface and replace it with air of lower humidity. This allows evaporation to continue as long as the wind keep blowing saturated air away and bring drier air.

(v) Cloud cover

The cloud cover prevents solar radiation and thus influences the air temperatures at a place. This way, it indirectly controls the process of evaporation.

It is interesting to note that about 600 calories of heat is used for converting each gram of water into water vapour. A calorie is unit of heat energy spent in raising temperature of one gram of water by 10°C. The heat energy used for changing the state of water or a body from liquid to gaseous state or from solid (ice) to liquid (water) state without changing its temperature is called latent heat. It is a sort of hidden heat. The effect of which is not seen on the thermometer. The latent heat consumed in changing water into gaseous form is released when water vapour changes into water or ice. The release of latent heat in the air is an important source of energy for causing changes in weather.

A special case of evaporation is transpiration, which entails a loss of water from leaf and stem tissues of growing vegetation. The combined losses of moisture by evaporation and transpiration from a given areas are termed evapo-transpiration.

- The evaporation is the process of changing water into water vapour.
- The rate of evaporation is affected by the accessibility of water, temperature, aridity of air, wind and cloud cover.
- The heat energy used for changing the state of water, or a body from liquid to gaseous state or from solid to liquid state without changing its temperature is called latent heat.

12.4 CONDENSATION

Condensation is the process by which atmospheric water vapour changes
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into water or ice crystals. It is just reverse of the process of evaporation. When the temperature of saturated air falls below dew point, the air cannot hold the amount of humidity which it was holding earlier at a higher temperature. This extra amount of humidity changes into water droplets or crystals of ice depending upon the temperature at which condensation takes place.

(a) **Process of condensation**

The temperature of the air falls in two ways. Firstly, cooling occurs around very small particles of freely floating air when it comes in contact with some colder object. Secondly, loss in air temperature takes place on a massive scale due to rising of air to higher altitudes. The condensation takes place around the smoke, salt and dust particles which attract water vapour to condense around them. They are called hygroscopic nuclei. When the relative humidity of an air is high, a slight cooling is required to bring the temperature down below dew point. But when the relative humidity is low and the temperature of the air is high, a lot of cooling of the air will be necessary to bring the temperature down below dew point. Thus, condensation is directly related to the relative humidity and the rate of cooling.

- Condensation is a process of changing water vapour into tiny droplets of water or ice crystals.
- Condensation takes place when temperature of air falls below dew point and is controlled by relative humidity of the air and rate of cooling.

(b) **Forms of condensation**

Condensation takes place in two situations, firstly, when dew point is below freezing point or below 0° C and secondly, when it is above freezing point. In this way, the forms of condensation may be classified into two groups:

(i) Frost, snow and some clouds are formed when dew point is below freezing point.

(ii) Dew, mist, fog, smog and some clouds are formed when dew point is above freezing point.

The forms of condensation may also be classified on the basis of place where it is occurring, for example, on the ground or natural objects such as grass blades and leaves of the plants or trees, in the air close to the earth’s surface or at some height in the troposphere.

(i) **Dew:** When the atmospheric moisture is condensed and deposited in the form of water droplets on cooler surface of solid objects such as grass
The domain of Air on the Earth

Humidity and Precipitation

blades, leaves of plants and trees and stones, it is termed as dew. Condensation in dew form occurs when there is clear sky, little or no wind, high relative humidity and cold long nights. These conditions lead to greater terrestrial radiation and the solid objects become cold enough to bring the temperature of air down below dew point. In this process the extra moisture of the air gets deposited on these objects. Dew is formed when dew point is above freezing point. Dew formation can be seen if the water is poured into a glass from the bottle kept in a refrigerator. The outer cold surface of the glass brings the temperature of the air in contact with the surface down below dew point and extra moisture gets deposited on the outer wall of the glass.

(ii) **Frost:** When the dew point is below freezing point, under above mentioned conditions, the condensation of extra moisture takes place in the form of very minute particles of ice crystals. It is called frost. In this process, the air moisture condenses directly in the form of tiny crystal of ice. This form of condensation is disastrous for standing crops such as potato, peas, pulses, grams, etc. It also creates problems for road transport system.

(iii) **Mist and Fog:** When condensation takes place in the air near the earth’s surface in the form of tiny droplets of water hanging and floating in the air, it is called mist. In mist the visibility is more than one kilometer and less than two kilometers. But when the visibility is reduced to less than one kilometer, it is called fog. Ideal conditions for the formation of mist and fog are clear sky, calm and cold winter nights.

(iv) **Smog:** Smog is a fog that has been polluted and discoloured by smoke, dust, carbon monoxide, sulphur dioxide and other fumes. Smog frequently occurs in large cities and industrial centres. It causes respiratory illness.

(v) **Cloud:** Clouds are visible aggregates of water droplets, ice particles, or a mixture of both along with varying amounts of dust particles. A typical cloud contains billions of droplets having diameters on the order 0.01 to 0.02 mm; yet liquid or solid water accounts for less than 10 parts per million of the cloud volume. Clouds are generally classified on the basis of their general form or appearance and altitude. Combining both these characteristics, clouds may be grouped as under.

**Low clouds:** The base level of low clouds varies from very near the ground to about 2000m. The basic type of this family is the status, a low, uniform layer resembling fog but not resting on the ground.

Stratocumulus clouds form a low, gray layer composed of globular masses or rolls which are usually arranged in groups, lines, or waves.

Clouds with vertical development fall into two principal. **Categories:** cumulus and cumulonimbus. Cumulus clouds are dense, dome-shaped and have flat bases. They may grow to become cumulonimbus, the extent of vertical development depending upon the force of vertical currents below the clouds as well as upon the amount of latent heat of condensation liberated in the clouds as
Humidity and Precipitation

To an observer directly beneath, a cumulonimbus cloud may cover the whole sky and have the appearance of Nimbostratus. The word nimbus (or prefix nimbo) applies to a cloud from which rain is falling. It derives from the Latin for “violent rain”.

**Medium clouds:** These clouds are formed at altitudes between 2000 to 6000 metres. This group of clouds include altocumulus and altostratus.

**High clouds:** These clouds are formed above the altitude of 6000 metres and include cirrus, cirrostratus and cirrocumulus (see fig. 12.2).

Fig. 12.2 : Cloud types are grouped into families according to height and form

- Forms of condensation include dew, frost, mist, fog, smog and clouds.
- Frost and some clouds are formed when condensation takes place below freezing point.
- Clouds are grouped into three types on the basis of appearance and altitude.

**INTEXT QUESTIONS 12.2**

(1) List five factors which affect the rate of evaporation.
12.5 PRECIPITATION

Precipitation is defined as water in liquid or solid forms falling to the earth. It happens when continuous condensation in the body of air helps the water droplets or ice crystals to grow in size and weight that the air cannot hold them and as a result these starts falling on the ground under the force of gravity.

Forms of precipitation

The precipitation falls on the earth in various forms of droplets of water, ice flakes and solid ice balls or hail and at times droplets of water and hail together. The form that precipitation takes is largely dependent upon the method of formation and temperature during the formation. The forms of precipitation are as follows:

(i) Drizzle and Rainfall: Drizzle is a fairly uniform precipitation composed exclusively of fine drops of water with diameter less than 0.5 mm. Only when droplets of this size are widely spaced are called rain.
Humidity and Precipitation

(ii) **Snowfall**: When condensation takes place below freezing point (-0°C), the water vapour changes into tiny ice crystals. These tiny ice crystals grow in size and form ice flakes which become big and heavy and start falling on the ground. This form of precipitation is called snowfall. Snowfall is very common in Western Himalaya and mid and high latitude regions in winter.

(iii) **Sleet**: Sleet is frozen rain, formed when rain before falling on the earth, passes through a cold layer of air and freezes. The result is the creation of solid particles of clear ice. It’s usually a combination of small ice balls and rime.

(iv) **Hail**: Hail is precipitation of small balls or pieces of ice (hail stones) with diameters ranging from 5 to 50mm, falling either separately or agglomerated into irregular lumps. Hailstones are comprised of a series of alternating layers of transparent and translucent ice.

- Falling down of atmospheric moisture on the earth’s surface is called precipitation.
- The precipitation in the form of tiny droplets of water and bigger water droplets are known as drizzle and rainfall respectively.
- When the precipitation is in the form of big ice balls, it is called Snow fall.

12.6 **TYPES OF RAINFALL**

We know, when a mass of moist air ascends to high altitudes it cools down to lower temperatures. In doing so it attains dew point which leads to condensation and precipitation. Thus the cooling of air occurs mainly when it rises. There are three important ways in which a mass of air can be forced to rise and each of these ways produces its own characteristic precipitation or rainfall.

(a) **Convectional Rainfall**

Excessive heating of the earth’s surface in tropical region results in the vertical air currents. These currents, lift the warm moist air to higher strata of atmosphere. When-the temperature of such a humid air starts falling below dew point continuously, clouds are formed. These clouds cause heavy rainfall which is associated with lightning and thunder. This type of rainfall is called conventional rainfall. It is very common in equatorial region where it is a daily phenomenon in the afternoon (see fig. 12.3)
(b) Orographic or Relief Rainfall

Orographic rainfall on formed where air rises and cools because of a topographic barrier. When their temperature fall below dew point, clouds are formed. These clouds cause widespread rain on the windward slopes of the mountain range. This type of rain is called orographic rainfall. However when these winds cross over the mountain range and descend along the leeward slopes, they get warm and cause little rain. Region lying on the leeward side of the mountain receiving little rain is called rainshadow area (see figure 12.4). A famous example of orographic rainfall is Cherrapunji on the southern margin of the Khasi Hills in Meghalaya India.
Humidity and Precipitation

(c) Convergence or Cyclonic Rainfall

Convergence rainfall, produced where air currents converge and rise. In tropical regions where opposing air currents have comparable temperatures, the lifting is more or less vertical and is usually accompanied by convection. Convectional activity frequently occurs along fronts where the temperature of the air masses concerned are quite different. Mixing of air along the front also probably contributes to condensation and therefore to the frontal rainfall. When two large air masses of different densities and temperature meet, the warmer moist air mass is lifted above the colder one. When this happens, the rising warm air mass condenses to form clouds which cause extensive down pour. This rainfall is associated with thunder and lightning. This type of rainfall is also called frontal rainfall. This type of rainfall is associated with both warm and cold fronts, (fig. 12.5) It is generally steady and may persist for a whole day or even longer.

(a) Rainfall Associated with a warm Front

(b) Rainfall Associated with a Cold Front

In all these types, the cooling of large masses of humid air is essential to produce rainfall. In conventional rainfall, after rising of air, the subsequent processes are similar, to those of relief rainfall.

In nature, these three methods work together and infact most of the
earth’s precipitation or rainfall is the result of two or more causes of lifting of air rather than of anyone.

- On the mode of occurrence, the rainfall is classified into conventional, orographic and convergence.

### INTEXT QUESTIONS 12.3

1. List the various forms of precipitation.

2. Name three types of rainfall.
   - (a) __________________ (b) __________________ (c) __________________

3. Give one term for each of the following:
   - (a) Throwing down of atmospheric moisture on the earth’s surface
   - (b) Frozen raindrops and melted snow falling on the earth’s surface
   - (c) The plane of contact between two air masses of varying characteristics
   - (d) Precipitation in the form of ice balls
   - (e) Rainfall caused by uplift of the air due to excessive heating

4. Below are given true and false statements. Mark ‘T’ if the statement is true and ‘F’ if it is false:
   - (a) Precipitation is the process of converting water vapour into liquid or solid state __________________
   - (b) Precipitation in the form of ice flakes is called snowfall ______
   - (c) Area lying on the leeward side of a mountain range receive scanty rainfall __________________
   - (d) Orographic rainfall is caused by ascend of warm moist air due to excessive heating __________________

### 12.7 DISTRIBUTION OF PRECIPITATION

The spatial distribution of precipitation is not uniform all over the world. The average annual precipitation for the world as a whole is about 97.5 centimeters but the land receives lesser amount or rainfall than the oceans. The annual precipitation shows marked difference on the land. Different places of the earth’s surface receive different amount of annual precipitation and that too in different seasons.

The main features of the distribution of precipitation can be explained with
Humidity and Precipitation

the help of global pressure and wind belts, distribution of land and water bodies and the nature of relief features. Before arriving at any conclusion regarding the causes for regional and seasonal variation, let us first see regional and seasonal distribution patterns of precipitation.

(a) Regional Variations
On the basis of average amount of annual precipitation. We can recognize the following precipitation regions in the world. (see fig. 12.6)

(i) Regions of Heavy Precipitation: The regions which receive over 200 centimeters of annual precipitation are included in this category. These regions include equatorial coastal areas of tropical zone and west-coastal regions of temperate zone.

