GOVERNMENT OF TAMIL NADU

GEOGRAPHY

HIGHER SECONDARY FIRST YEAR

Untouchability is Inhuman and a Crime

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B169_11_GEO_EM

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Lets use the QR code in the text books ! How ?
- Download the QR code scanner from the Google PlayStore/ Apple App Store into your smartphone
- Open the QR code scanner application
- Once the scanner button in the application is clicked, camera opens and then bring it closer to the QR code in the text book.
- Once the camera detects the QR code, a url appears in the screen.Click the url and goto the content page.

HOW TO USE THE BOOK

Chapter Outline
Provides the major components of the unit to be learned.

Learning Objectives
At the begining of each lesson it provides the scope of lesson.

Introduction
The subject to be discussed in the lesson is introduced

Unit IV

Lithosphere: Exogenic Processes

Chapter Outline

4.1 Introduction
4.2 Exogenic Processes
4.3 Weathering
4.4 Mass wasting
4.5 Gradational Processes
4.6 River
4.7 Glacier
4.8 Ground water (Karst Topography)
4.9 Wind
4.10 Waves (Coastal)

Learning Objectives:

- Understand how external forces reshape the surface of the earth.
- Distinguish between physical weathering and chemical weathering.
- Identify the different types of mass wasting and its characteristics.
- Distinguish between the actions of various gradational agents.

At Mahabalipuram, Chennai, the 6 meter high and 5-meter wide rock estimated to weigh over 250 tons is known locally as Krishna's Butter Ball. Its original Tamil name is "Vaanirai Kal" which literally translates to "Stone of The Sky God".
Look at the figure above Krishna's Butter ball inserted on the top and let's discuss:

- What, do you think, made this rock stone to get this shape?
- Guess how many years it might have taken to get such a shape.
- Think about how it is standing balanced?

4.1 Introduction

Let's recall that you have learned in the previous chapter about geomorphic processes - Endogenic processes in detail. Now we deal with the exogenic processes. The forces which act on the earths exterior are called as exogenic forces or external

Agriculture in India mostly depends on the rainfall brought by the monsoons.

During the El Nino year the temperature of the ocean water increases. This weakens the high pressure over Indian Ocean thereby reduces the strength of south west monsoon over south Asia. However during winter, it induces the low pressure over the ocean resulting in severe depressions and cyclones.

6.4.9 Tertiary Winds

The tertiary winds are formed due to pressure gradients which may develop on a local

DO YOU KNOW?

Mountain and valley wind system influences the weather pattern of the mountain top and valley bottom. Mountain top can be seen clearly at early morning and valley bottom at evening. But mountain top will be covered with clouds at evening due to rising of valley wind system and valley bottom would be covered by clouds at early morning due to arrival of mountain wind system.

CASE STUDY

Mawsynram, world's wettest place!

"It was the kind of rain you wouldn't see anywhere else. We could barely see four feet ahead of us. We could touch the clouds, smell the clouds, and taste the clouds" said a local resident. Yes, it is about Mawsynram which is located in Meghalaya's East Khasi Hills, with the cluster of about 1,000 homes. It holds the Guinness Record for "the wettest place on earth". The average annual rainfall is 11,861mm, according to the Guinness website.

However, the soil in the limestone plateau doesn't absorb water. "There is barely any forest cover, so a lot of erosion of top soil happens. All of it flows down into Bangladesh. The irony is that "the wettest place on earth" grapples with an acute water shortage after monsoon ends around October. Hence, people call world's rainiest place Mawsynram, which is also world's wettest desert.

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Case Study
provides Detailed account of an aspect related to the topic .

Do You Know ?
Provides additional information related to the subject in boxes to stir up the curiosity of students.

QR Codes

Given to make content more interesting and dynamic in nature to enhance thinking skills.

Interactive Atmosphere's URL:
https://www.pbslearningmedia.org/resource/ess05.sci.ess.watcyc.vertical/vertical structure-of-the-atmosphere/#.Wq-xD8OuzIU
*Picture are indicative only.

Student Activity

Students have to collect the recent names of the hurricanes, typhoons and cyclones and date and location of landfall in last 5 years.

6.8.5 Tornado and Water Spouts

It is a very small intense, funnel shaped very speed whirl wind system. Its speed and direction of the movement are erratic (Figure 6.36). The winds are always as fast as 500 km ph. The fast moving air converges in the middle and rises up. The uplift is capable of rising dust, trees and other weaker objects in its path. South and western part of Gulf States of USA experiences frequent tornados.

Water spouts are formed over water body similar to tornados in the formation and structure. This sometimes leads to fish rain, if the mass of fish comes under the water spout.

Fact File

Cloud Seeding or Artificial Rainfall

People have always wanted to create rain, so that they would not suffer from drought. Modern science has been successful in causing rain in a limited way through cloud seeding. This method is based on the knowledge of growing ice crystals in clouds.

One method to cause rainfall from clouds is to introduce particles of dry ice (solid CO_2) into the cloud from an air plane. The dry ice causes ice crystals to form in the cloud. These ice crystals coalesce, grow, melt and fall as rain. Cloud seeding will not be successful unless the cloud is already saturated with water vapour.

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Fact File

Gives information in short and expresses connection with other areas of interests.

Student Activity

For self study and self evaluation of the students.

ICT Corner

The access to digital resources on the content through linkage with a specialised app providing scope for students to learn.

GLOSSARY

1. Orogeny: structural deformation of lithosphere due to interaction between tectonic plates
2. Conorod boundary: Margin between the upper crust and the lower crust.
3. Shearing fault: the fault is created by shearing along the plate boundary.
4. Laccoliths: are large dome-shaped intrusive rock connected by a pipe.
5. Lapolith: When the magma moves upwards, a saucer shape, concave shaped body called lapolith.

TOPIC: Atmosphere Vital Blanket

Use the URL to reach 'Vertical Structure of the Atmosphere' page. Click launch to start the interactive atmosphere page.

Figure 2.15 Lunar eclipse

Reference

1. Physical geography: fundamentals of the physical environment V. Ettwein and M. Maslin
2. Introducing Physical Geography, John Wiley & Sons.
3. Fundamentals of Geomorphology Richard John Huggett

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Glossary

The highlighted key terms at the end of the lesson for conceptual clarity.

Reference

References and web resources have been provided for getting additional information.

CAREER GUIDANCE FOR GEOGRAPHY ASPIRANTS

NRSC

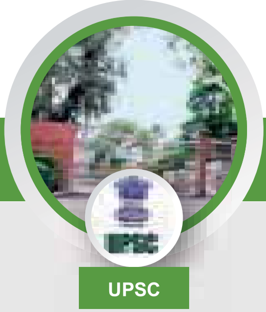
Geographers in State and Central Government Agencies

- Census of India Offices in different States.
- National Remote Sensing Centre (NRSC), Hyderabad.
- Survey of India (SoI), Dehra Dun and in different States.
- National Atlas and Thematic Mapping Organizaiton (NATMO), Kolkata.
- Regional Planning/Town and Country Planning Organisations.
- Naval Hydrographic Office, Dehra Dun.
- National Centre for Earth Science Studies, Thiruvananthapuram.
- Centre for Water Resources Development and Management, Kozhikode.
- Central Arid Zone Research Institute, IndianCouncil of Agricultural Research, Jodhpur.
- Central Research Institute for Dry Land Agriculture (ICAR), Hyderabad.
- National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Nagpur.
- French Institute of Pondicherry, Puducherry.
- National Institute of Malaria Research, (ICMR), New Delhi.

IMD

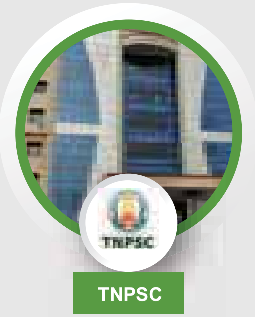
Organisations Supplying Special Publications / Databases and Impart Trainings to Geographers

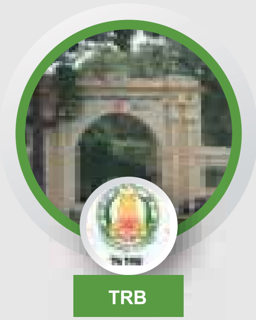
- Remote Sensing:Publications and Public Relations Unit, ISRO HQ, AntarikshBhavan, New BEL Road, Bangalure-560 094; NRSC Data Centre, National Remote Sensing Centre, Balanagar, Hyderabad-500 037; Remote Sensing Applications Group, Space Application Centre, SAC Post, Ahmedabad- 380 053;Indian Institute of Remote Sensing, 4-Kalidas Road, Dehradun- 248 001.
- Cyclone, Rainfall and Weather Information: Indian Meteorological Department, Nungambakam, Chennai – 600 006.
- Survey of India - Topographic Sheets: Map Sales Office, Electronic Complex - Block II Ground Floor, Thiru. Vi. Ka. Industrial Estate, Guindy, Chennai – 600032.
- Geology and Minerals:Department of Geology and Mining, Thiru. Vi. Ka. Industrial Estate, Guindy, Chennai - 600 032;Geological Survey of India, No A 2 -B Rajaji Bhavan, Besant Nagar, Chennai – 600090.
- Surface and Groundwater and Climate Data: Office of the Chief Engineer, State Ground and Surface Water Resources Data Centre,Tharamani, Chennai - 600 113; Central Ground Water Board. http://www.india-wris.nrsc.gov.in
- Soil Data and Maps:Regional Head, ICAR-NBSS&LUP, P.B.No. 2487, Hebbal, Agricultural Farm, Post, Bengaluru - 560 024.
- Rainfall, Landuse, Irrigation and Crop Data:Village / Block/Taluk level Data available at Department of Economics and Statistics, All District Headquarters; Department of Economics and Statistics, 259, Block II, DMS Compound,Teynampet, Chennai-600006.
- Soil, Rainfall and Weather Data: Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore – 641003.http://tawn.tnau.ac.in/General/HomePublicUI.aspx
- Population Data:Census of India - Tamil Nadu, 'E' Wing, 3rd Floor, Rajaji Bhawan, Besant Nagar,Chennai – 600090. http://censusindia.gov.in/
- Economic Appraisals & Annual Statistical Abstracts of Tamil Nadu:Stationery and Printing Department, 110, Anna Salai, Chennai-600002.http://www.stationeryprinting.tn.gov.in
- Soil and Watershed Atlas: Remote Sensing Centre, Agriculture Engineering Department, Nandanam, Chennai - 600 035. http://www.aedatlas.tn.nic.in
- GIS Data Layers of Tamil Nadu:Tamil Nadu Geographical Information System (TNGIS), Chepauk, Chennai – 600 005. http://www.tngis.tn.gov.in



Competitive examinations comprising Geography subject matter are listed below

- UPSC civil service examinations conducted by Govt. of india.
- Tamilnadu Public Service Commission Group services Examinations conducted by Govt.of Tamilnadu.
- Teachers Recruitment Board,School education and Collegiate education,Govt.of Tamilnadu.





Universities and Colleges Offering B.Sc., M.Sc., in Geography and M.Tech Programme in Geoinformatics in Tamil Nadu

- Department of Geography, University of Madras, Chepauk, Chennai – 600 005.
- Department of Geography, Madurai Kamaraj University, Madurai - 625 021.
- Department of Geography,BharathidasanUniversity,Tiruchirappalli - 620 024.
- Department of Geography, Central University of Tamil Nadu, Thiruvarur –610 005.
- Department of Environmental Remote Sensing and Cartography, Madurai KamarajUniversity, Madurai - 625 021.
- Department of Geography, Presidency College (Autonomous),Chennai – 600 005.
- Department of Geography,Queen Mary's College (Autonomous), Chennai - 600 004.
- Department of Geography,Bharathi Women's College (Autonomous), 85, PrakasamSalai, Chennai-600 108.
- Department of Geography, Tourism and Travel Management, Madras Christian College (Autonomous), Tambaram, Chennai - 600 059.
- Department of Geography, Government Arts College (Autonomous),Salem – 636 007.
- Department of Geography,Sri Vijay Vidyalaya College of Arts and Science, Nallampalli, Dharmapuri – 636807.
- Department of Geography,Arignar Anna Government Arts College, Namakkal – 637002.
- Department of Geography, Government Arts College (Autonomous), Coimbatore - 641 018.
- Department of Geography, Nirmala College for Women (Autonomous), Coimbatore – 641 018.
- Department of Geography, Bharathiar University Arts & Science College, Amaikulam, PuliamParai (P.O.), Gudalur - 643 212.
- Department of Geography, Government Arts College (Autonomous), Karur – 639 005.
- Department of Geography, Periyar E.V.R. College (Autonomous), Tiruchirappalli – 620 023.
- Department of Geography,Government Arts College,Thiruverumbur, Tiruchirappalli – 620 022.
- Department of Geography,KundavaiNachiar Government Arts College for Women (Autonomous), Thanjavur - 613 007.
- Department of Geography, A.V.V.M Sri Pushpam College (Autonomous),Poondi - 613 503, Thanjavur District.
- Department of Geography, Government Arts College (Autonomous), Kumbakonam- 612 002.
- Department of Geography, Government Arts College for Women (Autonomous), Kumbakonam - 612 002.
- Department of Geography,SriMeenakshi Government Arts College for Women (Autonomous),Madurai – 624 002
- Department of Geography, MVM Government Arts College for Women, Dindigul - 624 008..
- Department of Geography, Government Arts College for Women, Nilakottai - 624 208, Dindigul District.

Unit I

Fundamentals of Geography

7VXSHI

Chapter Outline

Learning Objectives:

- *Define the concept of geography*
- *Appreciate the developments of geography*
- *Understand the traditions and themes of geography*
- *Associate the relationship of geography with other disciplines*
- *Identify the approaches to study geography*
- *Examine various branches of geography*
- *Appreciate the tools, skills and scopes of geography*

1.1 Introduction

"*The study of Geography is about more than just memorising places on a map. It is about understanding the complexity of our world, appreciating the diversity of cultures that exists across continents. And in the end it is about using all that knowledge to help bridge divides and bring people together*" - Barak Obama, Former President of USA.

The subject 'Geography' was considered as 'The Mother of all Sciences' as most streams of sciences took root from geography. It is a subject much needed in everyday life .Unfortunately, in the recent past it has been demoted to the back seat in most parts of the world, while certain other sciences hold prominent places in the society. Just as an intellectual understands the value of a library, a financier understands the value of money, a parent understands the value of their child a geographer understands the value of our planet earth and the wealth of resources it offers to us. A society that lacks sufficient geographic knowledge cannot be expected to exhibit its strength of resource potentials and empowerment to make decisions in real-world context. Therefore, the knowledge of geography is very much vital for the care and concern of the earth, growth and development of every country and for minimising the issues related to human activity. In this context, the National Geographic Society, USA defines geographic literacy as being equipped to understand the complexity of the world, how our decisions affect others (and vice versa), and the interconnectedness of this rich, diverse, and not-so-large world.

This unit introduces the student to the foundations over which the subject had developed in the past, the content it offers now and the changes that it had undergone. It also opens the door to the world of physical geography and the practical skills to be acquired to understand geography which are explained in the units following this.

1.2 Defining Geography

Geography is one of the oldest earth sciences and its roots date back to the works of the early Greek scholars. The term '**Geography**' was coined by the Greek scholar **Eratosthenes** who combined two Greek words 'Geo' (The Earth) and 'Graphien' (to describe). Therefore, in the literary sense, geography is the description of the Earth. Over the ages, geography has become the art and science of studying the physical characteristics of the earth and man's role in adapting to and modifying the environment.

Geography was born through explorations and discoveries. Earlier, the aim of geography was to discover new lands, sea routes, prepare maps and describe them. Later, its emphasis had shifted to scientific investigation of earth's landforms, oceans and atmosphere, as well as the interactions with human beings and the environment.

In essence, geography can be defined as a multifaceted discipline studying intra and inter relationships of various spheres of the earth, collects and analyses relevant data, applies the latest tools and methods to prepare maps and visuals and provides sustainable solutions to human and environmental issues of the earth.

1.3 Evolution of Geography

Geography had evolved over a long period of time. Some of the earliest geographical studies go back about four thousand years ago through explorations. The early explorers travelled and tried to map the new places. The evidences of such explorations come from the archaeological discovery of a Babylonian clay tablet map that dates back to 600 BCE. During this time, Phoenician, Chinese and Egyptian civilisations were in the beginning to explore places outside their homelands. It was the ancient Greek scholars who laid the foundations and gave a solid form to geographic studies and on these foundations, the pillars of modern geography were erected by others in the subsequent ages. The Romans, the Arabs, the Indians, the Chinese, the Germans, the French, the British and the American geographers have contributed to the development and enrichment of the subject.

The Greek philosophers and scientist focused on the spatial nature of human and physical features of the Earth. The first Greek geographer was Herodotus (484 - 425 BCE) who wrote a number of volumes on the human and physical geography of the Persian Empire. The other early Greek contributors to geography are, Thales, Aristotle and Eratosthenes (276 - 194 BCE).

The earlier geographers were descriptive geographers concerned with answering questions like 'what is where' on the earth and the question like 'why it is there' came later. 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, housing and agriculture. They discover the linkages and movements between places and are able to infer the spatial processes that are working in these areas.

The development of geography can be summarised in three phases namely (1) The age of discovery (1400-1800), (2) The period between 1800 and 1950 and (3) The period after 1950.

1.3.1 The age of discovery between 1400-1800

The period between 1400 and 1800 was when the subject matter and the methodology of geography were not fully developed. The discipline was in an embryonic stage. This period was characterised by exploration, discovery and conquest through the voyages of Vasco da Gama and Christopher Columbus. Numerous journeys of geographical exploration were commissioned by a number of Nations in Europe (Figure. 1.1, 1.2, 1.3 and 1.4). Most of these voyages were financed because of the potential commercial returns from resource exploitation. The voyages also provided an opportunity for scientific investigation and discovery. Making of maps (cartography) was important in the discipline of geography due to the emphasis on location of phenomena on the earth surface, e.g. location of trade routes, relief features and settlements.

1.3.2 The period between 1800 -1950

The period between 1800 and 1950 was characterised by the work of various individual philosophers who helped to expand the scope of geography. The discipline of geography became more distinct as a subject matter. Geographic knowledge saw strong growth in Europe and the United States in the 1800s. This period also saw the emergence of a number of societies interested in geographic issues. In Germany, Alexander Von Humboldt, Carl Ritter and Friedrich Ratzel made substantial contributions to human and physical geography. Humboldt's publication 'Kosmos' in 1844, examines the geology and physical geography of the earth. This work is still considered by many academics as a milestone contribution to geography.

There are two schools of thought that emerged during this period as an attempt to explain the relationship between human beings and their environment. These were *environmental determinism* and *possibilism*. Proponents of environmental deterministic school of thought such as Mackinder, Ellen Semple and Huntington believed that human actions and activities were moulded by the physical (natural) conditions. In several developing countries, human beings are susceptible to natural disasters such as drought, famine, floods and earthquakes. Human beings under such natural conditions usually surrender to nature. A good example of environmental determinism is the influence of the natural environment on human activities such as nomadic pastoralism. Nomadic pastoralism is so much dependent on the natural environment. Pastoralists do very little to modify their environment.