(ii) Regions of Moderate Precipitation: The regions which receive 100 to 200 centimeters of annual precipitation are included in this category. These regions lie adjacent to the regions of heavy precipitation. Eastern coastal regions of subtropical zone and coastal regions of the warm temperate zone are included in this category.

(iii) Regions of Less Precipitation: This category includes regions which receive precipitation between 50 to 100 centimeters. These regions lie in the interior parts of tropical zone and eastern interior parts of temperate zone.

(iv) Regions of Scanty Precipitation: The areas lying in the rain shadows (leeward) side of the mountain ranges, the interior parts of continents, the western margins of continents along tropics and high latitudes receive precipitation less than 50 centimeters. These regions include tropical, temperate and cold deserts of the world.

Fig. 12.6 Distribution of Mean Precipitation in the world
Now let us carefully study the map showing the annual average precipitation distribution of the world (fig. 12.6) in order to come to the following conclusions.

1. Precipitation is greatest in the equatorial region and decreases towards the poles.
2. Precipitation is heaviest in the coastal regions and decreases towards the interior of the continents.
3. Eastern coastal areas of tropical lands and western coastal areas of temperate lands receive heavy precipitation including equatorial regions.
4. Precipitation is very heavy on the windward side of highlands; very dry condition prevail on the leeward side.
5. Coastal areas adjacent to cold currents are drier than coastal areas near warm currents.
6. The western margin of tropical land and polar region receive scanty rainfall. The main reason being that easterlies become dry winds and polar winds are cold and dry.

(b) Seasonal Variations

The regional variations in the distribution of precipitation in different parts of the world are based on average annual precipitation which do not give us any correct picture of the nature of precipitation specially of those regions where seasonal fluctuations in the amount of precipitation are very common, for example arid, semi arid or sub-humid regions. Therefore, it is important to study seasonal variations of precipitation in the world. The facts related to this are as follows:

(i) The equatorial regions and the western parts of temperate lands receive precipitation throughout the year. The former receive conventional type of rain while the later gets cyclonic cum orographic type through westerlies.

(ii) About 2 per cent land areas of the world receive precipitation only in winter. These include Mediterranean regions of the world and Coromandel Coast of India. Due to the seasonal shift in pressure and planetary wind systems, these regions (Mediterranean) do not get precipitation in summer as they come under sub-tropical high pressure belts and trade winds which become dry while reaching to the western margins of continents.

(iii) The remaining parts of the world receive precipitation only in summer. It makes us clear that most parts of the world experience marked seasonal variation in precipitation. Seasonal distribution of precipitation
Humidity and Precipitation

provides us idea to judge its effectiveness. For example, the scanty precipitation during short growing season in high latitudes is more effective than that of heavy precipitation in lower latitudes. Likewise, precipitation in the form of dew, fog and mist in some parts like Central India and Kalahari desert has an appreciable affect on standing crops and natural vegetation.

(c) Factors Affecting Rainfall Distribution

(i) Moisture supply to the atmosphere is the main factor in determining the amount of rainfall in any region. Equatorial and rest of the tropical region have highest evaporation and hence highest supply of moisture. Coastal areas have more moisture than interior parts of continents. Frigid regions have very low evaporation hence very scanty precipitation.

(ii) Wind direction in the belts of trades and westerlies winds is very important. Winds blowing from sea to land cause rainfall. Land bearing winds are dry. Winds blowing from higher to lower latitudes will get heated and give no rain while those blowing from lower to higher latitudes will get cooled and cause rainfall. Sub-tropical deserts have very little rainfall because they have off-shore winds.

(iii) Ocean currents: Warm current are associated with warm moist winds which cause rainfall, cold current have cold dry wind and hence no rainfall.

(iv) Presence of mountain across the direction of wind causes more rainfall on the windward side and creates rain shadow on the leeward side.

(v) Pressure belts are closely related with wind direction and rainfall. Areas of low pressure attract rain bearing winds while areas of high pressure do not.

- The distribution of precipitation in different parts of the world shows marked regional and seasonal variation.
- Factors affecting rainfall distribution are: moisture supply, wind direction, ocean currents, presence of mountains and pressure belts.

INTEXT QUESTIONS 12.4

1. Name any two regions of heavy precipitation.

2. Name any two regions of scanty precipitation.

GEOGRAPHY
3. Name the regions where precipitation is heavy throughout the year.

_______________________________________________________

4. Name the regions which receive precipitation only in winters.

_______________________________________________________

5. Name five factors affecting rainfall distribution in the world.

(a)__________(b)_______________(c)_____________(d)__________

**WHAT YOU HAVE LEARNT**

Water vapour is highly variable. It is an important component of atmosphere. It is responsible for global heat balance, atmospheric phenomena and sustaining plant and animal life on our planet. The water vapour present in the atmosphere is called humidity, which is expressed as absolute humidity and relative humidity. Of these, the relative humidity is most reliable measure. Water vapour enters into atmosphere through a process called evaporation. Temperature of the air controls the amount of moisture it can hold at a given volume. The air which holds the moisture to its full capacity is called saturated air and the temperature at which it reaches saturation point is termed as dew point. Condensation is a process of changing of water vapour into liquid or solid state. It happens when temperature of an air falls below dew point. Condensation occurs near the ground as dew, mist, or fog and at higher levels of clouds.

Falling down of atmospheric moisture is called precipitation which occurs due to continuous condensation. Drizzle, rainfall, snowfall, sleet and hail are various forms of precipitation. The rainfall occurs in three different ways conventional, orographic and cyclonic.

The distribution of precipitation in the world shows marked regional and seasonal variation. Some regions receive heavy rainfall while others scanty precipitation. Some regions receive precipitation throughout the year while others only in the winter or summer. Several factors affect rainfall distribution.

**TERMINAL QUESTIONS**

1. Explain the importance of water vapour present in the atmosphere.

2. What is evaporation? Discuss the factors which affect the rate of evaporation. Give examples in support of your answer.
Humidity and Precipitation

3. Explain the process and forms of condensation.

4. How does precipitation occur? Discuss the various forms of precipitation.

5. Differentiate between:
   (a) Evaporation and condensation;
   (b) Absolute humidity and relative humidity;
   (c) Saturated air and unsaturated air;
   (d) Rainfall and precipitation;
   (e) Sleet and hail;
   (f) Conventional and orographic rainfall.

6. Discuss in detail the regional and seasonal distribution of precipitation in the world.

7. Give reasons for each of the following:
   (a) Equatorial regions receive precipitation throughout the year.
   (b) Mediterranean regions receive rainfall only in winter.
   (c) Amount of precipitation decreases from coastal areas to interior, parts of continents.
   (d) Tropical deserts are found on the western parts of continent.
   (e) Evaporation decreases towards poles.

8. On the given outline map of the world, show the following with appropriate symbols:
   (a) Two areas getting precipitation above 200 cms.
   (b) Two areas of scanty precipitation in lower latitudes.
   (c) Two regions getting precipitation only in winter.
   (d) Cold deserts of the world.

ANSWER TO INTTEXT QUESTIONS

12.1

1. (a) Liquid (b) Solid (c) Gaseous

2. (a) humidity (b) absolute humidity (c) relative humidity (d) saturated air (e) dew point
12.2

1. (a) Temperature (b) air moisture (c) winds (d) cloud cover (e) accessibility of water bodies
2. (a) dew (b) frost
3. (a) mist (b) fog
4. (a) evaporation (b) condensation (c) cloud (d) cumulus (e) cumulonimbus.

12.3

1. Drizzle, rainfall, sleet and hail
2. (a) Conventional (b) Orographic (c) Cyclonic
3. (a) Precipitation (b) Sleet (c) Front (d) Hail (e) Conventional rainfall
4. (a) F (b) T (c) T (d) F

12.4

1. Equatorial, eastern sub-tropical and western coastal temperate regions.
2. Western margins along tropics and interior parts of continents in temperate zone and polar region.
3. Equatorial regions
4. Mediterranean regions
5. (a) Moisture supply (b) wind direction (c) ocean currents (d) presence of mountains (e) pressure belts

HINTS TO TERMINAL QUESTIONS

1. Please refer to section 12.1
2. Please refer to section 12.3
3. Please refer to section 12.4
4. Please refer to section 12.5
5. See under the respective headings.
6. Please refer to section 12.7
7. (a) Due to the uniform high temperature throughout the year in the equatorial region, there is much evaporation, conventional air currents are set up, followed by heavy rainfall of conventional type.
Humidity and Precipitation

(b) In summer the sun is overhead at the Tropic of Cancer, the belt of influence of the westerlies is shifted a little poleward. The Mediterranean Region falls under the sub-tropical high pressure belt and trade winds. Trade winds become dry before reaching the western margin of continents. Hence no rainfall in summer. But during winter, the Mediterranean region comes under the influence of westerlies due to their shift towards south. Thus the region gets rainfall in winter only.

(c) Precipitation decreases from coastal areas to interior parts because rain bearing winds lose their moisture as they go interior.

(d) The aridity of the tropical deserts located in the western part of continents is mainly due to the effects of off shore Trade winds.

(e) Evaporation decreases towards poles due to low temperatures.

(f) Please see maps.
WEATHER AND CLIMATE

In the preceding three lessons, we have discussed about the temperature, atmospheric pressure, winds and precipitation. These elements of weather have an important effect on our lives. For example the houses we construct, the clothes we wear and the food we prefer mainly depend on weather and climatic conditions. In this lesson, we will study about the difference among weather, season and climate and also the factors affecting climate of a place.

OBJECTIVES

After studying this lesson you will be able to:

• name the various elements of weather and climate;
• differentiate among weather, season and climate;
• explain the need for forecasting weather in advance;
• explain with specific example the various factors affecting the climate of a place or region;
• describe the important characteristics of each thermal zone with the help of a diagram;
• state Koeppen’s classification of climate.

13.1 WEATHER AND CLIMATE

(i) Weather

Temperature, pressure, wind, humidity and precipitation, interact with each other. They influence the atmospheric conditions like the direction and velocity of wind, amount of insolation, cloud-cover and the amount of precipitation. These are known as the elements of both weather and climate. The influence of these elements differs from place to place.
and time to time. It may be restricted to a small area and for a short
duration of time. We very often describe this influence in the name of
weather as sunny, hot, warm, cold, fine, etc depending upon the
dominant element of weather at a place and at a point of time. Therefore,
weather is the atmospheric condition of a place for a short duration
with respect to its one or more elements. Two places even a short
distance apart may have different kind of weather at one and the same
time.

(ii) Weather Forecast

It is important to know by some means the coming weather in advance.
You may be planning to go on a hike without knowing that the particular
day may be rainy. Farmers, sailors, aviators, tourists and many others
are interested to know the weather conditions in advance for their own
benefits. That is why newspapers publish weather reports and weather
forecasts along with a map showing this information. Now, better
weather forecasts are available with the use of weather satellites.
Weather conditions are televised every day. When a cyclone or
dangerous weather is expected, warnings are issued over the radio,
television and newspapers so that people can prepare to save themselves
and their property from its hazard.

The weather office collects data on temperature, wind, cloud cover,
rainfall and other atmospheric phenomena through its numerous
observation centres. These centres are scattered all over the country.
Similar information is also received from the ships sailing in the high
seas. The analysis of these data thus collected, helps in forecasting
weather conditions for the next 48 hours or even for a week. The
significance of a weather information supplied through a map and its
forecast is better utilised in a country like the U.K. where weather
changes are very rapid.

(iii) Season

You know that a year is divided into seasons depending upon variations
in atmospheric conditions. They are specified periods in a year which
have similar weather conditions. Season is a period of the year
characterized by a particular set of weather conditions resulting from
the inclination of the earth’s axis and the revolution of the earth round
the sun. The same cycle of season is repeated year after year. Four
seasons, each of three months duration have been recognized in
temperate regions. They are spring, summer, autumn and winter. In
our country, we have three distinct seasons which are summer, winter
and rainy. The Indian Meteorological Department has recognized four
main seasons. They are (1) cold weather season (December to
February.) (2) hot weather seasons (March to May) (3) advancing
monsoon season or rainy season (June to September.) and, (4) retreating monsoon season (October to November.)

Traditionally there are six seasons in north India. They are (1) Basant Ritu (Chaitra- Vaisakh or March-April), (2) Greeshm Ritu (Jaystha-Asharh or May-June), (3) Varsha Ritu (Shravan-Bhadrapad or July-Aug.), (4) Sharad Ritu (Aswina-Kartika or Sept - Oct.), (5) Hemant Ritu (Margashirsh-Posh or Nov-Dec.) and (6) Shishir Ritu (Magh-Falgun or Jan-Feb.)

The rays of the sun are more or less direct on the equator throughout the year. Hence, equatorial regions experience the same temperature all the year round. Therefore, seasons are insignificant on or near the equator. Near the coast, the oceanic influence reduces the seasonal variations. In the polar regions, there are only two seasons i.e. long winter and short summer.

(iv) Climate

The average weather conditions, prevalent from one season to another in the course of a year, over a large area is known as climate. The average of these weather conditions is calculated from the data collected for several year (about 35 years) for a larger area. Rajasthan, for example, experiences hot and arid climate, Kerala has tropical rainy climate, Greenland has cold desert climate and the climate of Central Asia is temperate continental. Climate of a region is considered more or less permanent.

- Weather is the atmospheric condition of any place for a short period of time with respect to its one or more elements such as temperature, pressure, wind, humidity, precipitation, sunshine, cloud cover etc.
- The periods of the year which are characterised by particular set of weather conditions are mainly caused by the inclination of the earth’s axis and the revolution of the earth around the sun, are known as seasons.
- The average weather conditions of a large area for the past several years is known as its climate persisting more or less permanent.

The difference between weather and climate can be tabulated as under

<table>
<thead>
<tr>
<th>Weather</th>
<th>Climate</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Weather is the study of atmospheric conditions for short duration of a limited area.</td>
<td>(1) Climate is the study of the average weather conditions observed over a long period of time for a larger area.</td>
</tr>
</tbody>
</table>
Weather and Climate

(2) Weather is influenced by anyone of its predominant elements i.e., temperature or humidity.
(3) The weather changes very often
(4) It is experienced over small areas of a country.
(5) A place can experience different types of weather conditions in a year.

(2) Climate is the collective effect of all its elements.
(3) It is more or less permanent.
(4) It is experienced over large area of the continent.
(5) A place can experience only one type of climate.

INTEXT QUESTIONS 13.1
Fill in the blanks by the most appropriate word from those given within brackets against each of the following:

1. Weather depends upon predominance of__________ of its elements
   {(a) one, (b) two, (c) three (d) one or more}
2. The season is________in equatorial region {(a) predominants, (b) good, (c) insignificant, (d) always changing.}
3. The average weather conditions for________duration represent climate. {(a) one year, (b) long, (c) short, (d) many years.}
4. The exposed skin of our body starts cracking in winter season mainly due to________{(a) rainy season, (b) high humidity, (c) summer season, (d) low humidity}
5. Seasons are caused by____________ {(a) ocean currents and revolution, (b) air masses and rotation of the earth (c) ocean current and rotation of the earth, (d) inclination of the earth’s axis and earth’s revolution}
6. Four seasons each of three months duration are noticed in________zone/region {(a) Temperate, (b) Tropical, (c) Equatorial, (d) Frigid.}

13.2 FACTORS AFFECTING CLIMATE

Different regions of the world have differences in temperature, humidity and precipitation. You know that these differences influence the lifestyle of the people living under different climatic conditions. To understand different climatic conditions, let us discuss the factors which cause the variations in the climate of a place or a region.
1. **Latitude or Distance from the Equator**

The places near the equator are warmer than the places which are far away from it. This is because the rays of the sun fall vertical on the equator and slanting in the temperate and polar regions. As we have discussed earlier the vertical rays are concentrated over a small area than the slanting one. Again, the vertical rays pass through a shorter distance in the atmosphere before reaching the earth’s surface. Therefore, lower the latitude higher is the temperature and vice versa. Malaysia which is near the equator is warmer than England which is far way from the equator.

2. **Altitude or the Height from the mean sea level**

We all know that mountains are cooler than the plains. Shimla situated on a higher altitude is cooler than Jalandhar, although both are almost on the same latitude. The temperature decreases with the height of a place. For a vertical rise of 165 metres there is an average decrease in temperature at the rate of 1°C. Thus the temperature decreases with increase in height.

3. **Continently or the Distance from the Sea**

The water is a bad conductor of heat i.e. it takes longer time to heat and longer time to cool. Due to this moderating effect of the sea, places near the coast have low range of temperature and high humidity. The places in the interior of the continent do not experience moderating effect of the sea. These places have extreme temperatures. The places far from the sea have higher range of diurnal (daily) and annual temperatures. Mumbai has relatively lower temperature and higher rainfall than Nagpur, although both are almost situated on the same latitude.

4. **Nature of the Prevailing Winds**

The on-shore winds bring the moisture from the sea and cause rainfall on the area through which they pass. The off-shore winds coming from the land are dry and help in evaporation. In India, the on-shore summer monsoon winds bring rains while off-shore winter monsoon winds are generally dry.

5. **Cloud Cover**

In areas generally of cloudless sky as in deserts, temperature even under shade are very high because of the hot day time sunshine. At night this heat radiates back from the ground very rapidly. It results in a large diurnal range in temperature. On the other hand under cloudy sky and heavy rainfall at Thiruvananthapuram the range of temperature is very small.

6. **Ocean Currents**

Ocean waters move from one place to another partly as an attempt to equalize temperature and density of water. Ocean currents are large movements of water usually from a place of warm temperature to one of cooler temperature or vice-versa. The warm ocean currents raise the temperature of the coast and sometimes bring rainfall, while the cold currents
lower the temperature and create fog near the coast. Port Bergen in Norway is free from ice even in winter due to warm North Atlantic Drift while Port Quebec in Canada remains frozen during winter months due to chilling effect of the Cold Labrador Current in spite of the fact that Port Quebec is situated in much lower latitude than Port Bergen. The on-shore winds passing over a warm current carry warm air to the interior and raise the temperature of the inland areas. Similarly, the winds blowing over cold current carry cold air to the interior and create fog and mist.

7. **Direction of Mountain Chains**
   The mountain chains act as natural barrier for the wind. The on-shore moisture laden winds are forced to rise after striking against the mountain; and give heavy rainfall on the windward side. These winds descending on the leeward side cause very low rainfall. The great Himalayas check the moisture laden monsoon winds from crossing over to Tibet. This mountain chain also checks biting polar cold winds from entering into India. This is the reason for which northern plains of India get rains while Tibet remains a perpetual rain shadow area with lesser amount of rainfall.

8. **Slope and the Aspect**
   The concentration of heat being more on the gentler slope raises the temperature of air above them. Its lesser concentration along steeper slopes lowers the temperature. At the same time, mountain slopes facing the sun are warmer than the slopes which are away from the sun’s rays. The southern slopes of Himalaya are warmer than the northern slopes.

9. **The Nature of the Soil and Vegetation Cover**
   The nature of soil depends upon its texture, structure and composition. These, qualities vary from soil to soil. Stony or sandy soils are good conductor of heat while black clay soils absorb the heat of the sun’s rays quickly. The bare surface reradiates the heat easily. The deserts are hot in the day and cold in the night. The forest areas have lower range of temperature throughout the year in contrast to non-forested areas.

   - The factors which affect the climate of a place or region are latitude or the distance from the equator, altitude or the height from the mean sea level, continentality or the distance from the sea, nature of the prevailing winds, ocean currents, direction of mountain chain, slope and its aspect, nature of soil and the vegetation cover.

Some of the following statements are false and some are true. Write true against
The domain of Air on the Earth

Notes

1. Higher the latitude lower is the temperature.
2. Higher the altitude lower is the temperature.
3. Nearer the sea coast lower is the range of temperature.
4. Interiors of the continent have lower range of temperature.
5. Cold ocean currents lower the temperature of the coast.

The varied effect of the major weather elements in different parts of the world and every location a distinct climate. Hence, the number of different climate is large. In order to easily understand and comprehend this large variety, the climate of the world have been classified into a few major groups, each having certain common important characteristics.

Although several attempts have been made by scholars to classify the climate of the world for the proper understanding of major climate types no single classification is perfect, as climate stands for the generalized and composite weather conditions. However, the Greeks, perhaps, made the first attempt to classify the world climates on the basis of the distribution of temperature and insolation. They divided the world into five latitudinal thermal zones, The boundary of these zones are fixed on the basis of the angle at which the sun’s rays strike the earth. The following are the five thermal zones.

![Fig. 13.1 Thermal Zone](http://smartprep.in)
Weather and Climate

(a) The Thermal Zones

(i) Torrid Zone: It is the largest of the thermal zones. It covers, almost half the area of the earth’s surface. It is situated between the Tropic of Cancer ($23\frac{1}{2}^\circ$N) and Tropic of Capricorn ($23\frac{1}{2}^\circ$ South) (See fig 13.1). The sun’s rays are almost vertical throughout the year in this zone. The mid-day sun is overhead at equator on equinoxes, i.e. on 21st March and 23rd September. It is also overhead at Tropic of Cancer on 21st June and at Tropic of Capricorn on 22nd December. The duration of day and night are always equal i.e. 12 hours each on the equator and they increase to 13 hours 27 minutes at tropics. The range of temperature is lowest at the equator and it increases towards the tropics.

(ii) Temperate Zone: The temperate zones are on either side of the Torrid zone. The North Temperate Zone lies between Tropic of Cancer ($23\frac{1}{2}^\circ$ North) and Arctic Circle ($66\frac{1}{2}^\circ$ North). The South Temperate Zone lies between Tropic of Capricorn ($23\frac{1}{2}^\circ$ South) and Antarctic Circle ($66\frac{1}{2}^\circ$ South) (see fig. 13.1). The sun is never overhead in this zone in winter season, the nights are longer and days are shorter and vice versa in summer. The difference between the duration of the day and night increases towards the poles. The maximum duration of day in summer and that of night in winter in the polar circles is 24 hours. When it is summer in the northern hemisphere it is winter in the southern hemisphere and vice versa.

(iii) Frigid Zones: Like the temperate zone, frigid zone is also found in both the hemispheres. The North Frigid Zone lies between Arctic Circle ($66\frac{1}{2}^\circ$N) and North Pole ($90^\circ$ North). The South Frigid Zone lies between Antarctic Circle ($66\frac{1}{2}^\circ$ South) and South Pole ($90^\circ$ South). During winter season, the sun does not rise above the horizon for almost six months. These are the coldest regions of the world. The surface remains permanently frozen under thick snow.

- The earth is divided into five thermal zones on the basis of distribution of insolation and temperature.
- Five thermal zones are torrid zone, north and south temperate zones and north and south frigid zones.

INTEXT QUESTIONS 13.3

1. Fill in the blanks with suitable answers:
   (i) The concept of thermal zones was first given by ______________
   (ii) The____________passes through the middle of the torrid zone.
(iii) Days and nights are always equal at the ____________

(iv) The sun is overhead twice at ____________ on 21st March and 23rd September.

(v) The sun is overhead throughout the year in ____________ zone.

(vi) The ____________ Zone lies between 23½° South and 66½° South.

(vii) The North Frigid Zone lies between 66½° North and ____________

(viii) The perpetual thick snow covers the ____________ zone.

(b) Climatic Types

The concept of thermal zone is theoretical and explains the distribution of solar energy over the earth’s surface. As discussed earlier, there are several other factors besides the angle of the sun’s rays which influence the climate of a place. Keeping in view other factors responsible for the distribution and combined influence of temperature and rainfall, modern scientists have arrived to several classifications of climate and its types. The most widely used system of climatic classification in its various modified forms is that of Wladimir koeppen (1846-1940). It is based upon temperature, precipitation and their seasonal characteristics. The relationship of climate with the vegetation is also included with it. According to this scheme, the world has been divided into five climatic groups and they are further sub-divided into 13 climatic types. They are as follows:

I Climatic Groups

(A) Tropical climates (hot all seasons)

(B) Dry climates

(C) Warm temperate rainy or Middle latitude rainy climates (mild winters)

(D) Humid Middle latitude climates (severe winters)

Climatic Types

Af (i) Tropical rain forest

Aw (ii) Savanna Climate

Am (iii) Monsoon Climate

Bw (iv) Desert Climate

Bs (v) Steppe Climate

Cs (vi) Mediterranean Climate

Cw (vii) China Type Climate

Cf (viii) West European Climate

Dw (ix) Taiga Climate

Df (x) Cool East-coast Climate

(xi) The Continental Climate
Weather and Climate

7. (E) Polar climates
   Ef. (xii) Tundra Climate
   Ef. (xiii) Ice-cap Climate

You will study the specific characteristics of some of these climatic types in the subsequent lesson dealing with the life of people in low latitude, mid-latitude and high latitude regions of the world.

- W. Koeppens scheme of climatic classification is based on temperature precipitation and their seasonal characteristics
- According to this scheme the world has been divided into 5 climatic groups and 13 climatic types.