Ratzel

La Blache

The proponents of possibilistic school of thought, such as Vidal de la Blache saw the environment as a limiting factor rather than as a deterministic force. According to the possibilism school of thought, human beings have several alternatives in their environment and their actions are influenced by the decisions they make in the environment. For instance, humans can survive in hot or extremely cold conditions due to their ability to modify the environment to suit them. A good example is that in many arid countries such as Israel, humans have overcome the constraints set by the natural environment such as low rainfall, high temperatures and poor soils.

1.3.3 The period after 1950

Until 1950s, geography was more of an art subject where facts were established by casual observation in the field rather than by careful measurement and hypothesis testing. In the 1950s there was a new development in the discipline and several laws were established to explain geographical phenomena. Using the laws, it is possible to predict what will happen in the future. If we can predict successfully, we can plan and limit the extreme possibilities.

One of the important developments in this period was the use of quantitative techniques in physical and human geography. These techniques refer to various statistical tools that are used to synthesise the data from maps, field, laboratories and questionnaires. Quantification came about as a result of the expanding scope of the discipline as well the need to understand the processes that were becoming more diversified and complicated.

This quantitative revolution was referred to as a revolution because it marked a new beginning in the way the subject matter of geography was to be studied. The quantitative revolution involves the use of statistics, mathematical equations and the use of deterministic models. Many geographers believed that numbers are more precise, and therefore perceived as more scientific compared to words. The map, both as graphic language and visual representation, continues to be used as a geographical tool and at present with the valuable assistance of remote sensing and Geographical Information Systems, map making has become digital and easier especially due to advances in computer and software technologies.

1.4 Themes of Geography

In any subject there will be certain themes, around which the scholars work and contribute. In this way, geography subject also has certain traditional themes. Let us look at them carefully. In 1963, **William D. Pattison** identified the core themes of geographic studies as **'The Four Traditions**

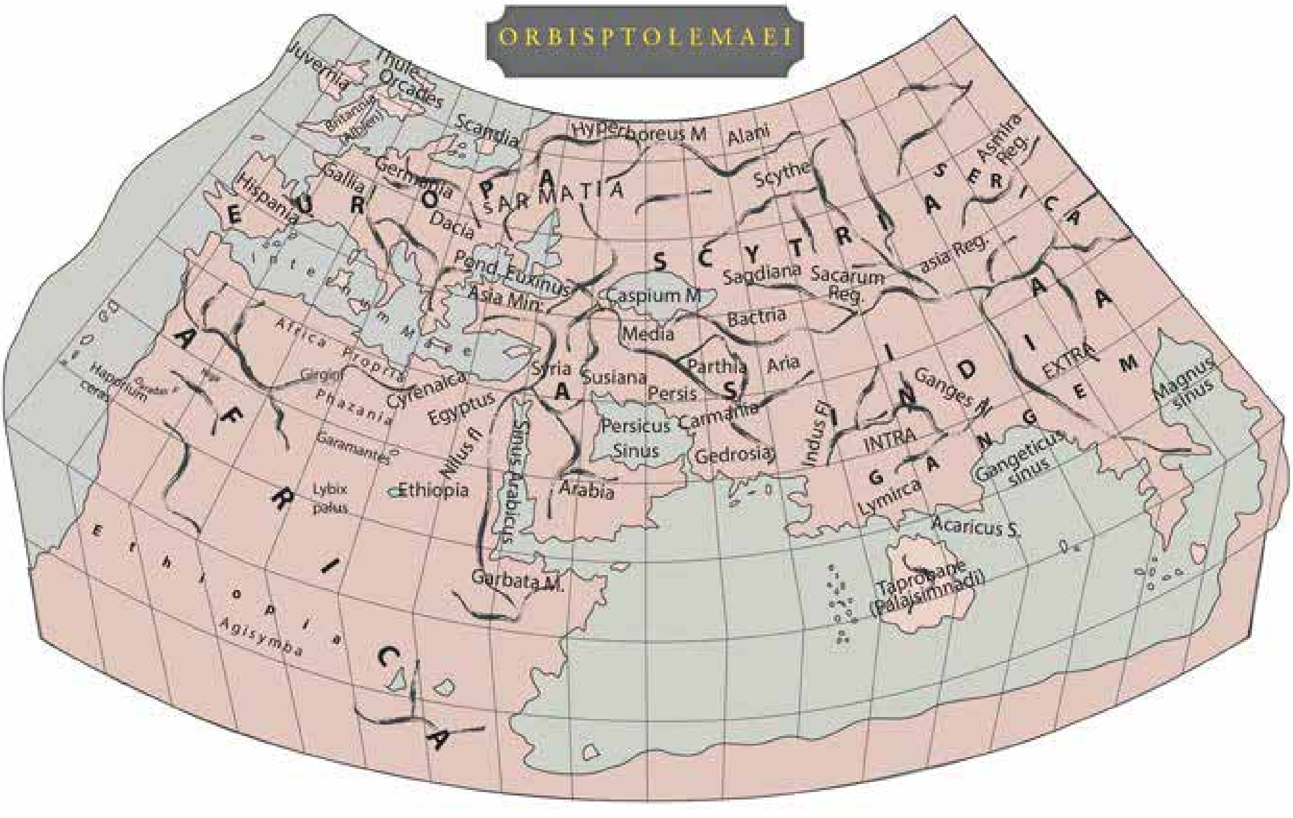


Figure 1.1 Ptolemy's World Map

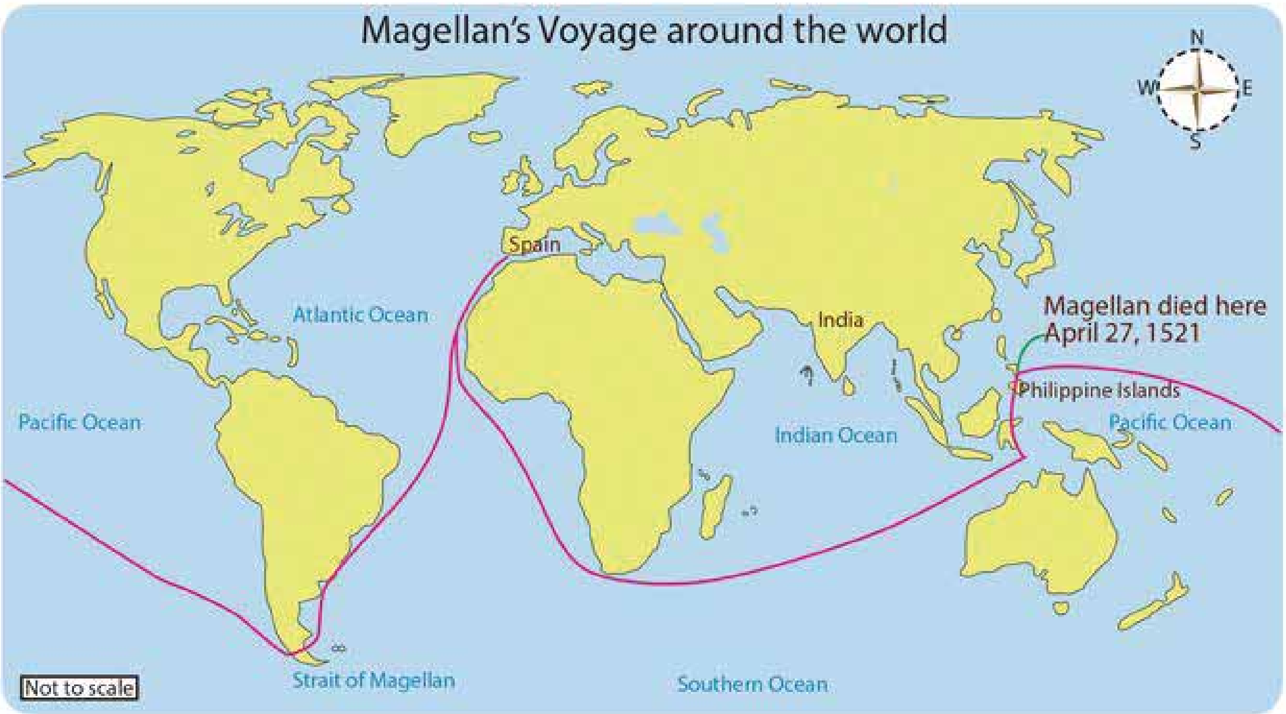


Figure 1.2 Magellen's Voyage around the World

of Geography'. These distinct, but related, traditions, of the discipline are: Spatial tradition (areal distributions and spatial patterns. Examples: Population movement) Area studies tradition, (hierarchy of areas, small to large) Man-land tradition

Figure 1.3 Vosco da Gama

HOTS

How might the ship that Columbus traveled have sailed at the time when no engine and power fuel available?

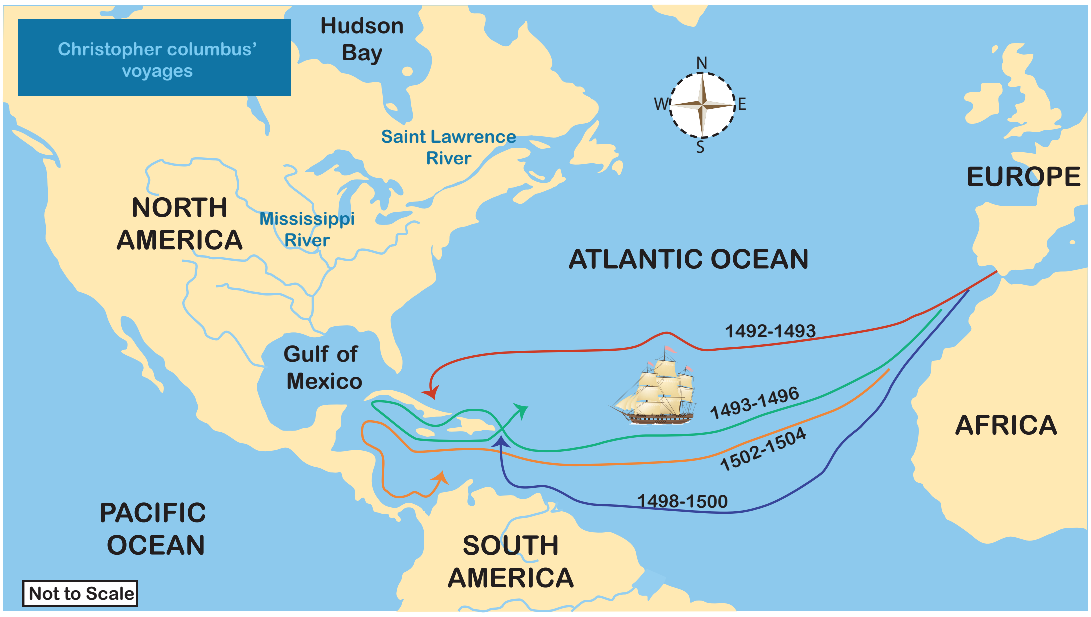


Figure 1.4 Christopher Columbus's Voyages to America

(relationship between man and his physical environment) and Earth science tradition (processes of the earth).

DO YOU KNOW?

Five Themes in Geography

Themes of Geography are the educational tools for understanding the geography subject in detail. It was adopted in the year 1984 by the Association of American Geographers and these five themes were published in the National Council for Geographic Education/Association of American Geographers' publication Guidelines for Geographic Education.

Like the major traditions identified in geography, the significant themes of the subject are also identified. The Association of American Geographers put forward the 'Five themes of Geography' and it has been widely accepted by geographers worldwide (Figure1.5). The themes are location, place, human – environment interaction, movement and regions.

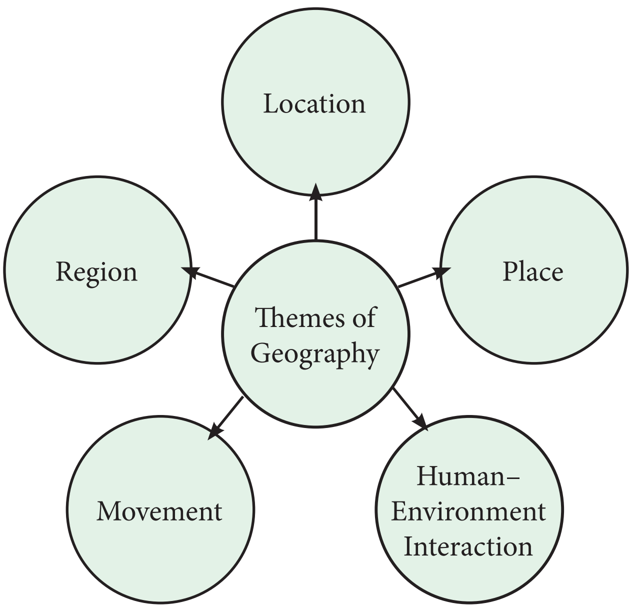


Figure 1.5 Themes of Geography

1.4.1 Location

Every point on earth has a location. The location can be described in two different ways:

- *Absolute location* is a location as described by its latitude and longitude on the earth. For example, the coordinates of Chennai Central Railway station are 13°04'56" N latitude and 80°16'32" E longitude.
- *Relative location* is the position of a place in relation to another well-known landmark. For example, Kallanai Dam or Grand Anicut is located roughly 350 km south –southwest of Chennai City. The absolute and relative location related surveys and studies fall under this category.

1.4.2 Place

A place is an area that is defined by everything in it. All places have features that give them personality to distinguish them from other places. A number of place names in Tamil Nadu, like Redhills, Fort St. George, Mint, and George Town are examples to this theme.

Student Activity

1. Find the absolute location of your district.
2. Find the important towns within a radius of 100 km from your residence or school along with their direction.
3. Find how the name of your village or town came into existence.
4. Find the total population of your town or village as per 2011 census.
5. Find the altitude of your village or town from Mean Sea Level.

- Toponym: A place name, especially one derived from topographical feature.
- Site: An area of ground on which a town, building, or monument is constructed.
- Situation: The location and surroundings of a place.

1.4.3 Human-Environment Interaction

The theme describes how people interact with the environment and how the environment responds. These are studied with reference to the following three key concepts:

- Dependency: How humans depend on the environment (Example: For water, fresh air, sunlight etc.)
- Adaptation: How humans adapt to the environment (Example: Life in polar or desert regions)
- Modification: How humans modify the environment (Example: Construction of Underground Metro rail, Agriculture in Israel).

1.4.4 Movement

Movement is the network of travel of people, goods and ideas from one location to another. Examples: Rural-urban migration and metro train commuting in Chennai. **Air transport** which carries people and goods and the **internet** that allows access to ideas and knowledge across the world are also examples of this kind.

1.4.5 Region

Regions are areas with distinct homogenous characteristics such as climate (Monsoon regions), natural vegetation (Tropical rain forests), crops (Corn Belt of USA), major landforms (Himalayan region), industries (Chota-Nagpur plateau) etc.

1.5 Geography's Relation with Physical and Social Science Disciplines

While defining geography, we have seen that some branches of geography have strongest affiliations with subjects like mathematics and environmental sciences, while others have very close connection with history and sociology. Some subjects deal with distinctive type of phenomena while geography examines several kinds of phenomena together. The diagram (Figure 1.6) gives clear idea about the relationship of geography with other disciplines.

Relations with Physical Sciences

1.5.1 Astronomy, Mathematics, Computer Science and Geography:

Astronomy basically deals with the celestial bodies including stars, planets, satellites, their motions, constellations, as well as different kinds of phenomena occurring in the outer space. The precise location, nature of movements, form and size of celestial bodies, including those of the solar system, have been accurately measured with the help of mathematics. The interaction of astronomy, mathematics and computer science with geography has paved way for the development of modern cartography and GIS.

1.5.2 Geology and Geography:

Geology is the study of rocks, their types, distribution, mineral content, petroleum, etc. The subject investigates all these phenomena, classify them and put them in a sequence. Geography interacts with the subject in studying the distribution of exposed rocks, interaction with climate and human activities, economic prospects of the minerals and so on. Interaction between geology and geography leads to formation of the new branch of study called geomorphology, the study of landforms.

1.5.3 Physics, Chemistry and Geography: As geography is the study of variable phenomena on the earth's surface, the dynamic mechanism of the phenomena requires to be studied within the framework of physics. The physics of atmosphere is studied under climatology and the physics of hydrosphere through oceanography, and both the subjects investigate, interpret and explain the atmospheric and hydrological processes. The chemical contents of rocks, soil, surface and groundwater, atmosphere are the interests of the geographers. They study how the physical and chemical contents are disturbed by human activities and vice versa.

1.5.4 Botany, Zoology and Geography: The systematic branches of botany and zoology have traditionally been confined to the classification and description of various kinds of species on the earth's surface. Geography, being the study of the spatial section of earth's surface, attempts to study the distributional aspects of flora and fauna

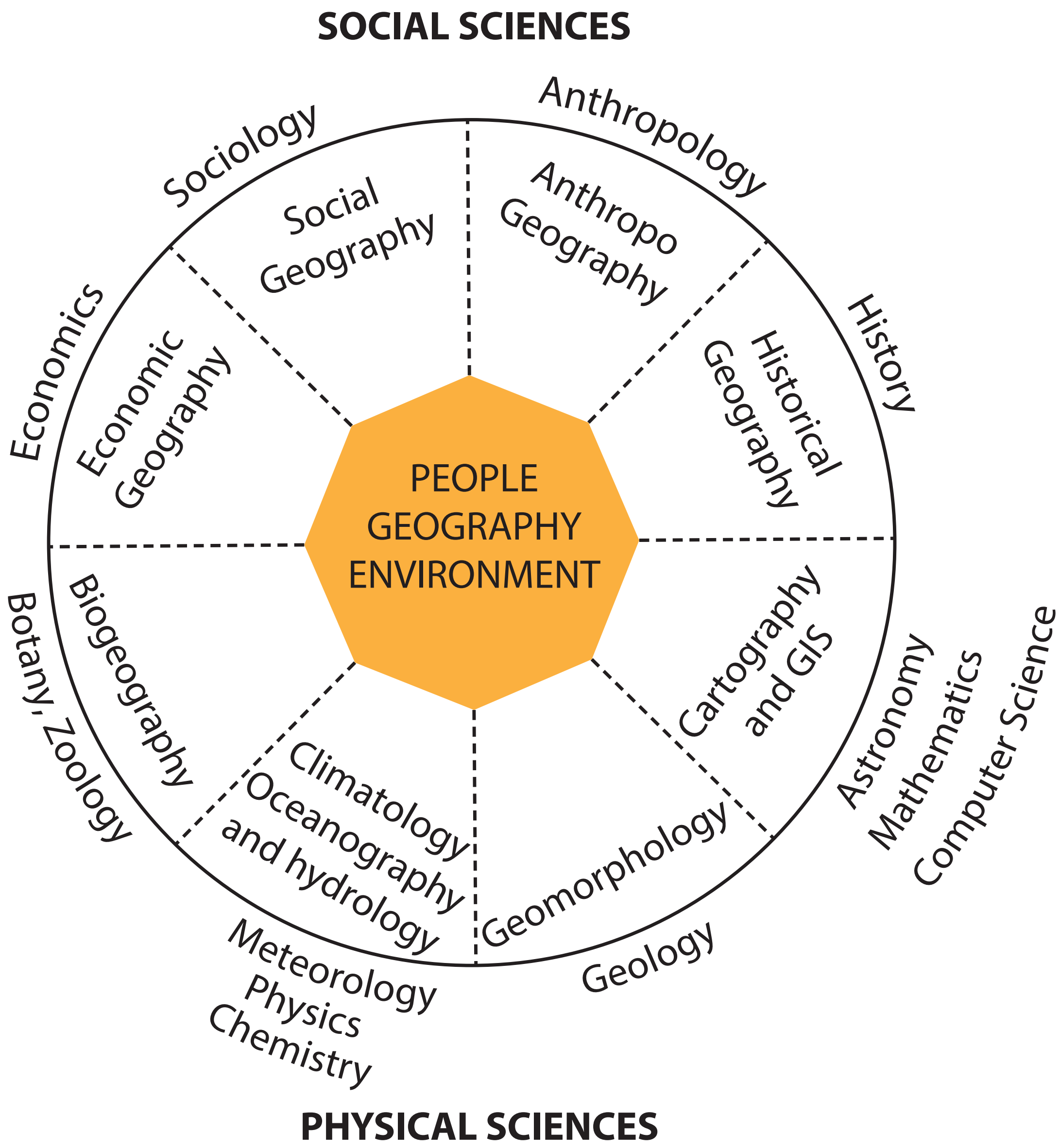


Figure 1.6 Relationship of Geography with Physical and Social Science Disciplines

especially with reference to climate and relief. The integration among these subjects has given birth to biogeography.

> DO YOU KNOW?
>
> The study of 'apartheid' (a system of institutionalised racial segregation as existed in South Africa) is an example of anthropo-geographic study.

Relationship with Social Sciences

1.5.5. Economics and Geography:

Economics is concerned with how human needs and wants are satisfied with the available resources. Economic geography is concerned with the study of resources endowment and patterns of utilisation. The economic activities of the human beings including agriculture, fishing, forestry, industries, trade and transport are studied in this branch. The economic activities are highly influenced by the relief and climatic factors of the region or the country. Therefore, economics and geography have close links with each other, especially for integrated resources development.

1.5.6. Sociology and Geography:

Sociology is mainly concerned with the institutional aspects of the society. A number of investigations including social behaviour, movement of people between rural-urban areas, spatial interactions between social groups, the relations between innovation and tradition in rural and urban areas etc., have been jointly undertaken by sociologists and geographers in different countries of the world. Social geography is the logical expression of the interaction between sociology and geography as it studies social phenomena in spatial context.

1.5.7. Anthropology and Geography:

Anthropology attempts to study human races and their classification. Both anthropology and geography seek to identify and classify the human races on the basis of their habitat and cultural traits and attempt to study the variable racial phenomena on the spatial context of the earth's surface. The relationship between anthropology and geography has resulted in the development of 'anthropogeography' or geography of humans.

1.5.8. History and Geography:

History is a framework of events as per time and place. Geography attempts to study these events with reference to the physical earth and depict the places of historical events using thematic maps. Anyone who attempts to study any historical events of India should always integrate the temporal and the spatial phenomena of that period together to arrive at a conclusion.

> DO YOU KNOW?
>
> **Tamil Rulers and Geographic Knowledge**
>
> History reveals to us that how the Great rulers like Raja Raja Chola or Rajendra Chola had trade relations with other countries of the world, especially South Asian countries by understanding the relief, seasons, ocean current movements etc., The sailors would have been experts in every aspect of geography to move their troops, sail overseas and trade with all known nations of that time. They also utilised the ocean currents to transport teak and other valuable timbers from Indonesia, Myanmar, and other countries to South India.

1.6 Approaches to the Study of Geography

Geography has undergone several 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. There are two distinct approaches or methods to study geography. They are:

1. Systematic approach and 2. Regional approach

1.6.1. Systematic Approach:

Systematic or nomothetic approach was introduced by Alexander Von Humbolt, a German geographer (1769-1859). In this approach a particular phenomenon is considered for detailed understanding. The study of specific natural or human phenomenon that gives rise to certain spatial patterns and structures on the earth surface is called systematic study. Generally, systematic geography is divided into four main branches.

i. Physical Geography: Study of various elements of earth systems like atmosphere (air), hydrosphere (water), lithosphere (rock) and biosphere (life) and their distributions.

ii. Biogeography, including environmental geography: It focuses on various kinds of forests, grasslands, distribution of flora and fauna, human-nature relationships, quality of the living environment and its implications for human welfare.

iii. Human Geography: It describes the human culture, population, dynamic socio economic and political aspects.

iv. Geographical methods and techniques: It is concerned with methods and techniques for field studies, qualitative, quantitative and cartographic analysis.

1.6.2. Regional Approach:

It is otherwise called as ideographical approach. It was developed by Carl Ritter

CASE STUDY

Born on 14 September 1769 Alexander Von Humboldt was a Prussian polymath, geographer, naturalist, explorer. Humboldt's quantitative work on botanical geography laid the foundation for the field of biogeography. Humboldt resurrected the use of the word *cosmos* from the ancient Greek and assigned it to his multi-volume treatise, *Kosmos*. He was the first person to describe the phenomenon and cause of human-induced climate change, in 1800. He described the Guanoco asphalt lake as "The spring of the good priest". Humboldt and Bonpland discovered dangerous electric eels, whose shock could kill a man. His stay in Ecuador was marked by the ascent of Pichincha and their climb of Chimborazo, where Humboldt and his party reached an altitude of 19,286 feet (5,878 m). This was a world record at the time. U.S President, Jefferson later referred to Humboldt as the most scientific man of the age.

(1779 – 1859), a contemporary of Humbolt. The regions could be classified based on a single factor like relief, rainfall, vegetation, percapita income or there could also be multi-factor regions formed by the association of two or more factors. Administrative units like states, districts and taluks can also be treated as regions. The main sub branches of regional geography are : i) Regional studies ii) Regional analysis iii) Regional development and iv) Regional planning.

1.6.3. Geographical Data Matrix:

The matrixis a simple method of arranging information in rows and columns for better understanding of complex spatial problems. **Brian J.L. Berry** adopted this method from anthropology for studying geography more effectively.Geographic data can be arranged in a rectangular array or matrix. Row-wise group of variables represent the systematic or topical branches of geography while, regions are represented by columns. Berry has explained that regional synthesis could be derived with the help of a series of geographic matrices in correct temporal sequence. Each time period has been taken to be equivalent to a 'slice' of the three-dimensional cake. The diagram of ***'Third Dimension'*** makes it possible to examine rows and columns, cutting across time.

1.7 Branches of Geography

Based on content and the available techniques, the discipline can be divided into three major domains. Each one has many sub divisions which deal with specific objectives (Figure 1.7).

a. Physical Geography b. Human Geography and c. Geographic Techniques.

1.7.1 Physical Geography

It is the study of natural features of the earth such as land, water, air and living organisms. The changes taking place within and among these natural features and their resultant features are studied under its various branches. The branches of physical geography are:

i. ***Geomorphology*** deals with the distribution of land forms, their origin and the forces causing changes over these landforms. Geology provides basic information to the study of geomorphology.

ii. ***Soil Geography*** is a study related to soil formation, soil profile, soil types, their fertility level and distribution. Soil erosion and conservation measures are also dealt in this branch.

iii. ***Climatology*** deals with the study of global and regional weather and climatic conditions by analysing relevant statistical data. Meteorology provides basic information on the composition, structure and the changes in the atmosphere.

iv. ***Hydrology*** encompasses the study of earth's realm of water such as oceans and surface water bodies like rivers, reservoirs and ponds. It also makes a study of underground water and its recharge and also pollution of water bodies.

v. ***Oceanography*** is the study of seas and oceans. The shape, size, depth and bottom relief of ocean, distribution of oceans, ocean currents and various

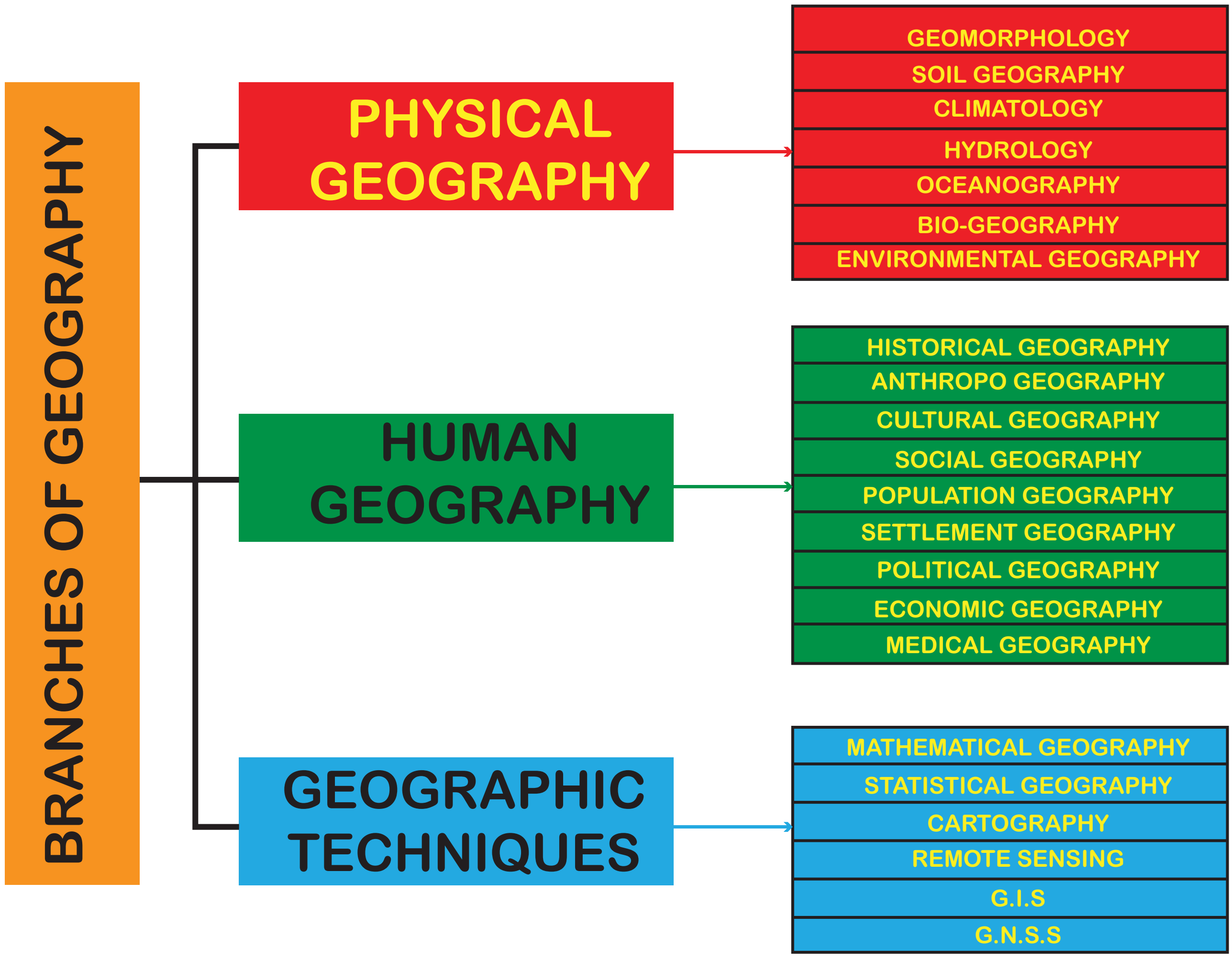


Figure 1.7 Branches of Geography

life forms existing in ocean are also studied under oceanography.

vi. ***Biogeography*** is a study of ecosystems over geographical space. It also analyses the changes in the ecosystems. *Phytogeography* or plant Geography, *Zoo Geography* or animal geography and *Ecology* are the branches of biogeography.

vii. ***Environmental Geography*** is the study of environmental issues arising out of misuse of various spheres of the earth and their implications. The ozone layer depletion, global warming, melting of polar ice caps, rising sea level and other related aspects are also given due importance. It also tries to give sustainable solutions to these problems.

1.7.2 Human Geography

Human Geography is concerned with the changes made by the humans over the natural or physical landscape. The ethnic and political aspects are taken into consideration. The issues like climatic change, natural and anthropogenic disasters are also the major concerns.

i. ***Population Geography*** is the study of distribution and density of population, the changing patterns in age and sex composition, birth and death rates, life expectancy, literacy level and dependency ratio, migrations at national and international level and the causes and consequences of migration.

ii. ***Settlement Geography*** deals with the characteristics of rural and urban settlements and transportation network. It seeks better understanding of the present landscape and plans for the future. The study is more important for town and country planning.

iii. ***Historical Geography*** tries to picturise the geography of an area or region as it was in the past and studies how it has evolved over time. The forces involved in transforming region such as colonisation by the Europeans or a natural disaster are also included in the study.

iv. ***Anthropo Geography*** deals with the distribution of human communities on the earth in relation to their geographical environment.

v. ***Cultural Geography*** gives emphasis on the location and diffusion of customs and cultural traits such as food habits, skills, clothing and beliefs and social organisations and their developments in different parts of the earth.

vi. ***Social Geography*** is closely related to cultural geography. It examines the relationships among the social groups and their social relationships in the places of their living.

vii. ***Political Geography*** tries to understand the countries and their neighbours, problems of resources sharing, boundaries and territorial limits. This branch is also concerned with understanding the political behaviour of the population, relations between independent states, and patterns of voting and delimitation of electoral constituencies.

viii. ***Economic Geography*** deals with the distribution of economic activities such as, primary, secondary and tertiary. The primary activities include food gathering, hunting, animal rearing, agriculture, and mining. The secondary activities include manufacturing and the tertiary activities include the service sectors such as trade, transport, communication and other related areas.

xi. ***Medical Geography*** mainly deals with study of geographical aspects of origin, diffusion and distribution of various communicable diseases and health care planning.

1.7.3 Geographic Techniques

Geography has developed a number of methods and tools to investigate and identify the spatial structures and patterns. Besides, it also lends or borrows some methods and tools to measure and investigate precise understanding of the spatial locations and patterns.

i. ***Mathematical Geography*** deals with the study of earth's size and shape, motions of the earth, concept of time and the time zones.

ii. ***Statistical Geography*** is concerned with the practice of collecting, analysing and presenting data that has a geographic or areal dimension, such as census data.

iii. ***Cartography*** is the study of making maps of various scales using authentic information.

iv. ***Remote Sensing*** is the art, science and technique of capturing the earth surface features using sensors or cameras in airplanes or satellites, processing and presenting the spatial information tousers.

v. ***Geographic Information System (GIS)*** is a computer-based tool of the recent decades for geographical studies. It is used for storing, retrieving, transforming, analysing, and displaying data to prepare useful thematic maps.

vi. ***Global Navigation Satellite System (GNSS)*** is used to pinpoint the geographic location of a user anywhere in the world. Airlines, shipping, travel agencies and automobile drivers use the system to track the vehicles and follow the best routes to reach the destination in the shortest possible time.

DO YOU KNOW?

Global Navigation Satellites System

GNSS is the standard generic term for satellite navigation systems that provide geo-spatial positioning with global or regional coverage. This term includes the GPS (USA), GLONASS (Russia), Galileo (Europe), Beidou (China), IRNSS (India) and other systems. The GPS was the first GNSS system of the United States and originally used for military applications. Today it is commonly used in mobiles, vehicles, agriculture and other areas that allow us to use it in all fields of mapping.

Geography is undergoing frequent changes to tackle the challenges of the dynamic world. The subject is more flexible and accommodates many principles of related subjects. At the same time, it lends concepts and knowledge to many related disciplines. Owing to these changes, the subject is attaining more refinement, accuracy, precision, depth and scientific rationale.

1.8 Geographical Tools and Skills

Every day the news media report several geographically significant events of near by or faraway places. Such reports include the occurrence of earthquakes, floods, forest fire, landslides etc., which trigger the interests of everyone to recollect their geographic knowledge they had acquired earlier.

The essential tools of geography are maps and globes and now the digital versions of aerial photographs, satellite images, Geographical Information Systems (GIS) and Global Navigation Satellite System (GNSS).These tools have become an integral part of geography and these products help us to visualise the spatial patterns over the surface of the earth.

The GIS technique has enhanced the skills and capabilities to compare and overlay the digital layers to create maps quickly and efficiently. It helps us to study the areas affected by floods or cyclones or forest fire and the damages can be assessed accurately and losses be estimated within a very short span of time. The navigation satellites provide accurate location of these occurrences.

In recent years, geography aims to develop a set of marketable skills to the students rather than preparing the students only for the teaching in educational institutions.

The job market is changing frequently. Therefore, the teaching methodology of the subject is to be adapted to the changing trends of the society and provides a couple of specialisations to the students so that they could be acquainted with the global market and get suitable employment. The maps still remains an important visual medium for geographers although the microchip revolution is expanding exponentially to address a number of societal issues.

1.8.1 Cartography:

Geographers who specialise in this branch make traditional maps, digital maps, atlases, charts, globes and models. Quantification and cartography are considered as two sides of the 'geography coin'. Owing to quantitative and computer revolutions, handling of spatial data become easier, not only for the preparation of 'instant maps' but also for statistical graphs, graphic images and models. Preparation of the computer-aided-maps and updating the existing ones become easier and faster. Creation of three dimensional models, changing the viewing angle of these models and plotting the images are made possible due to the introduction of computer expertise in cartography.

1.8.2 Land use Studies:

For studies of quickly changing phenomena on the earth surface, such as floods, drought, forest fires, etc, remote sensing data provide accurate information in different scales. The remote sensing organisations employ geographers who have the knowledge to process the frequently changing earth's surface features. Even before the introduction of satellites in remote sensing, aerial photographs were widely used by geographers for natural resources surveys and urban and regional planning. The satellite data from Landsat, SPOT, IRS and other satellites made it possible to repeatedly view each part of the earth surface at frequent intervals and thereby geographers' 'data thirst' is considerably quenched.

1.8.3 Geospatial Analysis:

A geospatial analyst designs databases, analyses geographical data, uses appropriate GIS software to a wide range of applications including defence, real estate, pollution and government administrations. The skill helps to identify optimum size and ideal location, establish new or relocate existing facilities like hospitals, police station, banks, shopping centres etc.,

1.8.4 Environmental Impact Assessment:

This investigation requires voluminous data related to physical, social, economic and other aspects of the area under study. The data are collected from maps, satellites and field and synthesised to provide meaningful visual results. Such complex thematic visual results allow the decision makers to take appropriate steps to tackle the day to day and long term environmental issues.