INTEXT QUESTIONS 13.4

1. Match correctly each item of column A with that of column B

<table>
<thead>
<tr>
<th>A Climate Group</th>
<th>B Climatic Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Tropical Climate</td>
<td>(1) Tundra Climate</td>
</tr>
<tr>
<td>(b) Dry Climate</td>
<td>(2) Taiga Climate</td>
</tr>
<tr>
<td>(c) Warm Temperate Climate</td>
<td>(3) Savanna Climate</td>
</tr>
<tr>
<td>(d) Humid Middle Latitude Climates (severs winters)</td>
<td>(4) Steppe Climate</td>
</tr>
<tr>
<td>(e) Polar Climates</td>
<td>(5) Mediterranean Climate</td>
</tr>
</tbody>
</table>

WHAT YOU HAVE LEARNT

The difference among weather, season and climate is that of duration, extent and permanency. Weather is the atmospheric condition of a place for a short period of time with respect to one or more of its elements. It is not permanent. Season is the period of a year which is characterized by a particular set of weather condition. It is mainly caused by the inclination of the earth’s axis and revolution of the earth round the sun. Its cycle is repeated year after year. Climate is the average weather conditions of a large area for the past several years. It is more or less permanent. Climate of any place or region is affected by several factors, such as distance from the equator, ocean currents, direction of mountains, slope and aspect, soil and vegetation cover etc. Ancient Greeks divided the world into torrid, temperate and frigid zones based upon the distribution of temperature. Torrid zone is the hottest. the frigid zone is the coldest and the temperature zone lies in between the two. It
The domain of Air on the Earth has a mild temperature. The length of the day varies from equator to poles. The days and the nights are almost equal on the equator. The length of the day increases in summer and decreases in winter as we move towards the poles.

Climate types are the outcome of the classification based upon regions of their formation. W. Koeppen classified the world into five climatic groups, namely (A) Tropical Climate, (B) Dry Climate, (C) Humid Mid-latitudes Climate (mid winters), (D) Humid Mid-Latitudes Climate (severe winters) and (E) Polar Climate. His classification is based on temperature, precipitation and their seasonal variation. He sub-divided the climatic groups into 13 climatic types.

1. Explain the factors which affect climate of a place.

2. Draw a simplified diagram of thermal zones and write important characteristics of each zone.

3. Distinguish between weather and climate by describing five points of distinction of each.

4. Name the three main basis of Koeppen’s classification of climate and also state the five climatic groups and their sub-divisions into climatic types.

13.1
1. (d); 2. (c); 3. (d); 4. (d); 5. (d); 6. (a)

13.2
1. True; 2. True; True; 4. False; 5. True

13.3
(i) Greeks; (ii) equator; (iii) equator; (iv) equator; (v) Torrid; (vi) South Temperate; (vii) 90° N or North Pole; (viii) Frigid

13.4
(a). (3); (b). (4) ; (c) . (5) ; (d) . (2) ; (c) . (1)

Hints to Terminal Questions

1. Please see para 13.2
2. Please see para 13.3 (a)
3. Please see para 13.1 (iv)
4. Please see para 13.3 (b)
BIOSPHERE

We know that our earth is the only planet where life is found. That is why this planet is also known as living planet or ‘sphere’ of ‘life’. This sphere contains those qualities atmosphere, lithosphere and hydrosphere. They all enable the life to exist on this planet. But do you know this is a very small portion of the earth where life exists. Beyond this narrow space of the earth, there is no life forms found. What is so special about this narrow zone of the earth which made life possible? It is because of right mixture of many things – energy, some living beings and some non-living things and their interaction. For millions of years, nature has provided some checks and balances which sustain these life forms without any problems. But today the situation has changed. Now this living planet is in danger. This is mainly due to unsustainable human intervention. Our Father of Nation, Mahatma Gandhi has rightly said “Earth has everything to meet human needs but not its greed.” It we want to save this unique living planet, then we have to control our greed and change our life style and behaviour pattern. In this lesson we will discuss about some of these issues related to biosphere.

OBJECTIVES

After studying this lesson you will be able to:

- state the elements of biosphere and its inter-relationship with lithosphere, atmosphere and hydrosphere;
- infer the limits of biosphere;
- give reasons for the unique nature of biosphere;
- define the key concepts like ecology, eco-system, global warming, ozone layer depletion, acid rain and sustainable development;
- state the ecological processes in the eco-system;
- understand the interactions of the biosphere with different types of environments;
appreciate the importance of balance, inter-dependance and energy flow in different ecosystems;

• identify the causes of climatic changes as global warming, ozone layer depletion, acid rain and also those caused by human activities;

• highlight the efforts made for coping with the elements of climatic change at global and local level;

• explain the need and importance of sustainable development.

14.1 BIOSPHERE AND ITS LIMIT

In simpler terms, biosphere refers to the narrow zone of the earth in which all life forms exist. Do you know why life becomes possible in this zone? It is because this is the zone in which all the three essentials things which are required for sustenance of life are found in a right mixture. They are land (lithosphere), air (atmosphere) and water (hydrosphere). In other words, this narrow zone is a place where lithosphere, atmosphere and hydrosphere meet (see fig. 14.1). We must appreciate that how narrow this zone is? It extends vertically into the atmosphere to about 10km, downward into the ocean to depths of about 10.4 km and into about 27,000 ft of the earth’s surface where maximum living organism have been found. There are some life forms which are found in extreme conditions. Two examples of this type are algae and thermophillic. Algae which is supposed to be one of the earliest forms of life can exist even in the most hostile environment such as frozen Antarctica. On the other extreme side, thermophillic (heat loving) bacteria usually inhabit deep sea volcanic vents having a temperature of more than 300°C. In fact, these bacteria can not survive in a temperature below boiling point.

The situation was not like this when the life form began. About 700 million years ago, it is believed to have been only a narrow discontinuous land encompassing only shallow parts of the oceans. As per the trend of expansion of area in terms of the availability of life form, it can be predicated that may be after a few million years, the expanse of the biosphere gets extended beyond the upper troposphere. This shows that biosphere has been evolving over the time. Till now we have discussed about the vertical expansion, but horizontally the biosphere covers the entire globe, though the life may not be possible in some of the hottest and the coldest parts. However, most living things are confined to a narrow band which permits the capture of solar energy through the process of photosynthesis, which is essential for any organic life. This narrow region extends from about 180-200 feet below sea level to the highest value of snowline in Tropical and sub-tropical mountain ranges (say 6,550M above sea levels). When it extends beyond this line, life forms become very limited.
14.2 COMPONENTS OF BIOSPHERE

Biosphere has three basic components. These are (A) abiotic (physical and inorganic) components; (B) biotic (organic) components and (C) energy components. Let us discuss about these three components in detail.

(A) Abiotic Components: These components broadly consist of all non-living elements which are essential for the survival of all living organisms. These are (i) lithosphere (solid part of the earth crust), (ii) atmosphere and (iii) hydrosphere. Mineral nutrients, certain gases and water are the three basic requirements of organic life. Soils and sediments constitute the chief reservoir of mineral nutrients. Atmosphere constitutes the chief reservoir of gases essential for organic life. Ocean constitutes the chief reservoir of liquid water. where all these three reservoirs intermingle and that area becomes the most fertile area for organic life. The upper layer of the soil and shallow parts of the ocean constitute the most important areas, box sustaining organic life. The upper layer of soil, permits easy penetration of gases and percolation of moisture, while shallow parts of oceans, allow penetration of sunlight, intermingling of dissolved gases and nutrients from land surface and ocean bottoms.

(B) Biotic Components: Plants, animals and human beings including microorganisms constitute the three biotic components of environment. In a way these can be called as the three sub-systems.

(i) Plants: Plants are most important among biotic components. They are the only primary producers as they produce their own food through the process of photosynthesis and hence are called autotrophs. Not only plants alone produce all kinds of organic matter but also help in cycling and recycling of organic matters and nutrients. Thus, plants are the major source of food as well as energy for all organisms.

(ii) Animals: While plants are the primary producers, the animals are the main consumers. Therefore, animals are heterotrophs. There are three main functions of animals: (i) to use organic matter made available by plants as food. (ii) to transform the food into energy and (iii) to utilise the energy for growth and development.
(iii) **Micro-organisms**: These consist of a variety of micro-bacteria, fungi etc. Their numbers are unlimited and are popularly known as decomposers. As the name suggest, these organisms decompose the dead plants and animals and other organic matters. It is through this process they obtain their food. Through this process of decomposition, they differentiate and separate the complex organic matter, so that the same could be put to re-use by the primary producers i.e., the plants.

(C) **Energy**: This is the third and vital component of the biosphere without which life could not have been possible on this planet. It is essential for generation and reproduction of all biological life on this planet. All organisms in the biosphere are like machines which use energy to work and also to convert one form of energy into another. But do you know the source of such energy required for the functioning of the biosphere? Sun is the major source of energy without which we can not think about the existence of the biosphere.

**INTEXT QUESTION 14.1**

1. Give one word for each of the following
   (a) The narrow zone in which life exists. ____________
   (b) The non-living components of the biosphere. ____________
   (c) The living component of the biosphere. ____________
   (d) The organisms which decompose, plant, animal, and organic matters. ____________

2. Fill in the blanks:
   (a) ____________ is the primary source of energy for the biosphere.
   (b) ____________ are those who take their food through their mouth.
   (c) The biotic component of the biosphere mainly consists ____________, __________ and __________.
   (d) Biosphere is a narrow zone where ____________, __________ and __________ meet which made life possible.

**14.3 ECOLOGY AND ECO SYSTEM**

Ecology is the study of interactions between the organisms and their environment. Now, the ecologists feel that the two components of nature–organisms and environment, are not only related but both these components function in an orderly manner as a definite system. Infact, the two components, organisms and environment are not distinct. For a particular organisms, other organisms can constitute a part of its environments. Similarly, environment can also be modified and influenced by organisms, thus, organisms and environment are interacting parts of a system.
Therefore, the term ecosystem is now used to describe such a system. The word eco-system is a short form of ecological system. The term was first used by A.G. Tansley in 1935. An ecosystem can be defined as a system of regularly interacting and interdependent components forming a unified whole. In other words, any segment of the landscape that includes biotic and abiotic components is known as ecosystem, if all its components are integrated with each other. For example, a lake or pond is an eco-system when it is considered in its totality and not just a water body. In that sense, pond is a representative of small ecosystem and biosphere is considered as the largest ecosystem. Basically, the concept revolves around two aspects.

(i) First, it studies inter-action among the various components and sub-components and

(ii) Second, flow of energy among various components of eco-system which is the essential determinants of how a biological community functions.

Fig. 14.2 : Flow of Energy in an Ecosystem
Therefore, if we study functional aspects of an ecosystem, then, we may study it in terms of the following:

- Energy flow
- Food Chain
- Nutrient or bio-geochemical cycles.
- Development and evolution.
- Control mechanisms or cybernetics.
- Diversity pattern in time and space
- Let us study each components briefly.

(a) **Flow of Energy in the Ecosystem**

As discussed earlier that continuous interaction goes on within an eco-system. This interaction between components and sub-components involves the flow of energy and cycling of mineral nutrients. A generalized diagrammatic representation of energy and mineral movements are given above (See figure No). In this process transfer of energy takes place from one level to another. This is known as trophic level. Therefore, trophic level is the level or the stage at which food energy passes from one group to another. To understand it in a better manner we have to discuss about food chain and its associated activities. In the biosphere, there are broadly two groups of living organisms. Autotrophs and heterotrophs. On the basis of food habits, these heterotrophs are further sub-divided into three categories. They are herbivores, carnivores and omnivores. Herbivores are plant eating animals, carnivores are flesh eating animals and omnivores are both plant and animal eaters organisms.

(b) **Food chain/cycle**

Let us now understand what is a food chain? Food chain can be defined as a sequence of transfer of energy from organisms in one trophic level to those in another trophic level. Sun is the major source of energy. It helps in the growth of plants on the soil and water bodies. Plants form the basis of food for large number of herbivores. These herbivores are used as food substances for carnivores. Besides, there are omnivores who feed on plants as well as animal flesh. The solar energy absorbed by the soil is reflected in the form of plants and animals. These herbivores are used as food substances for carnivores. Besides, there are omnivores who feed on plants as well as animal flesh. The solar energy absorbed by the soil is reflected in the form of plants and animals. These organisms have a limited cycle and die after some time. Once these organisms die, another group of organism start their functioning as they feed on dead material. They help in decomposing the dead bodies of plants and animals on releasing the energy which is again absorbed by the soil to enrich its production of plants. Thus cycle completes.