1.8.5 Regional Planning:

A planner who is responsible for planning an urban or a regional unit needs to have an overall view of the area. They should be able to synthesise the issues from multiple perspectives. The problems are increasingly concerned with balancing different, sometimes contradictory, interests into functional and sustainable suggestions and proposals. This specialisation is concerned with planning, housing, and smart city development projects. The regional land use maps are to be prepared to locate facilities and optimise the existing land for various uses.

1.8.6 Weather Forecasting / Nowcasting:

At present the meteorologists are using ground data and satellite data to forecast the wind direction, rainfall possibilities and cyclone movement. However, with the advancement of satellite sensors, navigation satellites and GIS technology it is possible to nowcast the weather conditions and provide live cyclone movement tracts, otherwise known as weather nowcasting.Geographers are utilising spatial and non–spatial data to analyse weather and climate parameters and conduct research concerning climate and climate changes and forecast the earth's future climate and weather conditions and their implications.

1.8.7 Surveying, Utilising Large Scale Maps/Sketches:

7H7NJ6

Surveying with instruments, starting from chain survey to differential GPS (DGPS), are an integral part of geography curriculum. The students survey and prepare sketches of various features in an area. They also survey the campuses with advanced survey instruments and prepare large scale maps. The geographical knowledge and training enable the students to interpret large scale maps of India and other countries of the world. **Ground Penetrating Radar (GPR),** one of the emerging field survey instruments, is gaining importance not only in earth sciences discipline but also in archaeology, civil engineering, city planning and other related fields.

The students of geography undergo special trainings in their college level studies and seek employment in the areas of their specialisation. Depending upon their area of specialization; geographers are employed as scientists in national and state planning commissions, water resources organizations, and land use planning units, agricultural or economic institutes or as demographers in government and research organizations.

HOTS

How does ground penetrating RADAR locate the archaeological site?

The geographers are also employed as climatologists, geomorphologists, GIS specialists and hydrologists. Geography background is an asset for careers in travel and tourism, particularly for 'Travel Journalism'. Besides these, the geography graduates apply for civil services examinations conducted by various States of India and also the UPSC. Recent developments in geography are technological in nature and mostly computer oriented. The average geography graduate is therefore well versed in the use of computers, and as they are trained in understanding patterns and relationships over space.

1.9 Geography in Tamil Nadu

A number of institutions of higher learning in Tamil Nadu have been offering graduate and post graduate programmes in geography for several decades. Some of the Departments are recognized as research centers and these are engaged in undertaking national and international research projects besides conducting research programmes in geography. The departments are also engaged in organizing short term and long term training programmes and workshops to disseminate the latest geographic knowledge and technology for the benefit of students, researchers and teachers of geography.

DO YOU KNOW?

Annual Geography Talent Tests for College / University Students and School Students of Tamil Nadu

The Indian Geographical Society is conducting talent test examination to final year UG and PG geography students across the State and present awards and cash prizes to a tune of Rs. 15,000 (top three M.Sc. students) and Rs. 10,000 (top three B.Sc students) in the names of the IGS Founder Prof N.Subrahmanyam and the former Head of the Department of Geography of University of Madras Prof. A.Ramesh, respectively.

The Association of Geography Teachers of India conducts Annual Geography Talent Tests to the school students. The talent test is conducted at two levels: Students of classes 7 and 8 take Junior Level test while the students of classes 9 and 10 take it at the Senior Level. Prizes and certificates are awarded to top ranking candidates.

Two geographical Associations are functioning in Tamil Nadu to disseminate geographic knowledge to the students and teachers of schools, colleges and universities through publishing journals, organizing workshops and conduct talent tests to the geography students.

1.10 Databases for Geography Teaching and Learning

Geographers are concerned about certain global and local issues like disasters, environmental problems, natural resources and other related aspects. Often these issues are discussed in the classrooms. Data relating to the issues are necessary for better understanding of the same and for seeking real world solutions. A number of organizations in India are engaged in disseminating such valuable information through special publications, especially to the student community. The schools, colleges, universities and research institutions can write to the following organizations and enroll themselves to receive the published materials like booklets, pamphlets, satellite images, manuals etc. They can also enroll for short term trainings / field visits / workshops arranged by these organizations.

DO YOU KNOW?

Awards to Geography Teachers and Scientists

The Indian Geographical Society has instituted Awards in the names of renowned Geographers Prof.B.M. Thirunaranan, Prof. A.R. Irawathy and Prof.V.L.S.PrakasaRao to the leading geographers who work in the areas of geomorphology, remote sensing and regional planning respectively.

The students can make use of the free software available from these organizations to visualize the earth's surfaces from space and map the existing and changing land cover details, traffic density, pollution levels etc., A number of spatial information, including satellite images can be downloaded freely for educational purposes such as classroom teaching, preparation of maps, for project work, field work and other activities.

A-Z GLOSSARY

Absolute Location: The exact position of an object or place stated in spatial coordinates of a grid system designed for the location purposes. In geography, the reference system is the global grid of parallels of latitudes north or south of equator and of meridians of longitude east or west of the Prime meridian.

Cartography: The art, science and technology of making maps.

Field Measurement Book (F.M.B): The FMB depicts the dimensions of each field boundaries and the sub divisions. In FMB the individual survey number maps are maintained at a scale of 1:1000 or 1:2000. Each survey number is divided into several sub divisions. Each sub division is owned by a owner. The FMB's also depicts the dimensions of each field boundaries and the sub divisions.

Global Positioning System (GPS): A method of using satellite observations for the determination of extremely accurate location information.

Greenhouse Effect: The heating of the earth's surface as shortwave solar energy passes through the atmosphere, which is transparent to it but opaque to reradiated long wave terrestrial energy. It also refers to increasing the opacity of the atmosphere through the addition of increased amounts of carbon dioxide, nitrous oxide, methane and chlorofluorocarbons.

Greenwich Mean Time (GMT): Local time at the prime meridian (Zero degree longitude), which passes through the observatory at Greenwich, England.

Map Projection: A method by which the curved surface of the Earth is shown on a flat surface map. As it is not possible to show all the Earth's features accurately on a flat surface, some projections aim to show direction accurately at the expense of area, some the shape of the land and oceans, while others show correct area at the expense of accurate shape.

One of the projections most commonly used is the Mercator projection, devised in 1569, in which all lines of latitude are the same length as the equator. This results in increased distortion of area, moving from the equator towards the poles. This projection is suitable for navigation charts.

The Mollweide projection shows the land masses the correct size in relation to each other but there is distortion of shape. As the Mollweide projection has no area distortion it is useful for showing distributions such as population distribution. The only true representation of the Earth's surface is a globe.

Nation: A culturally distinctive group of people occupying a particular region and bond together by a sense of unity arising from shared ethnicity, beliefs and customs.

Natural Resource: A physically occurring item that a population perceives to the necessary and useful to its maintenance and well-being.

Ozone Layer: A gas molecule consisting of three atoms of oxygen (O_3) formed when diatomic oxygen (O_2) is exposed to ultraviolet radiation. In the lower atmosphere, it constitutes a damaging component of photochemical smog; in the upper atmosphere, it forms a normally continuous, thin layer that blocks ultraviolet light. A layer of ozone in the atmosphere (stratosphere) protects life on earth by absorbing ultraviolet radiation from the sun.

Prime Meridian: An imaginary line passing through the Royal Observatory at Greenwich, England, serving by agreement as the zero degree line of longitude.

Region: In geography, the term applied to an area of the earth that displays a distinctive grouping of physical or cultural phenomena or is functionally united as a single organisational unit.

Relative Location: The position of a place in relation to a well-known place.

Site: The place where something is located; the immediate surroundings and their attributes.

Situation: The location of something in relation to physical and human characteristics of a larger region.

Toponym: A place name with reference to topography.

Evaluation

Choose the correct answers

7HGJKT

1. The word 'geography' is coined from ________language.
   a. Latin
   b. Spanish
   c. Greek
   d. Tamil
2. Four traditions of geography were introduced by____________.
   a. Hartshorne
   b. Gerard Mercator
   c. William D Pattison
   d. Humboldt
3. Which one of the following is not a theme of geography?
   a. Location b. Place
   c. Movement d. Technology
4. Systematic approach to study geography was developed by____________.
   a. Carl Ritter b. Humboldt
   c. Pattison d. Hartshorne
5. Anthropology deals with human ____________.
   a. Migration b. Settlements
   c. Races d. Kingdoms
6. Geo1ogy is a study of____________
   a. Rocks b. Minerals
   c. Petroleum d. Animals
7. Meteorology is a study of ___________.
   a. Atmosphere b. Meteors
   c. Metals d. Mammal
8. Astronomy is a science which deals with_____________.
   a. Plants b. Animals
   c. Climate d. Celestial bodies
9. What is the GNSS system of India called as?
   a. IRNSS b. GPS
   c. GLONASS d. Beidou
10. Which one of the following countries first used the GPS for its military applications?
   a. Canada b. Germany
   c. India d. USA

Very short answers

1. Define Geography.
2. What are the four traditions of geography?
3. List the five themes of geography.
4. Write about the approaches to study geography.
5. What are the three domains of geography?
6. What is GNSS?
7. Define cartography.
8. What is mathematical geography?
9. What is the significance of man -land tradition?
10. How is regional approach helpful in studying political units?

Short answers

1. Distinguish between systematic approach and regional approach to study geography.
2. What is Geographical data matrix?
3. Write a note on remote sensing.

Detailed answers

1. How has geography developed over the years?
2. Describe how the five themes are interrelated.
3. Describe how geography is related to natural sciences.
4. Explain any four geographic techniques.
5. What are the advantages of developing the geographical skills?

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Internet Resources

Open GIS Software

http://www.saga-gis.org/en/index.html; https://qgis.org/en/site/; https://grass.osgeo.org/

Free Satellite Data and Images

https://earthexplorer.usgs.gov/; https://bhuvan.nrsc.gov.in

Online Mapping

https://www.openstreetmap.org; https://maps.google.com/; https://www.google.com/intl/en_in/earth

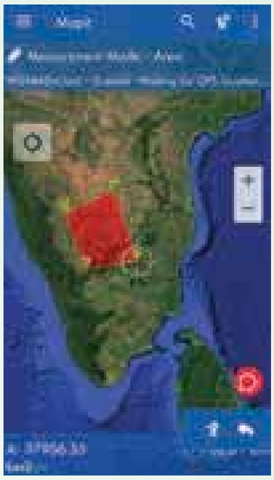
Online Learning Resource

www.mhhe.com/getis10e/

ICT CORNER

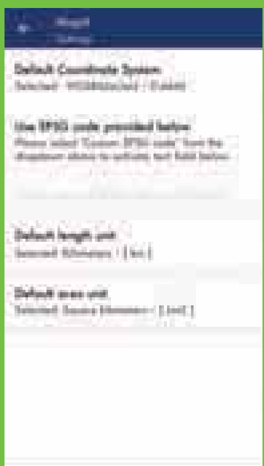
Modern Tools of Geography

Explore and survey geography using modern tools.

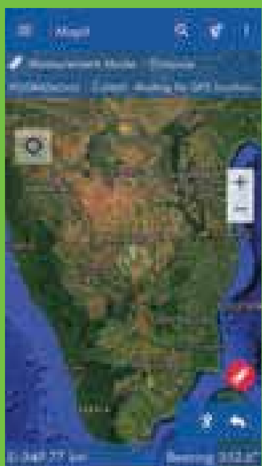


Steps

- Use the URL or QR code to download and install 'Mapit GIS' app in your smartphone. Open the app and go to settings tab on the top right corner of the page and set units of measurement of your choice.
- Select scale icon from the bottom and place the targets by pressing 'Balloon' icon from the bottom. Scale icon will provide you instant survey of distance using GPS.
- Long press the scale icon and it will transform into 'Area mode'. Follow the same step to drop the balloon and survey the area between any numbers of points.
- Touch the menu navigation button from the top left corner and change the map styles you want to survey.



Step 1



Step 2

Step 3

Step 4

Website URL:

https://play.google.com/store/apps/details?id=com.osedok.gisdatacollector&hl=en

*Pictures are indicative only.

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Unit II

The Solar system and the Earth

Chapter Outline

2.1 Introduction
2.2 Theories of the Earth's origin
2.3 Modern theories of the origin of the Universe
2.4 Star and Constellations
2.5 The Solar system
2.6 The Sun
2.7 The Planets
2.8 Dwarf Planets
2.9 Satellites
2.10 Asteroids
2.11 Comets
2.12 Meteors
2.13 Shape and size of the Earth
2.14 Motions of the earth
2.15 Seasons
2.16 Time Zones of the World

2.1 Introduction

Have you ever relaxed lying on the terrace of a building or in the front yard at a cloudless night? If yes, could you watch the night sky filled with glittering stars which appear to be growing in numbers?

Learning Objectives:

- *To know more about the universe, stars, planets and others.*
- *Understand theories of the origin of the Universe.*
- *Explain the position of the planets in the solar system.*
- *Describe the cause and effect of the motions of the earth.*

These glittering stars, which we see, are a part of the universe. Let us now discuss in detail about the Universe, stars, planets and other objects. **The universe** is a vast endless space which includes galaxies, stars, planets and other forms of matter and energy in it.

2.2 Theories of the Earth's origin

There are many theories supporting the origin of the earth. One of the earlier and popular arguments of the earth's origin was by a German professor Immanuel Kant. Mathematician Laplace revised it in 1796. It was known as Nebular Hypothesis. It considered that planets were formed out of a cloud of material associated with a youthful sun, which was slowly rotating. Lyttleton propounded the accretion theory of the earth's formation. According to this theory, approximately 4.6 billion years ago, the solar system was a cloud of dust and gas known as a solar nebula. As the solar nebula began to spin, the gravity collapsed the materials on itself and it formed the sun in the centre of the solar system. When the sun formed, the remaining materials began to clump up. Small particles drew together, bound by the force of gravity, into larger particles. The solar wind swept away lighter elements, such as hydrogen and helium, from the closer regions. It left only heavy rocky materials to create planets like the Earth. But farther away, the solar winds had less impact on lighter elements, allowing them to coalesce into gas giants. In this way, planets, moons, asteroids, comets, etc., were created.

DO YOU KNOW?

Voyager 2 travelling at the speed of more than 62,764.416 km/h will still take more than 296,000 years to pass Sirius, the brightest star in our night sky.

Earth's rocky core formed first when heavy elements collided and bound together. Dense materials sank to the center, while the lighter material created the crust. The planet's magnetic field probably formed around this time. Gravity captured some of the gases that made up the planet's early atmosphere.

2.3 Modern theories of the origin of the Universe

The most popular argument regarding the origin of the universe is **the Big Bang Theory**. It is also called expanding universe hypothesis. In 1927, Abbe Georges Lemaitre, a Belgian astronomer was the first to propose, a theory on the origin of the universe. It was Edwin Hubble who provided the evidence that the universe is expanding. It was called, **'the Big Bang Theory'**. According to it, the universe was formed during a period of inflation that began about **13.75 billion years** ago.

Like a rapidly expanding balloon, it swelled from a size smaller than an electron to nearly its current size within a fraction of a second. Matter from the universe was thrown out with great force in all directions and started expanding outwards. From this matter, many groups of stars were formed which we call 'galaxies'. A **galaxy** is a system of billions of stars, stellar remnants, interstellar gas, dust, and dark matter. The word galaxy is derived from the Greek word *Galaxias*, literally "milky", a reference to the Milky Way (Figure 2.1). The **Milky Way** is the galaxy that contains our Solar System.

Galaxies are in three major forms:

1. ***Spiral Galaxies:*** It consists of a flat and rotating disk of stars, gases and dust. It has a central concentration of stars known as the 'bulge'. The Milky Way and the Andromeda are spiral galaxies.
2. ***Elliptical Galaxies:*** It contains older stars with fewer gases. Messier89 galaxy is an elliptical galaxy.

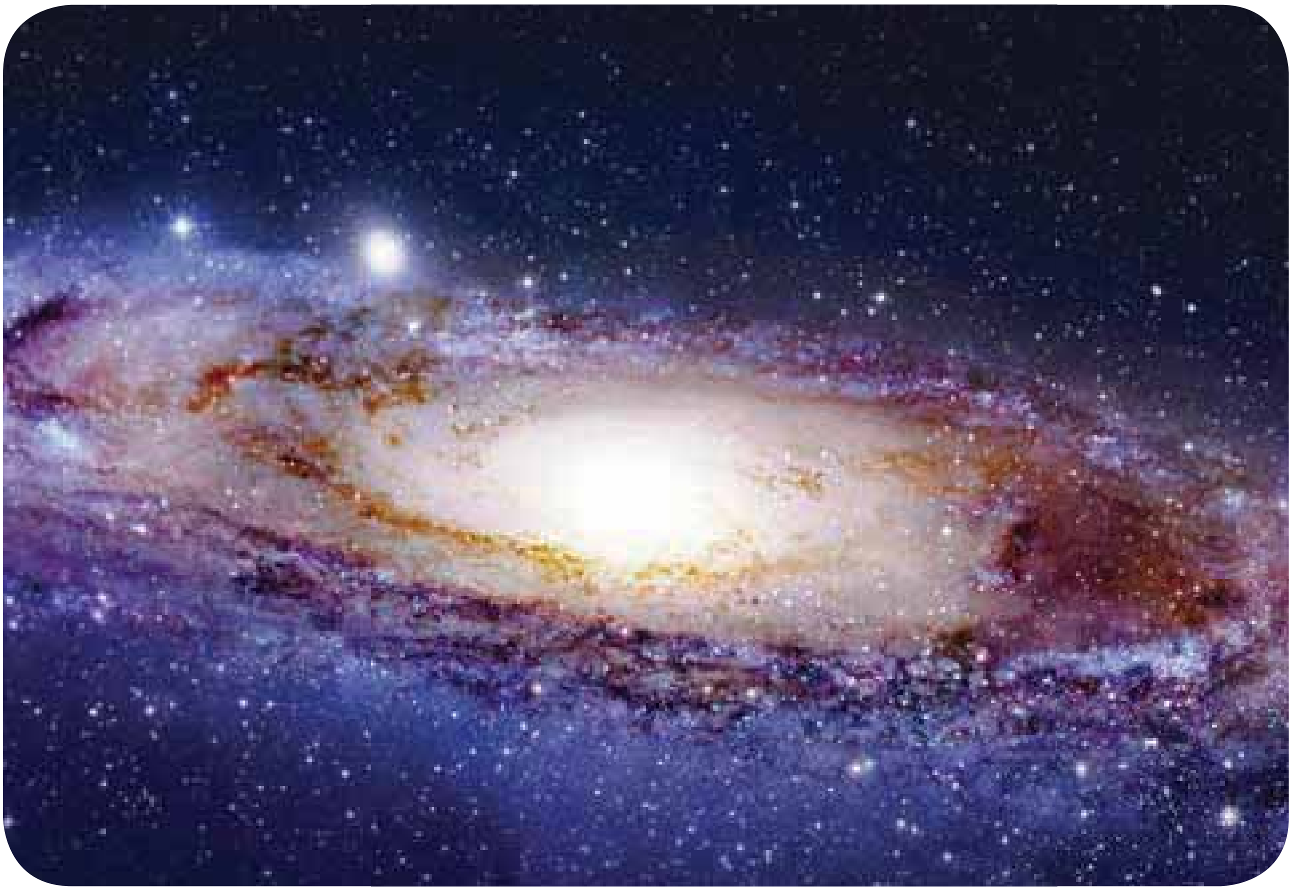


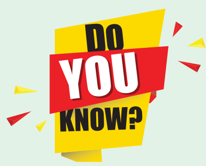
Figure 2.1 Milky Way Galaxy

3. ***Irregular Galaxies:*** They are youthful galaxies with more dust and gases. This can make them very bright. Large Magellanic Cloud is an example of irregular galaxy.

Initially, the universe was saturated only by energy. Some of this energy set into particles, which assembled into light atoms like hydrogen and helium. These atoms grouped first into galaxies, then stars and all the other elements. This is generally agreed-upon concept of our universe's origin as estimated by scientists.

In fact, the stars, planets and galaxies that can be detected make up only **4 percent** of the universe, according to astronomers. The other **96 percent** of the substances in the universe cannot be seen or easily understandable.

The new measurement technique called **gravitational lensing** confirmed the age of the universe and the strength of dark energy. Dark energy is responsible for the accelerating expansion of the universe. Scientists used gravitational lensing to measure the distances light traveled from a bright, active galaxy to the earth and some details of its expansion.



Three scientists, Saul Perlmutter, Brian Schmidt and Adam Riess won the Nobel Prize in Physics (2011) for their discovery that the universe is just expanding and picking up speed.

2.4 Star and Constellations

A **star** is type of astronomical object which has its own light and heat. The nearest **star** to earth is the Sun. Sirius is brighter star than the sun. 'Proxima Centauri' is the closest star to the sun. Star is formed when enough dust and gas clump together because of the gravitational forces. Star changes its forms during its lifetime such as-red giant, white dwarf, neutron star and black hole.

Constellation (Figure 2.2) is a group of stars that forms a particular shape in the sky. In 1929, the International Astronomical Union (IAU) adopted official constellation boundaries that defined 88 official constellations that

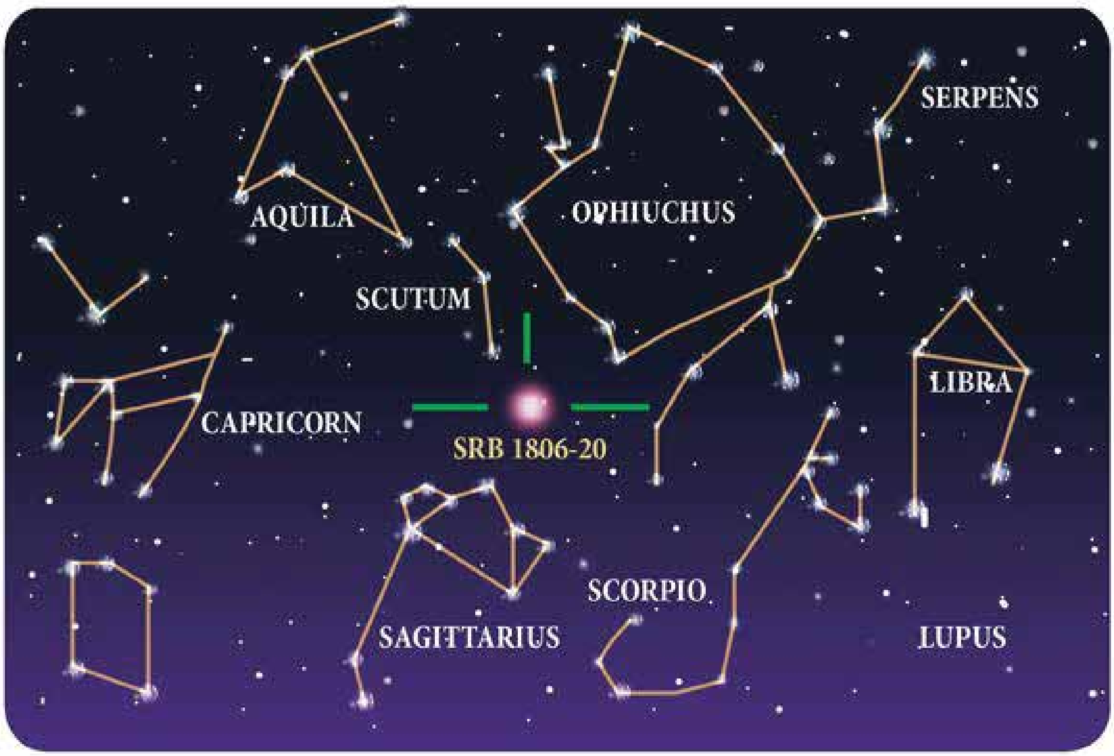


Figure 2.2 Constellation-Sagittarius, like a teapot

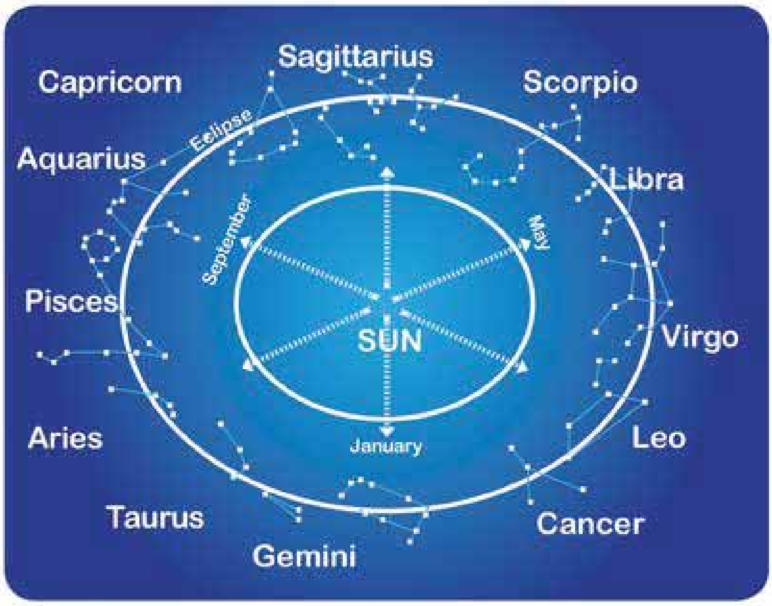


Figure 2.3 Constellation

Figure 2.4 Stars

exist today. Earlier Ptolemy, in his book *Almagest*, listed 48 constellations.

Ursa Major (Figure 2.3) is a constellation that can be seen in the northern hemisphere and part of the southern hemisphere. **Ursa Major** means **Great Bear** in Latin.

2.5 The Solar system

A solar system consists of a star (Figure 2.4) at the centre and the eight planets, moons, asteroids, comets and meteoroids that revolve it. The eight planets, namely the Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune, revolve around the sun in fixed elliptical paths known as '**orbits**'. Most stars host their own planets. So there are billions of other solar systems in the Milky Way galaxy alone.

Solar systems can also have more than one star. These are called binary star systems if there are two stars or multi-star systems if there are three or more stars. Our solar system is located in an outer spiral arm of the vast Milky Way galaxy. Our solar system orbits the centre of the Milky Way Galaxy at about 828,000 km/h. Our solar system takes about 230 million years to complete one orbit around the galactic centre.

The solar system is believed to have been formed about 4.6 billion years ago. The solar system also includes the Kuiper Belt that lies past Neptune's orbit. This is a sparsely occupied ring of icy bodies. This is almost all smaller than the dwarf planet Pluto. Beyond the fringes of the Kuiper belt (Figure 2.5) is the Oort cloud. This giant spherical shell surrounds our solar system. It has never been directly observed,

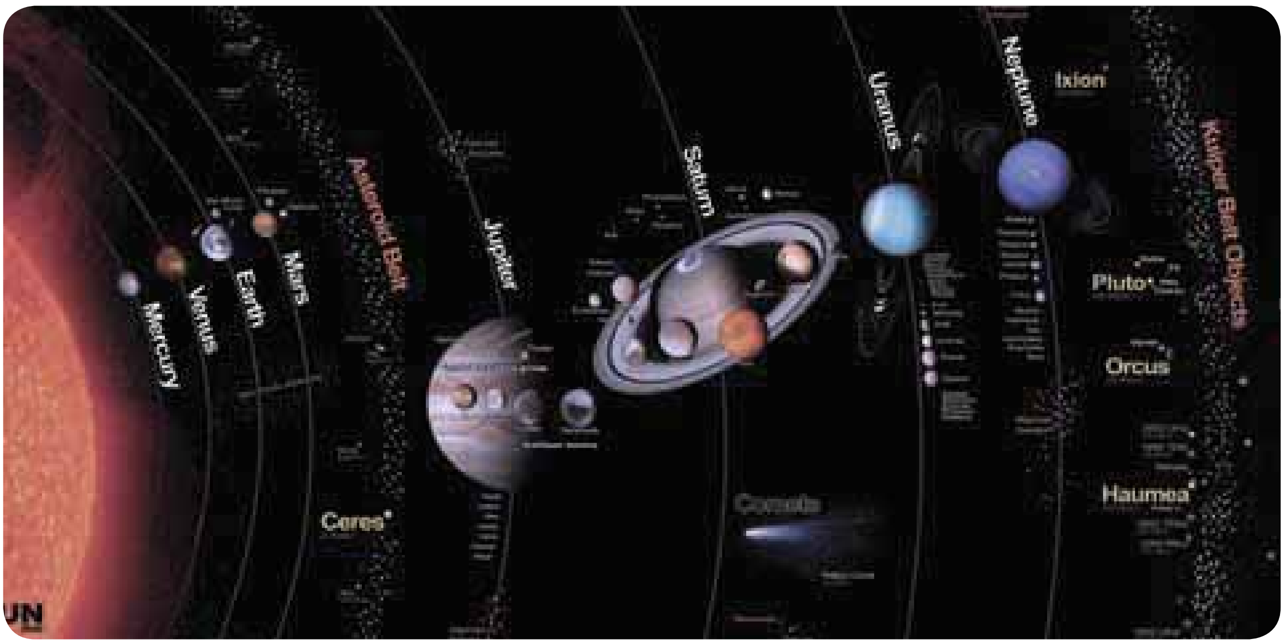


Figure 2.5 Solar system

but its existence is predicted based on mathematical models and observations of comets that likely originate there.

The Oort cloud is made up of icy pieces of space debris. It is orbiting our Sun as far as 1.6 light years away. This shell of material is thick, extending from 5,000 astronomical units to 100,000 astronomical units. One astronomical unit (AU) is the distance from the Sun to Earth, or about 150 million kilometre. The Oort cloud is the boundary of the Sun's gravitational influence, where orbiting objects can turn around and return closer to our Sun.

There are more than 163 known natural satellites in our solar system and several more awaiting confirmation of discovery. Of the eight planets, Mercury and Venus are the only planets with no satellites while the Jupiter and Saturn have the highest number of satellites in our solar system.

2.6 The Sun

7HZBP4

The Sun is at the centre of our solar system. It is a yellow dwarf star, with a hot ball of glowing gases. Its gravity holds the solar system together and it keeps everything from the biggest planets to the smallest particles of debris in its orbit. Electric currents in the Sun generate a magnetic field that is carried out through the solar system by the solar wind.

Structure of the Sun

By mass, the Sun is made up of about 70.6% hydrogen and 27.4% helium. The Sun's enormous mass is held together

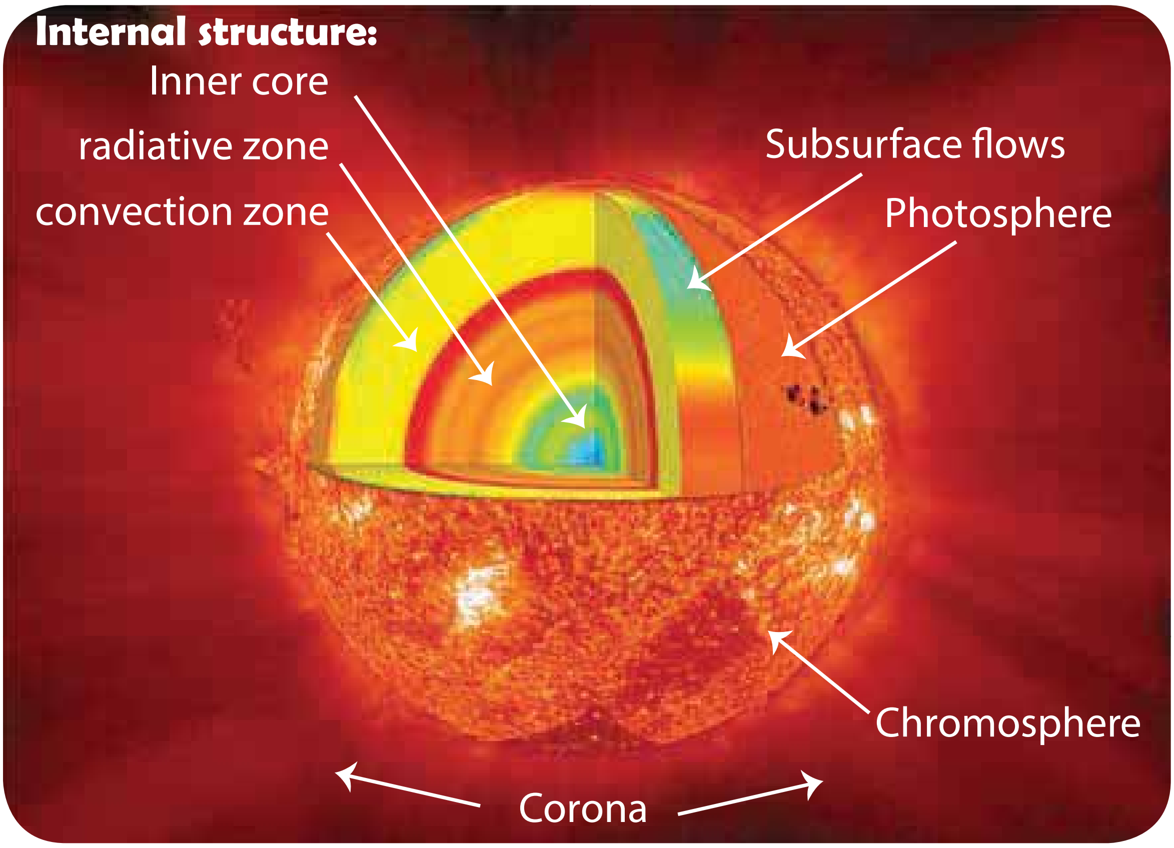


Figure 2.6 Structure of the sun

by gravitational attraction, producing immense pressure and temperature at its core. There are three main layers in the Sun's interior: the core, the radiative zone, and the convective zone (Figure 2.6). The core is at the centre. It is the hottest region, where the nuclear fusion reaction to give the sun power. Moving outward next come the radiative (or radiation) zone. Its name is derived from the way energy is carried outward through this layer, carried by photons as thermal radiation. The third and final region of the solar interior is named the convective (or convection) zone. It is also named after the dominant mode of energy flow in this layer. The boundary between the Sun's interior and the solar atmosphere is called the photosphere. It is what we see as the visible 'surface' of the Sun.

Did you know that the Sun has an atmosphere? The lower region of the solar atmosphere is called the chromosphere. Its name is derived from the Greek word *chroma* (meaning colour), for it appears bright red when viewed during a solar eclipse. A thin transition region, where temperature rises sharply, separates the chromospheres from the vast corona above. The uppermost portion of the Sun's atmosphere is called the corona, and is surprisingly much hotter than the Sun's surface (photosphere) The upper corona gradually turns into the solar wind. Solar wind is a flow of plasma that moves outward through our solar system into interstellar space.

Therefore, the Sun has six regions: the core, the radioactive zone, and the convective zone in the interior; the photosphere; the chromospheres; and the corona. The temperature of the sun's surface is about 5,500 to 6,000 degrees Celsius.

At the core, the temperature is about 15 million degrees Celsius, which is sufficient to sustain thermonuclear fusion. This is a process in which atoms combine to form larger atoms and in this process, released, staggering amounts of energy. Specifically, in the Sun's core, hydrogen atoms fuse to make helium.

Size and Distance

The sun has a radius of 695,508 kilometres. It is far more massive than earth and 3,32,946 Earths equal to the mass of the Sun. The Sun's volume would need 1.3 million Earths to fill it.

DO YOU KNOW?

Venus is hotter than **Mercury** because **Venus** has an atmosphere which is thicker and made almost entirely of carbon dioxide.

Orbit and Rotation

The **Milky Way** has four main spiral **arms**: the Norma and Cygnus **arm**, Sagittarius, Scutum-Crux, and Perseus. The Sun is located in a minor arm, the Sagittarius arm. From there, the Sun orbits the centre of the Milky Way Galaxy, bringing the planets, asteroids, comets and other objects along with it. Our solar system is moving with an average velocity of 828,000 kilometres per hour. It takes about 230 million years to make one complete orbit around the Milky Way. The Sun's spin has an axial tilt of 7.25 degrees with respect to the plane of the planets' orbits. Since the Sun is not a solid body, different parts of the Sun rotate at different rates. At the equator, the Sun spins around once about every 25 days, but at its poles the Sun rotates once on its axis every 36 Earth days. Most of the materials are pulled toward the centre to form our Sun. The Sun alone accounts for 99.8% of the mass of the entire solar system.

Like all stars, the Sun will someday run out of energy. When the Sun starts to die, it will swell so big that it will engulf Mercury and Venus and maybe even Earth. Scientists predict that the Sun is a little less than halfway through its lifetime and will last another 6.5 billion years before it shrinks down to be a white dwarf.

2.7 The Planets

The word planet in Greek means 'wanderer'. Planet is the celestial body which does not have light or heat of its own. A planet should possess the following qualities:

a. It should orbit around the sun.
b. It should not be a satellite of any planet
c. Due to its own mass and self-gravity, it should get a spherical shape and
d. Any other celestial body should not cross in its orbit.

The planets are classified in order of their distance from the sun and based on their characteristics. They are:

1. **The inner planets** or terrestrial planets or rocky planets. Mercury, Venus, Earth and Mars are called inner or terrestrial planets.
2. **The outer planets** or gaseous planets or giant planets. Jupiter, Saturn, Uranus and Neptune are called outer or gaseous planets.

Each planet spins on its own axis. This movement is called rotation. One rotation makes one 'planet day'. The planets moving around the sun is called revolution or a 'planet-year'.