The above said food chains are very simple food chain But food chains are not always so simple and isolated sequences. Several inter-connected and overlapping food chains present a complicated patterns. Such patterns are called food web.
Now let us see what are the various trophic levels? As we have discussed earlier sun or solar energy is the source for all the plants for preparation of their food. The energy which is stored by the plants is known as trophic level I. It becomes the source of energy for the herbivores. Therefore, transfer of energy from trophic level I to trophic level II takes place when the plant eating animals consume these plants. Again this chemical energy (through foods) consumed by herbivores gets stored at trophic level II and becomes source of energy for the carnivores at trophic level III. Carnivores are flesh eating animals and depend upon other animals for food. These animals require a lot of energy for building their tissues. They receive their energy from trophic level II through food consumption. A part of the chemical energy from this level III of the food chain is transferred to omnivores at trophic level IV. Therefore, omnivores are at the top level of the food chain which receives their energy from all the three levels. So, in a food chain the members at the successive higher levels becomes smaller in number. When the numbers at successive levels are plotted, they assume the shape of a pyramid, hence it is called food pyramid or pyramid of numbers. (see figure)
The number of organisms at any trophic level depends upon the availability of food at its lower level. With an increase in availability of food at the lower level, there is a consequent increase in the number and variety of organisms at its higher trophic level. Thus, availability of food is the main factor which maintains the grand balance of nature. This balance is dynamic and fluctuates within certain limits. So, every ecosystem has its own system of mechanism to control the balance. This happens because in an eco-system there are certain inherent processes in which nutrients or materials are transferred. Some times in a single direction and some times in cycles. Let us discuss some of these cycles.

(c) Natural / Bio-geochemical Cycles

Biogeochemical cycles (biological, geological and chemical interactions) are nothing but the movement and circulation of soluble inorganic substances (nutrients) derived from soil and atmospheric phases of inorganic substances through organic phase of various biotic components. Similarly, a return circulation and movement of organic substances takes place in favour of inorganic objects such as soil and atmosphere. Thus these two systems are supplementary to each other and complete the cycle. The study of biogeochemical cycles can be approached on two scales e.g., (i) cycling of all elements together or (ii) cycling of individual elements e.g., hydrological cycle, carbon cycle, nitrogen cycle, phosphorous cycle, oxygen cycle, sulphur cycle etc. Besides these cycles, sediment cycles and mineral cycles are also included in the broader biogeochemical cycles. These natural or biogeochemical cycles functions in a balanced manner which stabilizes biosphere and sustains the life processes on the earth. If we disturb them, it will lead to various negative
Biosphere

consequences which ultimately affects the biosphere. Let us discuss some of these cycles in brief. (These cycles are already discussed in lesson nine of this book, but here our discussion is related to biosphere or environment. You can refer these cycles which are given in detail under lesson – 9)

1. The Hydrological Cycle

This cycle helps in exchange of water between air, land, sea, living plants and animals. Solar energy is used to drive the hydrological cycle. Massive evaporation of water from the oceans, cloud formation and rainfall gives us our supply and reserves of fresh water.

At sub-zero temperature, rainwater freezes into snow and in presence of strong wind forms hail. Water as rain, snow and hail is precipitated on land and water surfaces. On land surface water seeps into the soil and is stored as ground water. The natural water level or water table exists below the ground. The water table is supported by the underlying clay and rock strata. Ground water does not remain static but moves in various directions. It moves up through capillary action and reaches soil surfaces where it is drawn by plant roots.

2. The Nitrogen Cycle

Nitrogen and its compounds are essential for life processes in the biosphere. There is continuous exchange of nitrogen within the ecosystem operating the nitrogen cycle. Proteins produced by plants and animals in their metabolic processes are organic compounds of nitrogen. The major load of nitrogenous organic residue in soil originates from death and decay of plants and excreta of animals. These organic residues in soil are taken up by various soil micro-organisms who break down soil nitrate into nitrogen by denitrification process while others transform nitrogen into soluble nitrogen compounds.

3. The Carbon Cycle

The carbon cycle is a very important chemical cycle. The atmosphere is the minor reservoir of carbon. Hydrosphere is the major reservoir which contains approximately 50 times more as that of atmosphere. It is stored as bicarbonate mineral deposit on the ocean floor. The later regulates the carbon dioxide level in the atmosphere. The cycle operates in the form of carbon dioxide exchanging among the atmosphere, biosphere and the oceans.
14.4 TYPES OF ECO-SYSTEMS

Ecosystem can be classified into various types on various basis. The most widely used and simple classification is on the basis of habitats. The idea behind this classification is that each habitat exhibits a particular physical environmental condition. These conditions determine the nature and characteristics of biotic communities and therefore there are spatial variations in the biotic communities. On this basis the eco-system can broadly be divided as (i) terrestrial ecosystems and (ii) aquatic ecosystems. These ecosystems are further sub-divided in to various sub-types. We will discuss briefly about these two eco-systems and their sub-types.

(i) Terrestrial Ecosystems

As the name suggests it covers the entire 29% of the land area found on the earth surface. The terrestrial ecosystems are the major source of food and raw material for human beings. Here, the plant and animal communities are more diversified than aquatic eco-systems. Land organisms have a greater range of tolerance than the aquatic ecosystem. But, in some cases, water is a limiting factor for terrestrial ecosystems. As far as productivity is concerned, terrestrial ecosystems are more productive than aquatic ecosystem.

The above said discussion is a comparison between terrestrial and aquatic ecosystem in general. But there are further variations in the terrestrial ecosystems in terms of physical conditions and their response to biotic communities. Therefore, the terrestrial eco-systems are further sub-divided into various sub-types. Major sub-types are (i) upland or mountain eco-system (ii) low land eco-system (iii) desert eco-system etc. These sub-systems, may be further sub-divided depending on specific purpose and objectives. Maximum life forms are found in low lands and they keep on decreasing with the increase in height as the level of oxygen and atmospheric pressure decreases.

(ii) Aquatic Eco-system

This ecosystem refers to the 71% of the water present on the earth surface in various forms. Like terrestrial eco-system, aquatic ecosystem can be further divided into various sub-types. But the major sub-divisions of this ecosystem may be fresh water, estuarine and marine. Again these ecosystems can be further subdivided into smaller ones. If we see in terms of extent or what we call in geography in terms of scale, it ranges from open sea to small pond. The variations within the various types of aquatic ecosystem are mainly related to abiotic factors. But, there are also variations in terms of biotic communities that are living within these ecosystems. Why are these variations?
As discussed earlier, the limiting factors in aquatic eco-systems are the depth upto which sunlight can penetrate, the availability of nutrients and the concentration of dissolved oxygen. If we keep all these factors into consideration, it is found that estuarine ecosystems are the most productive of aquatic eco-systems. In marine ecosystems, shallow continental shelves are more productive than open oceans. Though open oceans are most extensive in areas, they are the least productive of all ecosystems like the deserts in terrestrial ecosystem.

Another aspects which is the determinants of diversity of life in aquatic ecosystem is the adaptability of organisms. Some of the organisms exclusively live in water namely fishes whereas some of the organisms are amphibious in nature. Some of the important amphibians are frogs, crocodiles, hippopotamus and variety of aquatic birds. Again within water, some organisms live only in either fresh water or saline water and some organisms live in both fresh water and saline water. Hilsa fish is an example of the later type. Echinoderms and Coelenterates live only in saline water and there are various types of fishes like Rohu, Catla etc found only in fresh water.

INTEXT QUESTION 14.2

1. Fill in the blanks with appropriate words.
   (a) ___________ are those which manufacture their own foods.
   (b) Plant eating animals are known as ___________.
   (c) On the basis of food habits human being belongs to which category ___________.
   (d) Several inter-connected and overlapping food chains present a complicated pattern which is known as ___________.
   (e) ___________ is considered as the largest ecosystem.

2. Answer the following questions very briefly
   (a) Define ecology.

   ________________________________________________________

   (b) What is a food chain?

   ________________________________________________________

   (c) What is a food pyramid?

   ________________________________________________________

   (d) What is a biogeochemical cycle?

   ________________________________________________________
14.5 GLOBAL CLIMATIC CHANGE

We have read under bio-geochemical cycle that for the last billion years or so, earth’s atmosphere and hydrosphere have been composed of approximately the same balance of chemical components we live with today. The earth has a unique mechanisms for stabilizing and controlling the global climate. These mechanisms are as follows:

(i) The plants and animals balance carbon dioxide level of the atmosphere which in twin acts as global thermostat. It means these elements control the temperature balance within optimum limits.

(ii) The water bodies play important role in regulating global climate.

In recent years, the rapid growth of human population, the rate at which we consume the earth’s resources, extravagant life styles etc. lead to substantial increase in the carbon level of atmosphere which has accelerated the process of climatic change.

Let us discuss some of these processes affecting the climatic change.

(a) Green House Effects and Global Warming

Global warming refers to a gradual rise of atmospheric temperature and consequent changes in the radiation balance mainly due to human action leading to climatic change at different levels – local, regional and global. As per recent estimates, it has been found that the surface air temperature over the past 100 years has increased by about 0.5°C to 0.7°C. Do you know why it is happening. This is due to green house effect. To have a better understanding about global warming, we should know the functioning of a green house (See Box)

Working of a Green House

In cold countries, a green house is meant for plants, where total heat, especially during winter season, is not sufficient to support plant growth. The transparent walls and roof of the green house are such that these allow the visible sunlight to enter but prevent the longwave radiations to go out. Thus, the sunlight is absorbed by the soil and structure of the green house. It is then re-emitted as heat which can not pass through the glass. The amount of energy in the green house thus increases until its temperature is high enough for the slight leakage of heat through the glass to take away as much energy as gets in as sunlight. Subsequently walls and roof re-emit absorbed radiation into the house. Thus, during the day time, infra-red radiation pass into the green house and warm the atmosphere and the ground on which the green house stands. Coating of glass with a non-heat radiation film transparent to sunlight further maximizes heating effect of the radiation.
Therefore, if our earth has become a green house, then there are certain gases which act like the glass panels of a green house allowing the sun’s rays to pass through but preventing the heat from escaping into the outer space and there by warming the atmosphere. This is happening due to deforestation and industrialization. These gases are carbon dioxide (CO$_2$), methane (CH$_4$), nitrous oxides (NO$_x$) and chlorofluorocarbon (CFC) and hence known as green house gases. Out of these four gases, carbon dioxide contributes about 55%, chlorofluorocarbon contributes about 24%, methane (about 15%) and nitrous oxide (about 6%) towards heating of the atmosphere.

Do you know the sources of these gases? Burning of fossil fuels and fire woods, large fleet of automobiles and number of factories emit carbon dioxides. Growing paddies, livestock, waste dumps and coal mining are the major source of methane. The use of aerosols as coolants in refrigerators and air conditioning devices release chlorofluorocarbons into the atmosphere Nitrous oxide is mainly emitted from chemical industries, and due to deforestation and certain agricultural practices.

Construction of green houses in temperate region helps the plant protection and ecological balances whereas concentration of green house gases on the earth’s atmosphere upsets the earth’s biological system.

**Consequences of green house effect**

1. It is estimated that if the present rate of increase in CO$_2$ level continues, it will result in rise of atmospheric temperature by 2°C to 3°C by end of 21st century. This will result in receding many glaciers; melting of icecaps in the polar regions and disappearance of deposits of ice on the other parts of world in large scale. According to an estimate, if all the ice on the earth would melt, about 60M of water would be added to surface of all oceans and low lying coastal areas. A rise in sea-level of only 50-100 cm caused by global warming would flood low lying areas of the world such as Bangladesh, West Bengal as well as densely populated coastal cities from Shanghai to San-Fancisco.

2. Because of increased concentration of CO$_2$ and due to much warmer tropical oceans, there may occur more cyclones and hurricanes. Early snow melt in mountains will cause more floods during monsoon. According to United Nations Environment Programme (UNEP), within about three decades, rising levels of seas will be able to and flood coastal cities like Bombay, Boston, Chittgang and Manila.

3. A slight increase in global temperature can adversely affect the world food
production. Thus the wheat production zones in the northern latitudes will be shifted to north of temperate latitudes.

4. The biological productivity of the ocean would also decrease due to warming of the surface layer, which in turn reduces the transport of nutrients from deeper layers to the surface by vertical circulation.

Control and Remedial Measures of Green House Effect

The following measures may be adopted to reduce the ever increasing green house effect.

1. CO₂ concentration can be reduced by drastic cut in the consumption of fossil fuels in the highly developed and industrialized countries like USA and Japan and developing country like China and India.

2. Scientific efforts should be made to develop alternative efficient fuels. Methane may be a substitute of petroleum.

3. There should be a restriction on the emission of dangerous CO₂, CFCs, and as NO₂ from the factories and automobiles.

4. Limiting the driving days in megacities can be another option. Cities like singapore and mexico are following the practice.

5. In tropical and sub-tropical countries, the solar energy may be developed as an alternative to the fossil fuels.

6. Biogas plants should be used which is another source of conventional energy for domestic use.

7. Enhancing afforestation will certainly reduce the CO₂ level thereby decreasing the green house effect.

(b) Ozone Layer Depletion

Before discussing about the problem of ozone layer depletion, we should know about ozone and the ozone layer. Ozone is a form of oxygen that has three atoms (O₃) rather than the more common two atoms (O₂). It is created in the upper atmosphere by the action of solar radiation on oxygen molecules. As far as its position is concerned, it is found in the form of a thin layer in the stratosphere between 15 to 48 kilometre. About 90% of all atmospheric ozone is found in this layer. Ozne constitutes only less than 0.002 percent of the volume of the atmosphere. However, it’s role is very critical as far as lives on the earth is concerned. It strongly absorbs ultraviolet radiation from the sun. Ultraviolet radiation is biologically destructive in many ways. It causes skin cancer and cataracts, suppresses the human immune system, diminishes the yield of many crops, disrupts the aquatic food chain by killing micro-organisms on the ocean surface and many other negative effects which is still undiscovered.
This is happening due to certain recent human activities which have injected certain chemicals in the stratosphere which consume ozone and reduce its concentration. Depletion is mainly caused by chlorofluorocarbons (CFCs), halons, methyl chloroform and carbon tetrachlorides. These chemical substances are mainly either chlorine or bromine which can reach the stratosphere and catalytically break down ozone into oxygen. CFCs are odourless, non-flammable, non-corrosive and nontoxic. For this reason, scientist originally believed CFCs could not possibly have any effect on the environment. That is why it is widely used in refrigeration and air conditioning, in foam and plastic manufacturing and in aerosol sprays.

Not only is the ozone layer thinning, in some places it has temporarily disappeared. A hole in the layer has developed over Antarctic since 1979 and that hole has persisted for a longer and longer time every year. In 1988, an ozone hole was found over the Arctic for the first time and it too has lasted longer and longer each year since then.

Can we prevent this disaster? It needs certain actions both at individual as well as governmental level. Since the last two decades, certain actions have been initiated at global level. Among these Montreal Protocol of 1987 and London Conference of 1992 are important. In both these conferences it was decided that the developed countries would totally ban CFC production by 2000 and the developing countries by 2010 AD. Even if it is sincerely followed and strictly implemented by all the 150 countries including India, who are signatory to Montreal Protocol even then the chlorofluorocarbon and chlorine shall continue their influence for another 100 years. Therefore, all over the world research efforts are continuing for development of substitutes of CFC as coolants for refrigerators and air conditioners.

(c) Acid Rain

The term ‘acid rain’ refers to the deposition of wet or dry acidic materials from the atmosphere on the earth’s surface. Although most conspicuously associated with rainfall, the pollutants may fall on the earth’s surface either in the form of snow, sleet, hail or fog or in the dry form of gases or particulate matter. Sulphuric acid and nitric acid is considered as the principal agents responsible for acid rain. But the major culprit are human beings. Smokes emitted from the industries is the major source of sulphur dioxide whereas smokes emitted from the motor vehicle is the major source of nitrogen oxide. These emissions mixed with atmospheric moisture form the sulphuric acid and nitric acids which, sooner or later precipitate on earth in various form.

Acidity is measured on a pH scale based on the relative concentration of hydrogen ions. The scale ranges from 0 to 14, where the lower end represents extreme acidity and the upper end extreme alkalinity. (see diagram). As stated earlier acid rain is associated with various forms of precipitation. It we look at rainfall in clean and dust free air, a pH value varies between 5.6 to 6.0, which is slightly acidic in nature. Whenever or wherever the pH value is below 5.6, then the damage becomes noticeable.
The long-term effects of acid precipitation on human health and agricultural production have not yet been ascertained precisely. However, the most conspicuous damage is being done to aquatic eco-system. Below given are some of the effects of acid rain. The eco-system of a stream or lake may be severely affected when its pH falls below 5. Total biomass in such systems is reduced from two to ten times because few organisms can tolerate acid. The diversity of species also decreases. The most severe effect of acidification is on fish. Acidic conditions affect the reproductive capabilities of fish, resulting in a slow decline of fish population. This has been documented in various parts of Europe and North America. In Norway, thousands of lakes and streams have largely lost their fish population, over an areas of 33,000 square kilometer. Several lakes in Eastern United States and Canada have become biological deserts during the last quarter century. The precise effects of acid rain on forest are not clearly understood, evidence, however, shows that it is responsible for forests dieback which is occurring in each continent. Forest dieback is a German word which means death or decline of forest. Even buildings and monuments are being destroyed because acid deposition accelerated erosion capacity.

Acid rain is a serious global problem and its impact can spread over long distances from the origin of the pollutant. That is why Scandinavian countries complain about British pollution in Europe whereas Canadians blame United States in North America.

*Fig. 14.5 A pH Scale*
Biosphere

INTEXT QUESTIONS 14.3

1. Answer the following questions briefly
   
   (a) Name any two factors that are responsible for irreparable damage to the biosphere
      
         (i) ___________________     (ii) ___________________
   
   (b) Name any two major greenhouse gases.
      
         (i) ___________________     (ii) ___________________

   (c) Which are the two leading nations in the world that produced carbon dioxide gases.
      
         (i) ___________________     (ii) ___________________

   (d) Where do we generally find ozone layer in the atmosphere
      
         (i) ___________________     (ii) ___________________

   (e) Name any two major chemical substances that are responsible for ozone layer depletion.
      
         (i) ___________________     (ii) ___________________

   (f) What are the two main agents that are responsible for acid rain?
      
         (i) ___________________     (ii) ___________________

   (g) Name any two major effects of acid rain.
      
         (i) ___________________     (ii) ___________________

14.6 SUSTAINABLE DEVELOPMENT

Today, the world has made a lot of progress. Human beings with the help of technological advancement and consumption of energy resources have made many inventions and discoveries to make their life more and more comfortable. At present, without technology and mineral and power resources we can not think about the life. It has entered in a large scale in almost every sector, be it agriculture, industry, transport, communication and domestic. Have we ever thought that how it affects the life on earth? Even the situation is such that our ecology is in danger. If we continue in this fashion most of the minerals and power resources will be consumed within next hundred years. Simultaneously, it has affected and endangered four components of ecosystems. These are the climatic system, the hydrological cycle, nutrient cycle and the biodiversity. The situation has worsened to that extent that the resources which are considered renewable become non-renewable. Let us explain this with one example. Take the case of Yamuna water in Delhi. We have polluted the water to such an extent that little aquatic life (mostly fish) is found in this water within Delhi likely. This water can not be consumed despite the treatment.
It has also affected plants and their products. Then the questions arises what is the use of that water which could not be used though it is renewable. Same is the case with air, soil etc. Due to careless and selfish action of the human beings, these natural resources are degraded to such an extent that it becomes non-renewable.

It puts a question mark on the development itself. Does it mean that the world community needs to put a full stop to further development? This is not at all possible. This dilemma bothered entire human kind. A conscious effort was made to address this particular problem. A committee was formed by United Nations under the chairmanship of the then Norway Prime Minister Gro Harlem Brundtland. This Commission was known as United Nations Commission on Environment and Development (UNCED) or popularly Brundtland Commission.

The title of the report prepared by Commission is “Our Common Future.” In the beginning, the world was divided into two groups – developed and developing countries and started blaming each other. Developed countries blamed developing countries for the rapid population growth, poverty and primitive technology which leads to pollution. The argument of developing countries was that extravagant life styles of developed countries puts a lot of pressure on existing resources. But after a lot of heated discussions and arguments, it was felt that there should be some common grounds in which all the world should agree to protect it for future. It was felt that there should be balance between ecology, economics and technology. Therefore, Brundtland Commission defined sustainable development as “meeting the needs of the present generation without compromising the ability of future generation to meet their own needs.”

Strategies to be adopted for Sustainable Development

Some strategies are given below for achieving sustainable development.

1. **Reviving growth:** Sustainable development must address the issue of poverty. Poverty increases pressure on the environment by following life styles that degrade environment. For example forest cutting for fuel use or expanding deserts by overgrazing activities. At the same time, they are helpless as they do not have alternate sources of livelihood. Majority of people living below poverty line are found in Africa and Asia. Efforts should be made to provide them certain alternatives like skills, training, education, etc. so that they can earn livelihood and come out of poverty. Otherwise, the very purpose of sustainability or sustainable development will be forefeited. Because, as long as poverty will be there, poor people will depend upon nature for their survival.

2. **Ensuring a sustainable level of population:** Today one of the major challenge is to tackle the highest rate of population growth especially in Africa, South Asia and Middle East. Explosion of population has a direct link with quality of life, parameters like access to education, health, housing, safe drinking water, sanitation and means of livelihood. It puts a lot of stress on government to provide additional facilities when population is increasing rapidly.
3. **Meeting essential human needs:** This is a pre-requisite for reviving growth. It is evident that unless the basic needs are satisfied, the individual cannot participate in the growth process. Essential human needs include enough food, adequate housing, fresh water supply and health facilities. More food and quality food should be provided because this is not just to feed people but to attack under nourishment and to develop immune system for preventing diseases.

4. **Changing the quality of growth:** There is a need to change the orientation of growth. When we say growth, we always mean economic growth or materialistic growth, but there is a need for making growth less materialistic, less energy intensive and more equitable. Economic and social development have to be mutually reinforcing. In other words economic development should pay attention towards better social development like education, health, sanitation, etc. Simultaneously social development can boost the economy of the areas, region and country.

5. **Conserving and enhancing the resources base:** There are moral as well as economic arguments for this. The moral argument is that we have to preserve resources for the sustenance of next generation. But simultaneously we have to see economic argument also. The economic argument is that we can not say to the poor people that they must remain in poverty to protect environment. On the otherside, there is a need to challenge the consumerism of the developed countries and through following pro-capitalist economic systems. Somewhere, the process of liberalization, privatization and globalisation must answer the problem of inequality only meeting basic human needs of common people. The challenge in sustainability is that how we conserve resources without jeopardising the growth and equal access to resources for livelihood. Simultaneously there is a need to find out alternatives to non-renewable resources, more efficient use of resources, discovery of new resources and discovery of low waste technologies.

6. **Reorienting technology and managing risk:** The implications of above five strategies are for the orientation of technology in two principal ways. First the capacity for innovation needs to be greatly enhanced in developing countries. Second, the effort by developed countries must play a vital role as far as the transfer of technology is concerned. Therefore, all the technological development must pay greater attention to environmental factors. This is closely linked to the issue of risk management wherein environmental impact has to be effectively minimized.

7. **Merging environment and economics in decision making:** Economics and ecology should not be seen in opposition but as interlocking. Sustainable development requires the unification of economics and ecology in international relations.
INTEXT QUESTION 14.4

1. Answer the following question briefly

(a) Under whose Chairpersonship the United Nation Commission on Environment and Development (UNCED) was formed?
_________________________________________________

(b) What is the title of the report submitted by UNCED?
_________________________________________________

(c) Define sustainable development.
_________________________________________________

(d) Name any three strategies to be adopted for sustainable development.
(i) ________________________________________________
(ii) ________________________________________________
(iii) ________________________________________________

WHAT YOU HAVE LEARNT

Probably, our earth is the only planet where life is found. Biosphere refers to the narrow part of the earth in which all life form exists. Life is found in this region due to availability of right mixture of land, air and water. There are three major components of biosphere. These are abiotic, biotic and energy component. Examples of abiotic components are soil, air, water etc. whereas plants, animals and micro-organisms are major constituents of biotic component. The third one is energy component for which sun is the major source without which existence of biosphere is not possible.

Ecology is the study of interactions between the organisms and their physical environments on the one hand and among the organisms on the other hand. An eco-system can be defined as a system of regularly interacting and interdependent components forming a unified hole. It we study functional aspects of eco-system then an eco-system can be studied in terms of energy flow, food chain, diversity pattern in terms of time and space, bio-geo-chemical cycle, development and evolution and control mechanisms or cybernetics. In an eco-system, continuous interaction goes on between components and sub-components which involves the flow of energy. Food chain is one such example in which transfer of energy takes place in a sequential manner in one trophic level to those in another trophic level. In a food chain the members at the successive higher levels become smaller in number. When the numbers at successive levels are plotted, they assume the shape
Biosphere

of a pyramid, hence it is called food pyramid. Each ecosystem has certain inbuilt mechanism to maintain balance. Natural/biogeochemical cycle is one way. Biogeochemical cycles are nothing but the movement and circulation of soluble substances derived from sedimentary and atmospheric phases of inorganic substances through organic phase of various biotic components and finally their return to inorganic state. Some of the bio-geochemical cycles include hydrological cycle, carbon cycle, nitrogen cycle and phosphorous cycle.