Planets in the Solar System

The Mercury

Mercury is the nearest planet to the sun and it is the smallest planet in the solar system. It does not have any satellite. It rotates on its own axis in 58.65 earth days while it takes 88 Earth days to complete one revolution around the sun. Mercury is 0.4 astronomical units away from the Sun. The sunlight takes 3.2 minutes to travel from the Sun to Mercury. Mercury is the second hottest planet though it is nearest to the sun.

The Venus

'Venus' is the second nearest planet to the sun. It is also called as **'Earth's Sister'** planet due to its similar size and mass as that of our Earth. It is the hottest planet in the solar system and experiences a mean surface temperature of 462°C. It is popularly known as **"Morning star and Evening star"** It is seen in the east sky before sunrise (dawn) in the morning and in the west sky after the sunset (twilight). It rotates clockwise i.e. east to west direction on its own axis. The rotation and orbit of the Venus are unusual in several ways. Venus is one of just two planets that rotate from east to west. Only Venus and Uranus have this 'backwards' rotation. It completes one rotation in 243 Earth days which is the longest day of any planet in our solar system. The Venus takes 224.7 Earth days to complete one revolution around the sun, and it has no natural satellites. Venus is 0.7 astronomical units away from the sun. The sunlight takes 6 minutes to travel from the sun to Venus.

Table 2.1 Distance of the planets from the sun

Name Of The Planet	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Diameter (km)	4,879	12,104	12,756	6,794	1,42,984	1,20,536	51,118	49,528
Density (kg/m3)	5,427	5,243	5,514	3,933	1,326	687	1,271	1,638
Rotation Period (hours)	1,407.6	–5,832.5	23.9	24.6	9.9	10.7	–17.2	16.1
Length of Day (hours)	4,222.6	2,802	24	24.7	9.9	10.7	17.2	16.1
The Average distance from the sun(10^6 km)	57.9	108.2	149.6	227.9	778.6	1,433.5	2,872.5	4,495.1
Orbital Period (days)	88	224.7	365.3	687	4331	10,747	30,589	59,800
Number of Satellites	0	0	1	2	67	53	27	13

The Earth

Earth is the third nearest planet to the sun. It is the fifth largest planet in the solar system. The Earth's orbit lies between the orbits of Venus and Mars. It takes 23 hours 56 minutes and 4 seconds for the earth to complete one rotation on its own axis. The Earth takes 365.25 days (Table 2.1) to complete one revolution around the Sun. Earth's surface temperature varies from – 88° to 58°C and it is the densest planet in the solar system.

The Earth is a unique planet because of its distance from the sun, its motions, atmosphere with oxygen, presence of water and moderate temperature. The earth is neither too close nor too far from the sun. It is the only known planet to support life. It is also known as the **'Blue Planet'** because of the presence of water. Earth has only one natural satellite called the Moon. The sun light takes about 8.3 minutes to reach the earth.

The Mars

Mars is the fourth nearest planet to the sun and it is the second smallest planet in the Solar system. It is also described as the **"Red planet"**. It is reddish in colour due to the presence of iron oxide on its surface. The landmass of Mars and Earth are very similar. It takes 24 hours and 37 minutes to complete one rotation on its axis and its takes 687 days to complete one revolution around the Sun. The surface temperature of the Mars is ranging from -153° to 20°C. With the exception of the Earth, Mars probably is the most hospitable to life. This planet has seasons, polar ice caps, volcanoes, canyons and weather. Mars has two satellites namely Phobos and Deimos.

The Jupiter

Jupiter is the largest planet in the solar system. It is made primarily of gases and is therefore known as **'Giant Gas planet'**. It takes 9 hours 55 minutes to complete one rotation on its axis and it takes 11.86 years to complete one revolution. Jupiter has the shortest day in the solar system. Jupiter has a faint ring system around it. They are mostly comprised of dust particles. Jupiter has 67 confirmed satellites orbiting the planet. Ganymede, the satellite of Jupiter, is the largest natural satellite in the solar system (even bigger than the planet Mercury).

The Saturn

Saturn is the sixth planet from the sun and the second largest planet in the solar system. Saturn is called as the **Ringed Planet**. It is because of large, beautiful and extensive ring systems that encircles the planet. These rings are mostly made from the chunks of ice and carbonaceous dust. **Saturn** is the only planet in our solar system whose average density is less than water.

The Saturn has 30 rings and 53confirmed natural satellites. The Saturn takes 10 hours 34 minutes to complete one rotation on its axis and it takes 29.4 years to complete one revolution around the sun.

The Uranus

Uranus is the seventh planet from the sun and it is not visible to the naked eye. Like Venus, Uranus also rotates on its axis from east to west. Uranus is inclined on its axis at an angle of 98 degrees. The planet is almost lying on its side as it goes around the sun. The sunlight, thus, is received mostly in the polar areas. Hydrogen, helium and methane are the major gases of its atmosphere. It is very cold due to its great distance from the sun. Uranus is named after the ancient Greek god of the sky. It has a dense atmosphere primarily consisting of methane, which lends it a bluish-green appearance. Uranus also has rings and twenty-seven satellites.

The Neptune

Neptune is the eighth planet from the sun. It takes 16 hours to complete one rotation on its own axis and it takes nearly 165 years to revolve around the sun. It has 13 natural satellites and 5 rings. It is the **coldest planet** in the Solar System because it is the farthest planet from the Sun. Neptune was the first planet located through mathematical calculations. Neptune is our solar system's windiest planet.

2.8 Dwarf Planets

Dwarf planets are tiny planets in our solar system. Any celestial body orbiting around the sun, weighing for the self gravity and nearly be round in shape is called 'Dwarf Planet'. It should not be a satellite of any planet. They are five in number Ceres, Pluto, Heumea, Makemake and Eris. As Pluto has not cleared the neighbourhood around its orbit, it is officially demoted in 2006 from its ninth position as a planet.

DO YOU KNOW?

North Pole of the Uranus experiences 21 years of night time in winter, 21 years of daytime in summer and 42 years of day and night in the spring and fall.

HOTS

Which planet may float on water and why?

2.9 Satellites

The word 'Satellite' means companion. The moon was the only known satellite in the Solar System until 1610. Today, there are 163 known satellites in the Solar System. The satellites move around a planet from West to East. They do not have own light, but reflect the light of the Sun. They have no atmosphere and water.

Figure 2.7 Surface of the Moon

Moon: the Earth's Satellite

The moon is located at a distance of 8, 84,401 km from the earth (Figure 2.7). The moon revolves around the earth. The moon takes 27 days and 7 hours and 43 minutes for both its rotation and revolution around the earth.

Hence, the observers on the earth could see only one side of the moon.

The moon is the fifth largest natural satellite in the solar system. The moon was likely to be formed after a Mars-sized body collided with Earth. There are many craters, high and steep mountains of different sizes which cast shadows on the Moon's surface. The light which is reflected by the Moon will reach the Earth in just one and a quarter seconds.

> **DO YOU KNOW?**
>
> Apollo 11 was the first manned mission to land on the Moon sent by NASA. Two American Astronauts Neil Armstrong and Edwin Aldrin set foot on the moon's surface on the waterless Sea of Tranquility on 20th July, 1969. They stayed there for 21 hours 38 minutes and 21 seconds on the moon. Michael Collins piloted Apollo 11.

Since the moon is smaller than the earth, it has 1/6 of the gravitational pull of the earth. So, man weighs 6 times less on the moon than the earth.

2.10 Asteroids

Asteroids are small rocky celestial bodies that revolve around the Sun, like other planets. They are also called 'Minor Planets'. There are lots of asteroids in the solar system. Larger asteroids are called Planetoids. These are found in between the planets Mars and Jupiter. This belt is known as 'Asteroid belt'. The diameter of the asteroids varies from 100 km to a size of a pebble. The asteroids may be the fragments of a planet exploded in the past or some parts of comets. The new asteroids are being discovered continuously.

2.11 Comets

Comets are the most exciting heavenly bodies and have ever been the objects of man's curiosity as well as fear. The word **Comet** (Figure 2.8) is derived from the Greek word **Aster Kometes** meaning **'Long Haired Star'**. They are made up of small ice particles and meteoric fragments. They revolve around the Sun. But their orbits are irregular. Sometimes they get very close (Perihelion) to the sun and in other times they go far away (Aphelion) from the sun.

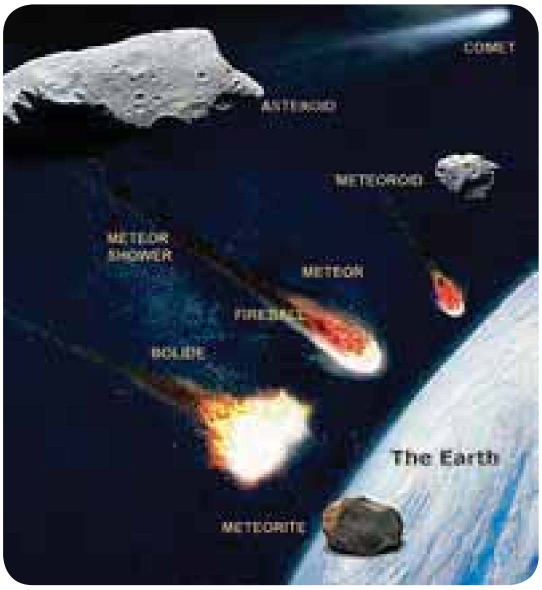


Figure 2.8 Comets

> **DO YOU KNOW?**
>
> The best known Comet, Halley's Comet, appears once in every 76 years. The Halley's Comet was seen last in 1986 and it will be seen again on 28th July 2061.

CASE STUDY

Titan – only moon with clouds and atmosphere.

Titan is Saturn's largest moon and the second largest (after Ganymede of Jupiter) in the solar system. It is the only moon in the solar system with clouds and a dense, planet-like atmosphere.

Scientists believe that conditions on Titan are similar to Earth's early years (the main difference is that, because it is closer to the sun, Earth has always been warmer). According to NASA, "In many respects, Titan, is one of the most Earth-like worlds we have found to date."

Titan was discovered by Dutch astronomer Christiaan Huygens in 1655. The Huygens lander probe sent to the moon aboard NASA's Cassini spacecraft by the European Space Agency is named in his honor. Huygens was the first human-built object to land on Titan's surface. Diameter:5,150 kilometres, about half the size of Earth and almost as large as Mars. Surface temperature: - 179 degrees Celsius, which makes water as hard as rocks and allows methane to be found in its liquid form. Surface pressure: Slightly higher than Earth's pressure. Earth's pressure at sea level is 1 bar while Titan's is 1.6 bars. Orbital period: 15,945 days. Titan's mass is composed mainly of water in the form of ice and rocky material. Titan has no magnetic field.

2.12 Meteors

There is a bright streak of light flashing seen often in the sky during night for a few seconds. They are called as **'shooting stars'**. They are the removed pieces of rocks mainly from the Asteroid belt. They are called **Meteoroids** before they enter into our atmosphere. They enter into the atmosphere with great speed. But most of them are burnt when they enter into the atmosphere.

After entering into our atmosphere they are called as **Meteors**. Some pieces do not burn fully and they fall on the earth and make craters. The large unburned pieces of rocks that fall on the earth are called **Meteorites**.

Examples for Meteorite Fall: Meteor crater in Northern Arizona and Lake Lonar in Buldhana District of Maharastra in India were created by meteor impacts.

2.13 Shape and size of the Earth

It once was believed that the Earth was flat and that ships could sail over the edge. This view persisted even in the middle ages and was an issue in recruitment of Columbus.

Early Greek view was that the world was surrounded by the ocean (*Oceanus*), origin of all rivers. Anaximander (600 B.C) proposed that cylindrical earth was surrounded by celestial sphere. Pythagoras (582-507 B.C.) believed that the Earth was a sphere, which was considered the most harmonious geometric shape. Aristotle (384-322 B.C.) described observations that supported the theory that the Earth was a sphere. These included the fact that the shadow of the moon is circular in lunar eclipses and constellations were higher in the sky as one traveled south. Eratosthenes

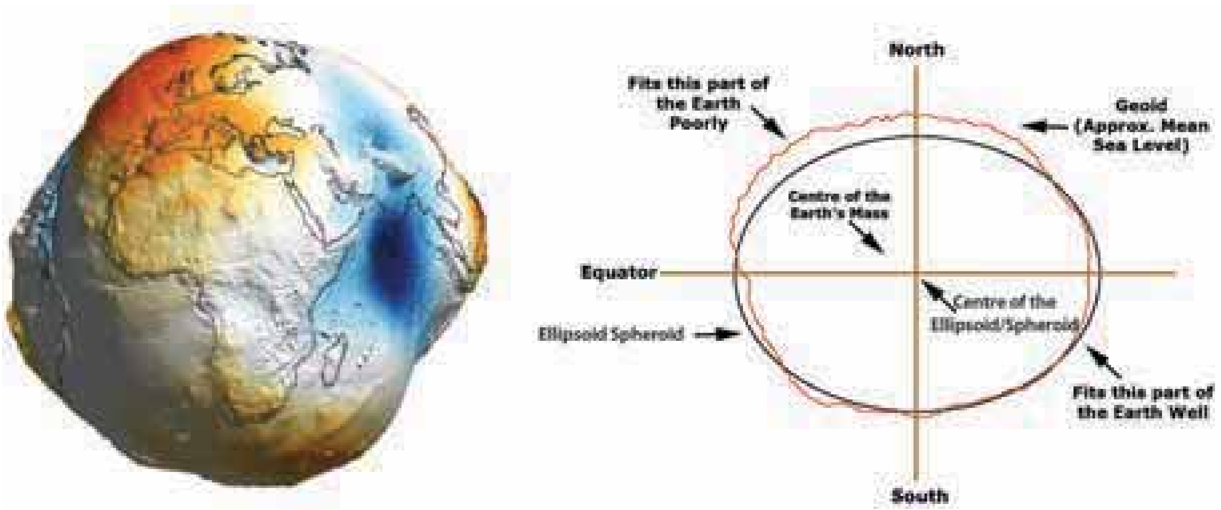


Figure 2.9 Geoid shape of the earth

(275-195 BCE) estimated size of earth from observations that the elevation of the sun varied with position on the Earth's surface in Egypt. Observations of the following suggested that the Earth is a sphere.

1. Mountain peaks lit by the Sun after sunset.
2. Ships disappear below the horizon as they sail across ocean.
3. The moon looks like a disc.
4. The Earth casts a circular shadow during lunar eclipses.

The Earth is an oblate spheroid, bulged at the equator and flattened at the poles. It is called 'Geoid' (Figure 2.9) meaning the earth is earth-shaped. The bulge at the equator is caused by the centrifugal force of the Earth's rotation. The gravitational pull of the earth is the strongest at the flattened poles and it is weaker towards the equator.

HOTS

Chimborazo in Ecuador is higher than Mount Everest, if measured from the centre of the Earth. Why?

The Sun's gravitational pull differs in force at the poles. The North Pole points in the same direction to the North Star when it revolves about the Sun. If the Earth would not have been tilted on its axis, the days and nights would have been of same duration always.

2.14 Motions of the earth

The earth has two basic movements: 1) Rotation and 2) Revolution.

DO YOU KNOW?

Galactic movement: This is the movement of the earth with the sun and the rest of the solar system in an orbit around the centre of the MilkyWay Galaxy. This, however, has little effect upon the changing environment of the earth.

1. **Rotation:** The spinning of the earth around its axis is called the rotation of the earth. The axis is the imaginary line passing through the centre of the earth. The earth completes one rotation in 23 hours, 56 minutes and 4.09 seconds. It rotates in an eastward direction

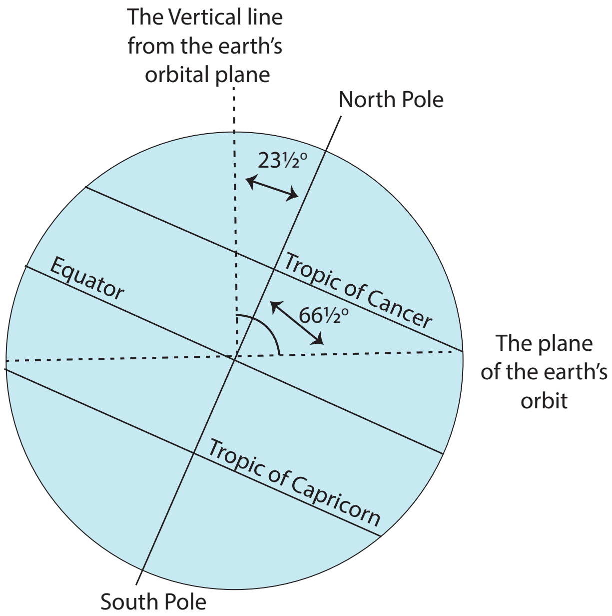


Figure 2.10 Tilt of the Earth's axis

opposite to the apparent movement of the sun. The earth's axis is inclined at an angle of 66½° to the orbital plane as it moves around the sun. We can say, the earth's axis is tilted at an angle of 23½° (Figure 2.10) from a perpendicular to the elliptic plane. The velocity of earth's rotation varies depending on the distance of a given place from the equator.The rotational velocity at the poles is nearly zero. The greatest velocity of the rotation is found at the equator. The velocity of rotation at the equator is 1,670 km per hour.

Effects of earth's rotation: The rotation of the earth causes the following effects:

1. The apparent rising and setting of the sun is actually caused by the earth's rotation which results in the alternate occurrence of day and night everywhere on the earth's surface.
2. Rotation of the earth is also responsible for the difference in time between different places on the earth. A 24 hour period divided by 360 degrees gives a difference of 4 minutes for every degree of longitude that passes the sun. The hour (60 minutes) is thus 1/24 of a day.
3. When you observe through a moving train, trees, houses and fields on the other side of the track appear to move in the direction opposite to that of the speeding train. The apparent movement of the sun and the other heavenly bodies in relation to the rotating earth is similar. As the earth rotates from west to east, the sun, moon, planets and stars appear to rise in the east and set in the west.
4. Rotation causes the working of the Coriolis force which results in the deflection of the winds and the ocean currents from their normal path.
5. Tide is caused by the rotation of the earth apart from the gravitational pull of the sun and the moon.

Rotation causes a flattening of Earth at the two poles and bulging at the Equator. Hence, there is a difference in diameter at the poles and equator.

Circle of Illumination: The line around the earth separating the light and dark is known as the circle of illumination (Figure 2.11).

It passes through the poles and allows the entire earth to have an equal amount of time during the daylight and night time hours. This line can be seen from space, and the exact location of the line is dependent on the various seasons.

Revolution of the Earth

The movement of the earth in its orbit around the sun in an anti-clockwise direction, that is, from west to east is called revolution of the earth. The earth revolves

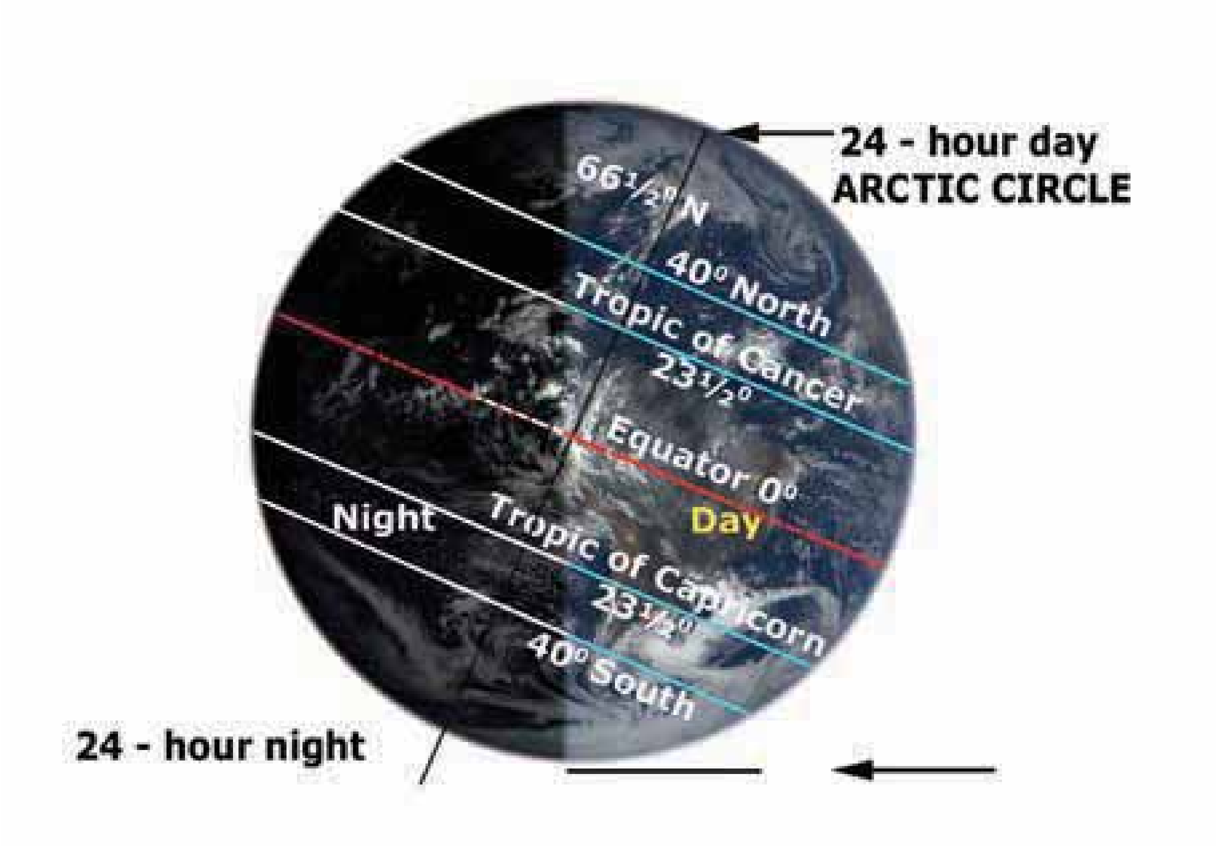


Figure 2.11 Circle of Illumination

in an orbit at an average distance of 150 million km. The distance of the earth from sun varies time to time due to the elliptical shape of the orbit. About January 3rd the earth is closest to the sun and it is said to be at *Perihelion* ('peri' means close to and *Helios* means sun). At Perihelion, the distance is 147 million km.

Around July 4th the earth is farthest from the sun and it is said to be at *Aphelion* (Ap means away and *Helios* means sun). At Aphelion the distance of the earth is 152 million km away from the sun.

The period taken by the earth to complete one revolution around the sun is 365 days and 6 hours (5 hours, 48 minutes and 45 seconds) or 365¼ days. The speed of the revolution is 1,07,000 km per hour. The speed is 30 km per second. The bullet from a gun travels with a speed of 9 km per second.

Period of Revolution and Leap year

The period of time the earth takes to make one revolution around the sun determines the length of one year. The earth takes 365 days and 6 hours to complete one revolution. Earth takes 365.25 days to complete one trip around the Sun .That extra quarter of a day presents a challenge to our calendar system, which has one year as 365 days. To keep our yearly calendars consistent with our orbit around the Sun once in, every four years we add one day.

The extra day added to is called a leap day, and the year the extra day is added to is called a leap year. The extra day is added to the month of February which has 29 days in a leap year.

Brain storming

How many birth days a person, whose life span supposed to be 60 years, would have seen in his/ her life time, if born on 29th February?

Let us know!

How to calculate leap year? Take any year and divide by 4 or 100 or 400. If it is divisible (whole number with no reminder), it is a leap year.

Students' activity: calculate and identify the leap years from the following years

1992, 1995, 2000, 2005, 2008, 2010, 2012, 2014, 2017, 2020, 2024, 2030, 2035, 2040 and 2044.

Effects of revolution of the earth

The revolution of the earth around the sun results in the following

- Cycle of seasons,
- Variation in length of days and nights,
- Variation in distribution of solar energy over the earth and the temperature zones.

2.15 Seasons

The seasons are caused due to the combined effect of the earth's revolution and the tilt of its axis in the same direction throughout the year. In general, spring, summer, autumn and winter are the four seasons (Figure 2.12). The latitude at

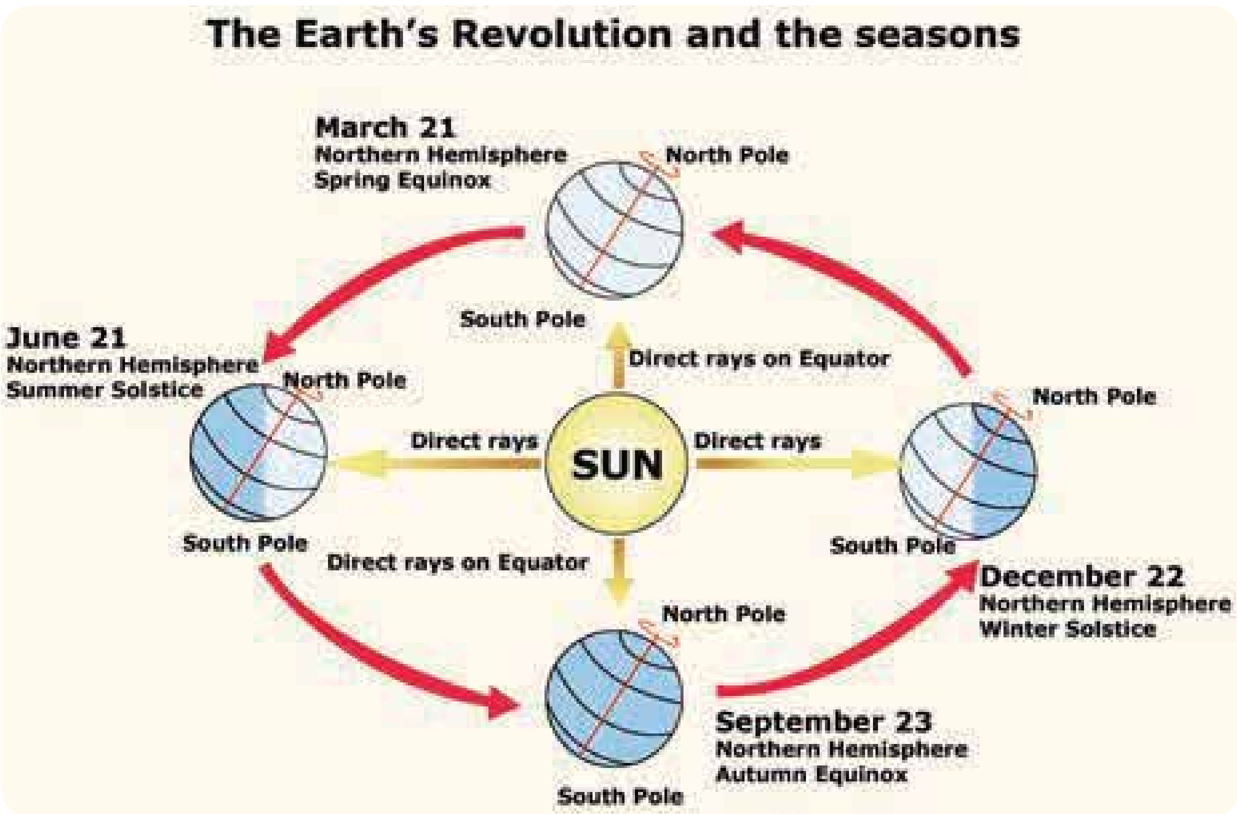


Figure 2.12 Earth's revolution and the seasons

which the sun appears directly overhead changes as the earth orbits the sun. The sun appears to follow a yearly pattern of northward and southward motion in the sky, known as the 'apparent movement of the sun'. It gives an impression that the sun is continuously swinging north and south of the equator. Actually it is the earth that is moving around the sun on its tilted axis. It varies when observed on a daily and monthly basis, at different times of the year. On 21 March and 23 September the sun rises precisely in the east and sets exactly in the west.

Equinoxes and solstices

You already knew that the sunrays are vertical at noon. The vertical rays fall on a small area, giving more heat.

Equinoxes

Equinoxes occur when the earth reaches the points in its orbits where the equatorial and the orbital planes intersect, causing the sun to appear directly overhead at the equator. During the equinoxes the periods of day light and darkness are equal all over the world. On 21 March the sun is directly overhead at the equator. Throughout the world, on this day all the places experience almost equal hours of day and night. This position of the sun is called spring equinox. Again on 23 September the sun is directly overhead on the equator and it is called autumn equinox.

Position of the earth on 21 March

Neither pole is inclined towards the sun. The rays of the sun fall vertically on the equator. All the places have equal days and nights as both the poles receive the rays of the sun. It is spring in the northern hemisphere and autumn in the southern hemisphere. This day (21 March) is known as spring equinox.

Position of the earth on 23 September. Neither pole of the earth is inclined towards the sun. The rays of the sun fall vertically on the equator. All the places have equal days and nights. It is autumn in the northern hemisphere and spring in the southern hemisphere. This day (23 September) when sun's rays for fall verticaly on the equator, is known as autumnal equinox (Figure 2.13).

Position of the earth on 21 June

The North Pole is inclined or tilted towards the sun. It, therefore, experiences complete light for 24 hours. The South Pole is tilted away from the sun so it is in complete darkness for 24 hours. The rays of the sun fall vertically at the tropic of cancer (23½° N). In the Northern hemisphere, the days are longer than the nights (Table 2.2). It is summer in the northern hemisphere and winter in the southern hemisphere. The day 21 June is known as summer solstice.

Position of the earth on 22 December

The South Pole is inclined towards the sun and the North Pole is away from it. The rays of the sun fall vertically at the tropic of Capricorn (23½° S). The greater part of the southern hemisphere gets the direct rays of the sun so the days are long and the nights are short here. In the northern hemisphere the nights are longer than the days at this time. The southern hemisphere has summer. The northern hemisphere has winter. This day (22 December), when the sun's rays fall vertically on the Tropic of Capricorn, is known as winter solstice.

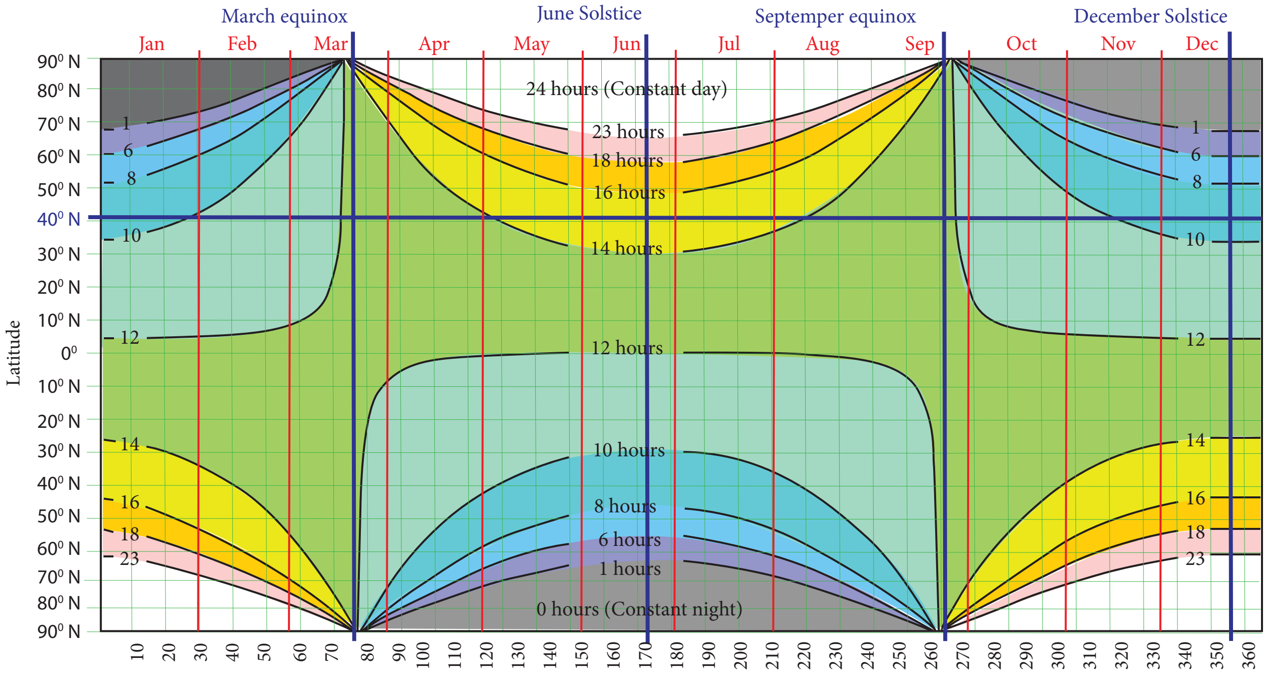


Figure 2.13 Variations in the Length of Day and Night

Table 2.2 Variation in the length of day time

Latitude	Summer Solstice	Winter Solstice	Equinoxes
0°	12 hrs	12 hrs	12hrs
10°	12hrs 35 min	11hrs 25 min	12hrs
20°	13hrs 12min	10hrs 48min	12hrs
30°	13hrs 56min	10hrs 4 min	12hrs
40°	14hrs 52 min	9 hrs 8 min	12hrs
50°	16hrs 18min	7 hrs 42 min	12hrs
60°	18hrs 27min	5 hrs 33min	12hrs
70°	24 hrs (for 2 months)	0 hrs 00 min	12hrs
80°	24 hrs (for 4 months)	0 hrs 00 min	12hrs
90°	24 hrs (for 6 months)	0 hrs 00 min	12hrs

Eclipses

Let us understand the effect of the revolution of the earth on the length of the days and the nights. The duration of the daylight varies with latitude and seasons.

An eclipse is a complete or partial obscuration of light from a celestial body and it passes through the shadow of another celestial body. The eclipses are of two types. They are:

A) Solar Eclipse

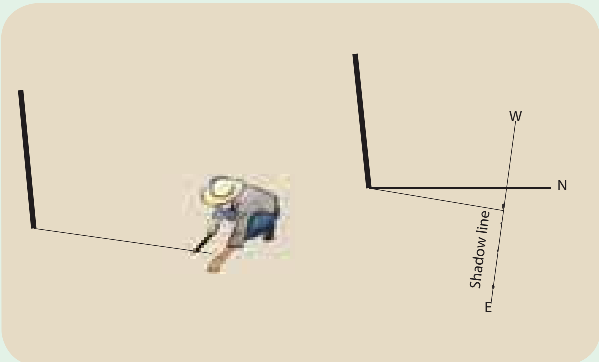
It occurs on New Moon days, when the moon is between the Sun and the Earth. Thus it obscures a part of the Sun viewed from the Earth, but only from a small area of the world. It lasts only for a few minutes. **A partial solar eclipse** (Figure 2.14) happens when the moon partially covers the disc of the sun. **An annular solar eclipse** occurs when the

Fact File

Geo connects History

Secret to **Great Pyramid's** Near Perfect Alignment Possibly Found!

The Great Pyramid of Giza, 4,500 years ago, is an ancient feat of engineering. Now an archaeologist has figured out how the Egyptians may have aligned the pyramid almost perfectly along the cardinal points, north-south-east-west. Egyptians may have used **the autumn equinox**. Methods used by the ancient Egyptians to align the pyramids along the cardinal points are accurate.



On the day of the fall equinox, a surveyor placed a rod into the ground and tracked its shadow throughout the day. The result was a line running almost perfectly east-west. The Egyptians could have determined the day of the fall equinox by counting forward 91 days after the summer solstice.

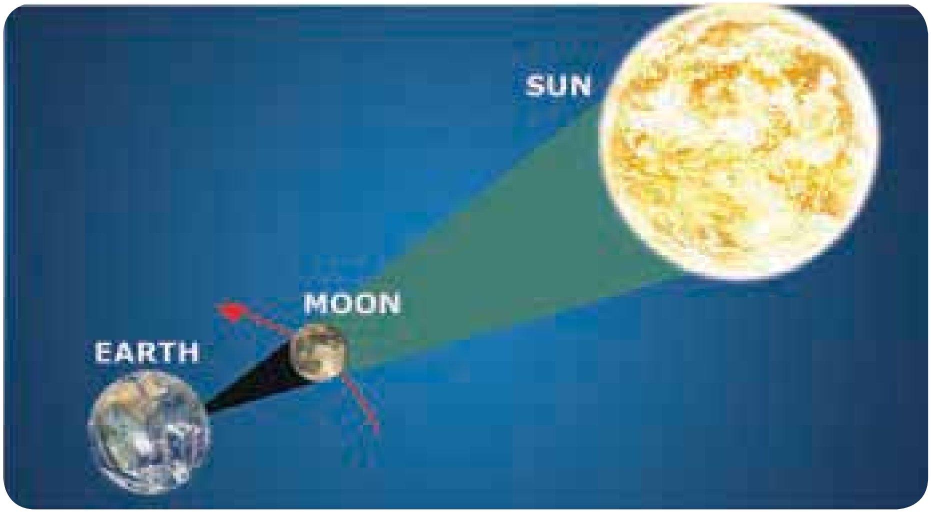


Figure 2.14 Solar eclipse

moon passes centrally across the solar disc. During a **total solar eclipse**, the moon's shadow is short enough to cover the whole sun. The outer regions still glow and look bright as a ring. Such a phenomenon is called **Diamond Ring**.