Ecosystem can be classified into various types. The most widely used and simple classification is on the basis of habitats. On this basis, ecosystem can be divided as terrestrial and aquatic ecosystem. These ecosystems are further subdivided into various subtypes. Biosphere as the largest ecosystem remained undisturbed for billion years. But in recent years due to adverse human actions, lot of damage has been made and some of these are irreversible. Some of these phenomena are global warming, ozone layer depletion, acid rain, sea level changes etc. Today, at the global level, initiatives have been taken to address these problems. One of the significant development was United Nation Commission on Environment and Development. The Commission submitted its report whose title was “Our Common Future”. In this report the concept of sustainable development was brought forward. Sustainable development was defined as “meeting the needs of present generation without compromising the ability for future generation to meet their own needs”. Some of the strategies for sustainable development include revising growth, meeting essential human needs, ensuring a sustainable level of population, changing the quality of growth, conserving and enhancing the resource base, re-orienting technologies and managing the risks, and merging environment and economics in decision making process.

TERMINAL QUESTIONS

1. What is biosphere? Describe various components of biosphere with suitable examples.
2. Define eco-system. Explain the energy flow in the ecosystem with appropriate diagrams and examples.
3. What are bio-geochemical cycles? Explain hydrological cycles with suitable diagram.
4. Describe various causes and consequences of global warming?
5. Define sustainable development? Suggest measures to be adopted for achieving sustainable development.
14.1
1. (a) biosphere (b) biotic (c) biotic (d) decomposer
2. (a) sun (b) biologic (c) plants, animals and micro-organisms (d) lithosphere atmosphere and hydrosphere.

14.2
1. (a) autographs (b) herbivores (c) omnivores (d) food web (e) biosphere
2. (a) Ecology is the study of interactions between the organisms and their interaction
   (b) Food chain can be defined as the sequence of transfer of energy from organisms in one trophic level to those in another trophic level.
   (c) When the numbers at successive levels are plotted they assume the shape of a pyramid, hence it is called food pyramid.
   (d) Bio-geochemical cycles are nothing but the movement and circulation of soluble inorganic substances derived from sedimentary and atmospheric phases of inorganic substances through organic phase of various biotic components and finally their return to inorganic state.

14.3
3. (a) Rapid growth of human population, alarming rate of consumption, extravagant life styles (any two)
   (b) Carbon dioxide, methane, nitrous oxide and chlorofluorocarbon (CFC) (any two)
   (c) United States and Russia
   (d) Stratosphere
   (e) CFCs, halons, methyl chloroform, carbon tetrachloride
   (f) Sulphuric acid and nitric acid
   (g) Effects of acid rain are
      (i) Severely affects biomass and aquatic life in the lakes and streams
      (ii) Death or decline of forest (iii) destroy building and monuments

14.4
1. (a) Gro-Harlem Brundtlandt
   (b) Our common Future
Biosphere

(c) “Meeting the needs of the present generation without compromising the ability for future generation to meet their own needs”

(d) (i) Reviving growth (ii) Meeting essential human needs (iii) Ensuring a sustainable level of population (iv) changing the quality of growth. (v) conserving and enhancing the resource base (vi) Reorienting technology and managing risk (vii) Merging Government and economics in decision making. (Any three)

HINTS TO TERMINAL QUESTIONS

1. Please see para 14.1 and 14.2
2. Please see 14.3 Ecology and Ecosystem and its part (a) Flow of energy in the Ecosystem.
3. Please see para 14.3 (c) Natural/Bio-geo-chemical cycles
4. Please see para 14.5 (a) Green House Effects and Global warming
5. Please see para 14.6
In the previous lesson, you have learnt about the various aspects of biosphere. We have also discussed how various components of biosphere interact as well as complement each other. Energy which reaches from sun is the prime source for various lives on the earth. But, its distribution on the surface of the earth varies because of various reasons which you have already studied in the previous chapters. Because of this reason, the biotic life varies tremendously from hot humid to cold dry. Hence, they give rise to assemblage of plants and animal life in various geographical settings. In this context we will study the biotic lives and their interactions.

**OBJECTIVES**

After studying this lesson, you will be able to:

- recall the meaning of terms ecology, ecosystem, energy Flow etc.
- explain the term biome;
- identify different types of biomes;
- locate different types of biomes on the map of the world;
- describe environmental conditions of these biomes;
- establish the relationships between plant and animal communities;
- analyse the human responses with the biotic lives of that region.

**15.1 MEANING OF BIOME**

The word biome is a short form of biological home. There is no unanimity among the scientists as for as the definition as well as classification of biome is concerned. Biome may be defined as a large natural eco-system wherein we study the total assemblage of plant and animal communities. Here, all the biota have the minimum common characteristics and all the areas of biomes
are characterized by more or less uniform environmental conditions. Though a biome includes both plant and animal communities but a biome is usually identified and named on the basis of its dominant vegetation, which normally constitutes the bulk of the biomass. These vegetations are most obvious and conspicuous visible component of the landscape. By biomass we mean the total weight of all living organisms – plants and animals, found in the biome.

**Factors Affecting Biomes**

There are various factors which affects the size, location, and character of a biome. Important factors are as follow:

(i) Length of day light and darkness. This is mainly responsible for duration of photosynthesis.

(ii) Mean temperature as well as difference in temperature. Differences (both diurnal and annual) to find out extreme conditions.

(iii) Length of growing season.

(iv) Precipitation which includes total amount, variations over time and intensity.

(v) Wind flow that include speed, direction, duration and frequency.

(vi) Soil types

(vii) Slope

(viii) Drainage

(ix) Other plant and animal species.

**15.2 CLASSIFICATION OF BIOME**

There are two major bases of classifying biome.

In this section we will discuss two classifications which are simple and widely used. The bases of these two classifications and its various types are discussed below:

(A) On the basis of climate with special emphasis on availability of moisture

According to this basis biomes are determined by the degree to which moisture is available to plants in a scale hanging from abundant (forest biome) to almost scarce (desert biome). But within each biome, conditions of temperature are vastly different from low to high altitudes and low to high latitudes. Consequently there is a need to sub-divide each biome in to further sub-types. However, according to this classification, there are four major types of biomes:

(i) Forest biome

(ii) Savanna biome
(iii) Grossland biome
(iv) Desert biome

(B) On the basis of climate and vegetation

This classification argues that there is a close relationship between the world distributional patterns of plants and animal species and the climatic types of the world. Thus, based on this relationship the world has been divided into different biome types. The vegetation is the most dominant component of the biomes. As the vegetation and climate have intimate relationship the world is divided into various types on the basis of climates. Further, these climate based biomes are divided into various sub-types on the basis of vegetation. Look at the table No. 15.1 given below.

<table>
<thead>
<tr>
<th>Biomes of the first order (Based on climatic zones)</th>
<th>Biomes of the Second order (Based on Vegetation)</th>
<th>Biomes of the Third order (Combination of climate and vegetation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tropical Biome</td>
<td>(i) Tropical Forest Biome</td>
<td>(a) Evergreen Rain-Forest Biome</td>
</tr>
<tr>
<td></td>
<td>(ii) Savanna Biome</td>
<td>(b) Semi-evergreen Forest Biome</td>
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<td></td>
<td>(iii) Desert Biome</td>
<td>(c) Deciduous Forest Biome</td>
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<td></td>
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<td>(d) Semi-deciduous Forest Biome</td>
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<td></td>
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<td>(e) Monanne Forest Biome</td>
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<td></td>
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<td>(f) Swamp Forest Biome</td>
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<td></td>
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<td>(a) Savanna Forest Biome</td>
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<td></td>
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<td>(b) Savanna Grassland Biome</td>
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<td></td>
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<td>(a) Dry and arid desert Biome</td>
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<td>(b) Semi-arid Biome</td>
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<tr>
<td>2. Temperate Biome</td>
<td>(i) Boreal Forest Biome (Taiga Forest Biome)</td>
<td>(a) North American Biome</td>
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<td></td>
<td>(ii) Temperate Deciduous Forest Biome</td>
<td>(b) Asiatic Biome</td>
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<td>(iii) Temperate Grassland Biome</td>
<td>(c) Mountain Forest Biome</td>
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<td>(c) Soviet Steppe Biome</td>
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<td>(b) North-American Praries Biome</td>
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<td>(c) Pampa Biome</td>
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<td>(i) Austration Grassland Biome</td>
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<td>(ii) Southern Hemisphere Biome</td>
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<td>(a) Dry and arid desert Biome</td>
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<td>3. Tundra Biome</td>
<td>(i) Arctic Tundra Biome</td>
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<td></td>
<td>(ii) Alpine Tundra Biome</td>
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Table No. 15.1
Classification of Biomes on the basis of climate and vegetation
From the table 15.1 it is quite clear that a number of biomes are found in different parts of the globe. For detailed study, three Biomes – One from each climatic zone have been selected. Those three biomes are:

(i) The Evergreen Rainforest Biome
(ii) The Temperate Grassland Biome
(iii) The Arctic Tundra Biome

15.3 THE EVERGREEN RAINFOREST BIOME

(i) Geographical Background

This biome extends up to 10° latitude on both sides of the equator. It covers the area of Amazon low land of south America, Congo basin of equatorial Africa and South Eastern Asian Islands extending from Sumatra to New Guinea. This area is shown in the Fig. 15.2.

This area experiences high temperature throughout the year with range as little as 2°C. However, the daily range of temperature is much higher than the annual range of temperature. This area gets heavy rainfall ranging between 150cm-250cm. It is distributed throughout the year. Rainfall occurs in the afternoon almost on daily basis. This also happens because of huge amount of water vapor reaching in the atmosphere due to high temperature. Hence, this area is considered to be an equable climate as both temperature and rainfall are high for whole of the year.
(ii) Natural Vegetation and Animal Life

The combination of heat and moisture make this biome as perfect environment for a great variety of plants and animal species. The variety of plant species can be understood from the fact that one square kilometer may contain as many as about thousand of different types of plant species. Most of the trees have buttressed trunks, shallow roots and large dark evergreen leaves. The evergreen rainforest arranged in three levels. (a) The canopy or upper level where trees lies between about 20 metres to 50 metres. Most of them are hard wood trees like ebony, Mahogany, rose wood, sandalwood, cinchona, etc. (b) The second level of intermediary level where trees lies between about 10 meters to 20 meters. The most important plant of this group is palm trees. Apart from palm trees, epiphytic and parasitic plants are also found in this layer (c) The third or lower level lies from surface level to about 10 meters of heights. Under this category variety of plants are found namely orchids, ferns, mosses, herbs, bananas, pineapples etc. Because of tall and broad leaved dense plants, sunlight could not reach at the lowest level/surface. Because of poor photo-synthesis process at this level, number of plant species are very low.

Like vegetation, evergreen rainforest is inhabited by numerous birds, mammals, insets etc. Some important animals of this biome are Jaguar, lemur, orangutan, elephant, etc. Macaw parrot, sloth and toucan are some of the important birds of this area. Most of the birds are colorful. The water bodies of the equatorial areas are also rich in animal life with alligators, tactless, fishes, frogs, Hippopotamus etc. Because of the impenetrability and high vegetation growth in the lower part, most of the insects, birds and animals resides on the branches of the trees. Generally, they do not come down to the ground.

The productivity of the tropical rainforest biome is the highest of all biome types of the world. It may be pointed out that the rainforest biome represents only 13 percent of the total geographical area of the world but this biome accounts for the 40 percent of the total productivity of the world.

(iii) Human Response

Human being has also started to damage this biologically rich ecosystem through various developmental activities. These activities are construction of large dams and reservoirs, roads and high ways, extraction of timber clearance for pasture or crops, encroachment and clearance by landless peasants etc.
Ecologists argue that if clearance continues at recent rates, all of the world’s undisturbed rainforest is likely to have disappeared or to be damaged by 2020. This would lead to an irreparable loss of biological assets. Rainforests contain about 40% of all known species of plants and animals. Clearance of rainforest causes the loss of valuable natural resources including hard wood trees and tree products such as quinine, rubber, vegetable gums, etc.

This loss is just not ecological but also has very significant environmental consequences. The evergreen forest provides various environmental services by helping to regulate global weather patterns, soil erosion, river flooding in the tropics, etc. Evidences show that tropical deforestation have lead to the greenhouse effect and global warming by removing an important carbon sink.

INTEXT QUESTION 15.1

1. Answer not more than one sentence.

(i) What is the latitudinal extent of the tropical evergreen forest in the northern and southern hemisphere.

(ii) During which part of the day is most of the rainfall in the tropical evergreen forest occurs.

(iii) Name the three levels in which plant species are arranged in tropical evergreen forest biome.

(a) __________ (b) __________ (c) __________

(iv) Name any three factors responsible for deforestation in tropical evergreen forest.

(i) __________ (ii) __________ (iii) __________

(v) What are the two major environmental consequences of deforestation in tropical evergreen forest.

(a) __________ (b) __________

15.4 TEMPERATE GRASSLAND BIOME

(i) Geographical Background

Temperate grasslands are located in two typical locations i.e. interior of the continent in the northern hemisphere and margin of the continents.
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in the southern hemisphere. Therefore, the temperate grasslands of the southern hemisphere have moderate climate than their counterparts of the northern hemisphere because of more marine influences as they are closer to the coast. The temperate grasslands of the northern hemisphere are characterized by continental climate wherein extremes of summer and winter temperatures are well marked. Though grasslands in the southern hemisphere are located along the coast, these are located in the rain shadow areas of the high coastal mountains. These locations account for scanty rainfall in all these regions.

These grasslands are found in all the continents under different names. In the northern hemisphere, the grasslands are far more extensive. In Eurasia, they are called the steppes and stretch east wards from the shores of the Black sea to the plains of Manchuria in China. In North America, the grasslands are quite extensive and they are called prairies. They lie between the foot hills of the Rockies and the Great Lakes. In the southern hemisphere, these grasslands are less extensive. These are known as Pampas in Argentina and Uruguay. In South Africa, these grasslands are sandwiched between Darkensberg mountains and the Kalahari desert and are called veldt. In Australia, these grasslands are known as Downs and are found in the Murray – Darling basins of South Australia. Since all these grassland are located in the temperate zones, they are also known as temperate grasslands (see figure no. 15.3).

(ii) Natural Vegetation and Animal Life

As the precipitation is too low for the growth of trees but is sufficient
for the growth of grass. The natural vegetation of these regions comprises treeless grasslands. Trees appear only on slopes of mountains where precipitation is more. The height of grass varies from place to place according to the amount of precipitation and fertility of the soil. Steppes in particular are known for short and nutritious grass. The appearance of these grasses on these lands varies with the seasons. In springs, the grass beings to appear green, fresh and blooming with small and colourful flowers. In summers, due to the scorching heat and evaporation, the green grass turns yellow and then brown. Towards autumn, the grass withers and dies, but, the roots remain alive and lie dormant throughout the cold winter season. When spring comes, the whole cycle is repeated.

These grasslands are natural habitat of a variety of animals. Note worthy among them are antelopes, wild asses, horses, wolves, kangaroo, emu, and dingo or wild dog.

(iii) Human Response

No other biomes has ever undergone so many changes as the temperate grassland biomes. This has happened due to the human activities. (i) Majority of the grasslands have been converted into agricultural lands which have now become famous ‘granaries of the world’ (ii) The second crucial factor responsible for alteration of this virgin grasslands is pastoralism or domesticated of animals. Today virgin grass lands are very rare sight (iii) Large scale hunting of animals has resulted into phenomenal decrease of the population of some animals and disappearance and extinction of some animals. For example many species of animals such as antelope, Zebra, lions, leopards, hayenas have disappeared from the African Veldts by the mass hunting of animals by the European immigrants. (iv) The introduction of new animal and plant species has altogether changed the composition of native vegetation. For example introduction of sheep by the European settlers in Australia have changed the composition of vegetation community which was originally suited to the native marsupial animals. Like this introduction of few leguminous plants in Australian temperate grasslands suppressed several species of native perennial grasses.

INTEXT QUESTION 15.2

1. Fill in the blanks by selecting appropriate words from those given in the bracket:
   (granaries, interior, low, more, less)
(a) Mid-latitude grasslands of the northern hemisphere are located in the ________ parts of the continents.

(b) The annual precipitation in mid-latitude grasslands are very _________.

(c) In the northern hemisphere grasslands are for extensive whereas in the southern hemisphere grass lands are _______ extensive.

(d) Mid-latitude grasslands are known as the _________ of the world.

2. Match the following

<table>
<thead>
<tr>
<th>Continents</th>
<th>Name of the grasslands</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) South Africa</td>
<td>(i) Praries</td>
</tr>
<tr>
<td>(b) Eurasia</td>
<td>(ii) Pampas</td>
</tr>
<tr>
<td>(c) North America</td>
<td>(iii) Veldt</td>
</tr>
<tr>
<td>(d) Australia</td>
<td>(iv) Steppes</td>
</tr>
<tr>
<td>(e) South America</td>
<td>(v) Downs</td>
</tr>
</tbody>
</table>

15.5 THE ARCTIC TUNDRA BIOME

(i) Geographical Background

This is essentially a cold desert in which atmospheric moisture is scarce and summers are so short and cool that trees are unable to survive. This biome is distributed along the northern edge of the Northern Hemisphere. It covers parts of Alaska, northern parts of Canada, the coastal areas of Greenland and the Arctic Coastal regions of Russia and Northern Siberia (see map No. 15.4).
(ii) Natural Vegetation and Animal Life

The plant cover consists of a considerable mixture of species. Many of these species are dwarf form such as grasses, mosses, lichens, flowering herbs, and a scattering of low shrubs. These plants often occur in a dense, ground hugging arrangements. The plants complete their annual cycle hastily during the brief summers, when the ground is often moist and waterlogged because of inadequate surface drainage.

The animal of this biome may be categorized as (i) resident and (ii) migrant. Resident animals like ptarmigan can adjust themselves to the changing climatic conditions. The migratory animals, in contrast, begin migrating to the warmer places in the very beginning of winter. Examples are birds such as water fowl, ducks, swans, geese etc. which leave their places of origin in the first half of autumn and return in the following spring or early summer. Mosquitoes, flies and other insects proliferate astoundingly during the short warm season, laying eggs that can survive the bitter winter. Other forms of animal life are scarce – a few species of mammals and freshwater fishes but almost no reptiles or amphibians. Besides, the rein deer, wolves, foxes, musk-ox, artic hare, seal and lemmings also live in this region. Productivity in tundra biome is exceedingly low.

Productivity is defined as the total accumulated amount of energy stored by the autographic primary producers per unit area per unit time is called productivity.

The reasons for low productivity are (i) minimum sunlight and insolation (ii) absence or scarcity of nutrients such as nitrogen and phosphorous in the soils, (iii) poorly developed soils (iv) scarcity of moisture in the soils, (v) permanently frozen ground and (vi) very short growing period.

The tundra comes alive diving the summer thaw, when flowering plants support large populations of mosquitoes and flies, which in turn provide food for large numbers of migratory waterfowl.

(iii) Human Response

The harsh environment supports less population. The tribes of Samoyeds, Lapps, Finns and Yakuts in Eurasian Tundra and Eskimos of Canada and Alaska are some of the original inhabitants of this place and lead nomadic life for centuries. These tribes are now leading permanent or seminomadic life. They have adapted to new technologies. For example, deadly rifles have replaced the traditional and outdated harpoons. Thus the modern Eskimos equipped with modern technologies are now in a position to damage the tundra ecosystem in
the same way as is done by already technologically advanced man in other biomes. The Samoyeds and other tribes of the Eurasian Tundra have also adapted new way of life. Some of them are leading permanently settled life. They rear reindeers and fur animals and foods crops mainly wheat in Siberian Tundra. The recent discoveries of minerals such as gold and mineral oil in Alaska, iron ore in Labrador, nickel in Siberia have encouraged the growth of mining settlements and development of transport facilities. But mining activities have also lead to pollution and other environmental problem to this fragile eco-

**INTEXT QUESTION 15.3**

Answer the following questions briefly.

(a) Name any three animals of Tundra region.
   (i)________________________(ii)________________________(iii)________________________

(b) Which are the three important minerals found in these regions.
   (i)________________________(ii)________________________(iii)________________________

(c) Why productivity is low in tundra region. Give any two reasons.
   (i)________________________(ii)________________________

(d) Name any two tribes found in the tundra region.
   (i)________________________and (ii)________________________

**WHAT YOU HAVE LEARNT**

The word biome is a short form of biological home. Biome may be defined as a large natural ecosystem wherein we study the total assemblage of plant and animal communities. Here all the biota have minimum common characteristics and all the biomes are characterized by more or less uniform environmental condition. There are various factors which affect the size, location and character of a biome. These factors are length of daylight and darkness, mean temperature, length of growing season, precipitation, windflow, soil types, slope, drainage etc. There are two major bases of classifying biome – on the basis of climate with special emphasis on availability of moisture and on the basis of climate and vegetation.

Three biomes – one from each climatic zone have been selected for detailed study. These are (i) the Evergreen Rainforest biome (ii) the Temperate
Grassland biome and (iii) the Arctic Tundra Biome. The evergreen rainforest biome extends up to 10° latitude on both sides of the equator. This area experiences high temperature and heavy rainfall throughout the year. The combination of heat and moisture make this biome as perfect environment for a great variety of plants and animal species. Important plants found in this area are ebony, mahogany, rosewood, sandal wood etc. Along with plants, there are various types of orchids, term, mosses, herbs are also found at the ground level. These plants are mostly hard-wood trees. Like vegetation, evergreen rainforest is inhabited by numerous birds, mammals, insects etc. both in land as well as in water. The productivity of the tropical rainforest biome is highest of all biome types of the world. Today, human being has also started to damage this biologically rich eco-system through various developmental activities. Due to this, various ecological as well environmental problems have emerged like green house effect and global warming. The temperate grasslands are located in two typical locations – interior of the continents in northern hemisphere and margins of the continent in the southern hemisphere. Both the locations receive scanty rainfall. These grasslands are known by different names in different parts of the world – steppes in Eurasia, prairies in North America, downs in Australia and veldt in South Africa. The natural vegetation of these regions comprises treeless grasslands. Trees appear only on mountain stapes where precipitation is more. These grasslands are inhabited by antelopes, wild asses, horses, wolves, kangaroos, emu and dingo or wild dog. No other biomes has ever undergone so much change than the temperate grassland biomes. This has happened due to various human activities. The Arctic Tundra Biome is essentially a cold desert in which atmospheric moisture is scarce and summers are short and cool. This biome is distributed along the northern edge of the northern hemisphere. The plant and animal species are few. The plant cover consists of a considerable mixture of species. Many of the species are dwarf forms such as grasses, mosses, lichens, flowering herbs and a scattering of low shrubs. The animals of this biome may be categorized as (i) resident and (ii) migrant. Important species are reindeer, wolves, foxes, musk-ox, artic-hare, seal and lemmings. The harsh environment of this biome supports less population. The tribes of Samoyeds, Lapps, Finns and Yakuts in Eurasia, Eskimos of Canada and Alaska are the original inhabitants of this biome and lead nomadic life for centuries. They inflected damage to Tundra animals through hunting. Now many of these tribes have adopted settled life. The recent discoveries of minerals have encouraged the growth of mining settlements. But mining activities have also lead to pollution and other environmental problems to this fragile eco-system.
TERMINAL QUESTIONS

1. What is a biome? Describe the classification of biomes on the basis of climate and vegetation.
2. Explain the location, climate, natural vegetation and animal life in the evergreen rainforest biome.
3. Describe various factors responsible for the size, location, and character of a biome.
4. “No other biomes has undergone so much changes as the temperate biomes” Justify the statements with suitable arguments.
5. Analyse the role of climate on the plants and animal life in the Tundra region.

ANSWER TO INTEXT QUESTIONS

15.1

1. (i) 10° North and South
   (ii) Afternoon
   (iii) (a) Construction of large dams and reservoirs (b) Construction of roads and highways (c) Extraction of timber (d) Clearance for pasture or crops (e) Encroachment and clearance by landless peasants.
   (iv) (a) greenhouse effect (b) global warming.

15.2

1. (a) interior
   (b) low
   (c) more, less
   (d) granaries.
2. a. iii
   b. iv
   c. i
   d. v
   e. ii
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15.3

(a) rein deer, wolves, foxes, musk-ox, arctic hare, seal, lemmings (any three)
(b) gold, iron and mineral oil.
(c) (i) minimum sunlight and insolation (ii) absence of nutrients (iii) poorly developed soil (iv) scarcity of moisture in the soils, (v) permanently frozen ground and (vi) very short growing period (any three)
(d) Samoyeds, Lapps, Finns, Yakuts, Eskimos (Any two)

HINTS TO TERMINAL QUESTIONS

1. Refer to section 15.1 and 15.2
2. Refer to section 15.3
3. Refer to section 15.1
4. Refer to section 15.4 (iii)
5. Refer to section 15.5