(b) Lunar Eclipse

7X97QR

It occurs on a Full Moon position when the earth is between the sun and the moon. The earth's shadow obscures the

Difference between Rotation and Revolution

Rotation	Revolution
Spinning of the earth from west to east on its axis.	Movement of the earth around the sun in its elliptical orbit.
It takes 24 hours to complete a rotation (or a day)	It takes 365¼ days to complete one revolution (or a year)
It is known as the daily or diurnal movement.	It is known as the annual movement of the earth.
Rotation causes days and nights to alternate, tides, deflection of winds and ocean currents and also gives the earth its shape.	Revolution results in the varying lengths of day and night, changes in the altitude of the midday sun and change of seasons.

moon as viewed from the earth. **A partial lunar eclipse** can be observed when only a part of the moon's surface is obscured by earth's umbra (Figure 2.15). **A penumbral lunar eclipse** happens when the moon travels through the faint penumbral portion of the earth's shadow. **A total lunar eclipse** occurs when the earth umbra obscures the entire the moon's surface. Lunar eclipse can be seen from anywhere on the night side of the Earth. It lasts for a few hours due to the smaller size of the moon.

Phases of the Moon

The changing angles between the earth, the sun and the moon determine the phases of the moon. Phases of the moon (Figure 2.16) start from the **'New Moon'** every month. Then, only a part of the Moon is seen bright called **'Crescent'**, which develops into the **'first quarter'**. With the increasing brightness it turns into three quarters known as **'Gibbous'** and then it becomes a **'Full Moon'**. These stages are the waxing moon. After the **full moon**, the moon starts waning or receding through the stages of Gibbous, last quarter, crescent, and

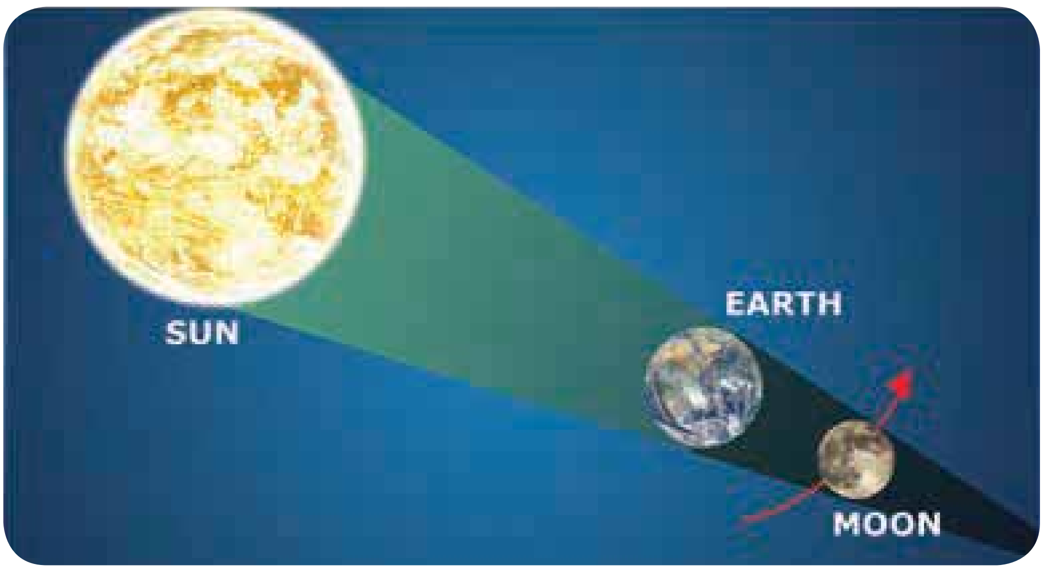


Figure 2.15 Lunar eclipse

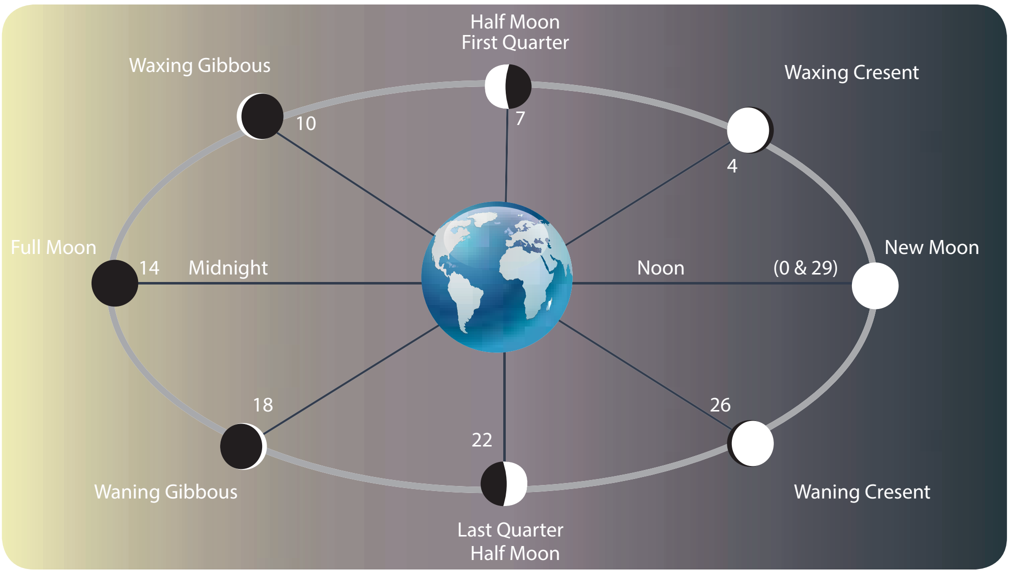


Figure 2.16 Phases of the Moon

finally becomes invisible as dark New Moon.

The varying lengths of daylight in different latitudes

It is evident from the table that the duration of daylight is 12 hours throughout the year at the equator only. As one moves away from the equator, the seasonal variations in the duration of daylight increase. The seasonal variations in the duration of daylight are maximum at the polar region.

Effects of the spherical shape of the earth

Variation in the amount of solar radiation received:

If the earth were a flat surface, oriented at right angle to the sun, all the places on the earth would have received the same amount of radiation. But the earth is spherical/ geoid. Hence the sunrays do not heat the higher latitudes of the earth as much as the tropics. On any given day only the places located at particular latitude receive vertical rays from the sun. As we move north or south of this location, the sun's rays strike at decreasing angles. The yearly fluctuations in the angle of the sun's rays and the length of the days change with the continual change of the earth's position in its orbit around the sun at an inclination of 66½ to the orbital plane.

Difference in the angle of the sun's rays striking different parts of the earth.

Away from the equator, the sun's rays strike the earth's surface at particular angle. The slanting rays are spread over a large area and do not heat with the same intensity as the direct rays. As we go pole wards, the rays spread over the regions beyond the Arctic and the Antarctic circles in an extremely slanting manner. This is how we get the various temperature zones.

Lower the degree of latitude; higher the temperature. Not only that, the rays striking at a low angle must travel through a greater

Figure 2.17 Time zones of the world

thickness of the atmosphere than the rays striking at a higher angle. The rays striking at a lower angle are subject to greater depletion by reflection and absorption by the atmosphere.

Temperature zones

The spherical shape of the earth along with its movement around the sun causes differences in the angles at which the sun's rays fall on the earth's surface. This causes a difference in the distribution of heat on the earth's surface.

As a result, the world has been divided into three distinct heat zones or temperature zones. They are the Torrid zone, Temperate zone and Frigid zone. You will learn more about it under the unit atmosphere.

2.16 Time Zones of the World

People during the medieval period were using sundials and water clocks to observe the Sun's meridian passing at noon. In 17^{th} century, the people started using pendulum clock which did not show accurate time while travelling in the sea. Later chronometer was invented in 1764. Chronometer measures time accurately and the mariners widely used this during the 19^{th} century. But in many towns and cities clocks were set based on sunset and sunrise. The use of local solar time hindered the development of railways and telecommunications. A time zone is a region on the earth where uniform standard time should be maintained for transport, commercial and social purposes. For example, if different time zones were followed, the trains coming from different regions, sharing single track may meet with accidents.

The world time zone (Figure 2.17) was formed, relating longitude and the rotation of the earth. The Prime Meridian is the centre of time zone extending from 7½°W and 7½ ° E longitudes. The 24 hours time zone system had been developed so that all the time zones should be referred with respect to Greenwich Mean Time. Earth was divided into 24 time zones, each one zone for one hour of the day. It is because earth rotates 15° of longitude in one hour (360° divided by 24 hours). The time when solar noon occurs at the Prime Meridian is fixed as noon for all places between 7½° E and 7½° W.

Daylight Saving Time

In the mid latitude countries of Europe, North America, Australia and South America, the day time are longer in summer than the night. In spite of employing daylight duration, the clocks are adjusted 1 hour forward in spring and 1 hour backward in autumn. This time is generally known as 'the Daylight Saving Time' (DST).

Time Zones

On its axis, the earth rotates 360 degrees every 24 hours. You can look at it as it takes one day to complete a full circle. Divided up into an hourly rate, the earth rotates 15 degrees every hour (360/24). This number plays an important role in determining time zones. You have already learned about the latitudes and longitudes and their importance in the lower classes.

An important factor in determining time zones is the lines of latitude and longitude, imaginary lines known as latitudes and longitudes dividing the earth. Latitude lines are drawn east - west and they measure the location in northern and southern hemisphere. The line starts at the equator and measure distance from 0 degrees to 90 degrees north and also 0 degrees to 90 degrees south. They also become shorter farther away from the equator. On the other hand, longitude lines are drawn north - south and they measure eastern and western hemisphere. They start at the Prime Meridian (or 0 degree) and measure from 0 degrees to 180 degrees east and 180 degrees west. Unlike lines of latitude, these lines are fairly equal in length. The origin of this spherical coordinate system is at 0 degree latitude and 0 degree longitude. This spot can be found in the Atlantic Ocean just south west of Africa. Also, the two lines connect at 180 degrees or at the International Date Line (Figure 2.18). This too helps to determining different time zones of the world.

Together all of the above information can be used to calculate the difference of time between two locations.

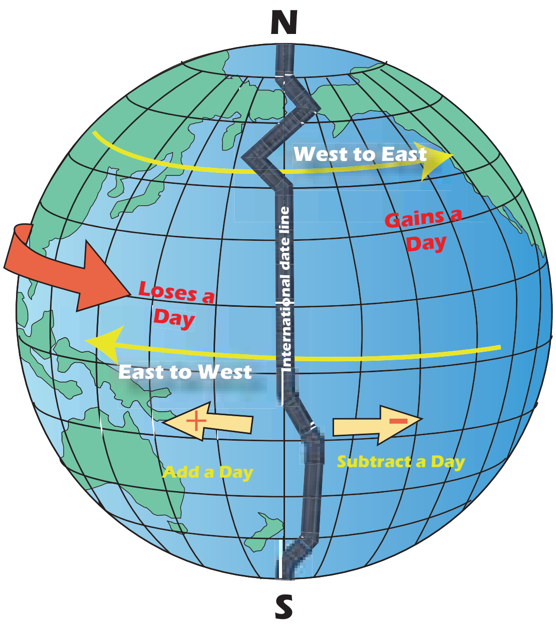


Figure 2.18 International date line

1. First, we need to know what longitudes the two places are located.
2. Next, you would need to find the differences in longitude (in degrees) between the two places. If both places are located on the same side of the Prime Meridian, then the numbers are just simply subtracted to find the difference. If they are on the opposite side of the Prime Meridian then the two numbers should be added together to find the difference.
3. Third, we need to divide the difference (measured in degrees) by 15 since there are 15 degrees in every hour. This will give us the difference in time between the two locations. So if you know what time it is in one location, and the longitude of another location, then just simple addition or subtraction problem will give us the time in a different time zone. Let's look at another way we may have to calculate the difference between times of two locations.

Another calculation you may have to make is over the International Date Line. This line is strategically placed in the Pacific Ocean so that no two neighboring cities are one day apart in time. It can be difficult to calculate though the International Date Line when trying to determine the amount of time difference between locations on either side. This calculation is very similar to the situation with the Prime Meridian. We must start by finding the difference in longitude (or degrees) of the two places. We do this by adding the two numbers. Then, divide by the 15 degrees that occurs in one hour and this will give you the time difference between two locations through the International Date Line. And again, just add or subtract that difference from the time that we already know to come up with the new time in the new time zone.

Example of Time Calculations

To review, to find the difference between the two longitudes and divide by 15, this gives you the difference in hours between the two locations. Second, add or subtract the number of hours from the time of day that was already known, we will need to add the numbers if we are going east, and subtract if we are going west. Here are some examples of how we may need to calculate the difference of time zones.

If you are in London at 12:00, and want to know what time it is in Japan, you would need to first figure out that London is 0 degrees (right on the prime meridian), and Japan is 135 degrees East. So the difference is 135 degrees (135–0), divided by 15 which equals 9. It means there is a 9-hour difference between London and Japan. Since Japan is further east than London is, you would add 9 hours to 12:00. The answer is at 12:00 noon London time, it is 9:00pm in Japan.

Now we suppose imagine that we are going through the International Date Line. Pretend you are in Japan, which is 135 degrees east and you wanted to know what time it is in Hawaii, which is 150 West. Well, there is 45 (180–135) degrees difference between Japan and the IDL. Also there is 30 (180–150) degrees difference between the IDL and Hawaii. Therefore the difference in time is (45 + 30/15 = 5) 5 hours. Now the tricky part is that Japan and Hawaii are on different days. It is one day ahead on the left side of the IDL compared to the right side. If it is 3:00pm in Japan on Thursday that means it is 3:00 + 5 hours = 8:00pm in Hawaii. However notice that when crossing the IDL we subtract a day going east. So, in Hawaii it is 8:00pm on Wednesday.

Now note that Latitudinal lines are imaginary horizontal lines over the Earth's globe. 0° longitudinal line is Equator. Earth completes one rotation on its axis in 24 hours and in the process turns a complete circle of 360°. This means Earth rotates 360°/24 = 15° in one hour. Every gain or loss of 1° longitude stands for 4 minutes.

360° = 24 hours = 1440 min

Difference of time for 15° longitude = one hour.

Difference of time for 1° longitude = 4 minutes.

Longitude Calculations Procedures

a. First locate the two places involved
b. find the longitude difference
c. Convert the longitude difference to time and,
d. Adjust the time according to the direction of movement, (west or east).

Example 1

Ponni starts her journey at longitude 0° at 12 noon and she's moving towards eastward of longitude 10°. Calculate the time that Ponni will arrive at her destination.

Solution

Initial time = 12 noon

Destination = 10°E

Conversion of degree to time

1 hour = 15°

and 4 minutes = 1°

Hence 10° = (4 × 10) minutes

= 40 minutes

Destination time = Initial time + calculated time

= 12 noon + 40minutes

= 12:40pm

Example 2

If the time at village A (long 75°W) is 5:00 pm on Friday. Calculate the time and day at village B (long 120°E)

Solution

360° = 24hrs

15° = 1 hour

1° = 4 minutes

Village A = 75°W

Village B = 120°E

We will add (west and east)

(75 + 120)° = 195°

195 divided by 15°

= 13hrs

Destination time = initial + calculated time

= 5:00 + 13 hrs

= 18:00

18:00 = 6:00

Answer = 6:00am on Saturday

Example 3

Calculate the local time in New York (USA) longitude 75°W, when it is 10am in Nigeria of longitude 15°E

Solution

Initial time = 10:00am

New York = 75°W

Nigeria = 15° E

We will add (west and east)

(75 + 15)° = 90°

90° divided by 15° = 6 hrs

Destination time = initial + calculated time

= 10:00am + 6hrs

= 14:00pm

14:00pm = 4:00pm

Answer = 4:00pm

A-Z GLOSSARY

1. **Dark energy:** A theoretical form of energy postulated to act in opposition to gravity and to occupy the entire universe, accounting for most of the energy in it and causing its expansion to accelerate.
2. **Magnetic field:** A force field that is created by moving electric charges and magnetic dipoles, and exerts a force on other nearby moving charges and magnetic dipoles.
3. **Penumbra:** The partially shaded outer region of the shadow cast by an opaque object.
4. **Asteroids:** Small rocky celestial bodies that revolve around the Sun, like other planets.
5. **Standard time:** A uniform time for places in approximately the same longitude, established in a country or region by law or custom.
6. **Galactic movement:** This is the movement of the earth with the sun and the rest of the solar system in an orbit around the centre of the MilkyWay Galaxy
7. **Equinox:** Time when the apparent movement of the sun is overhead the equator.
8. **Gibbous:** Third quarter of moon's phase is known as Gibbous.

9. **Solar flare:** A magnetic storm on the sun and releases huge amounts of gases. It can cause 'Sun quakes'.
10. **Super Nova:** The explosive death of a star. It obtains brightness of 100 million suns for a short time.

Evaluation

7XI3SE

I. Choose the best answer from the options given

1. The scientist who proposed Big Bang Theory was
   a. Abbe Georges Lemaitre
   b. Edwin Hubble
   c. Nicholas Copernicus
   d. Aryabhatta
2. ____________ is called the Morning and Evening Star in the Solar system.
   a. The Mercury b. The Venus
   c. The Uranus d. The Saturn
3. The Planet with 30 rings in the solar system is ____________
   a. The Jupiter b. The Mars
   c. The Earth d. The Saturn
4. The earth takes ____________ to complete one rotation.
   a. 23 hrs 56 min 4 sec
   b. 27 hrs 17 min
   c. 24 hrs 56 min 4 sec
   d. 10 hrs 7 min
5. The windiest planet is
   a. The Saturn b. The Neptune
   c. The Jupiter d. The Mars
6. The sun appears to be the closest to the earth on
   a. January 3 b. July 4
   c. September 5 d. December 4
7. The length of day time at 80^0 N during summer solstice is
   a. 18hrs 27min
   b. 24 hrs (for 2 months)
   c. 24 hrs (for 4 months)
   d. 24 hrs (for 6 months)
8. The apparent movement of the Sun is overhead the Equator twice a year on
   a. Dec 22 and Mar21
   b. Mar21 and Sep23
   c. Jun 21 and Dec 22
   d. Sep 23 and Dec22
9. On June 21 the Sun's rays fall vertically on the
   a. The Tropic of Cancer
   b. The Tropic of Capricorn
   c. The Equator
   d. The Arctic Circle
10. The Prime Meridian is the centre of time zone extending between
    a. 7 ½° W and 7 ½° E longitudes
    b. 7 ½° N and 7 ½° S
    c. 17 ½° W and 17 ½° E Longitudes
    d. 17 ½° N and 17 ½° S

II. Very short answer

11. Define a star.
12. Why is the Venus hottest?
13. Mention any two differences between the Mercury and Neptune.
14. What are the inner planets?
15. Define the circle of illumination.

III. Short answer

16. What are dwarf planets?
17. Why could we see only one side of the Moon always?

18. Mention the characteristics of the Saturn.
19. Distinguish between the solar eclipse and lunar eclipse.
20. Calculate the local time of Chennai (80^0 27’ E) when it is 8 pm in Singapore (103^0 81’E)

IV. Detailed answer

21. Explain the Big bang Theory.
22. Describe the structure of the Sun.
23. Draw the four positions of the Sun during equinoxes and Solstices and briefly explain them.

Additional questions

1. Lines of latitude
   a. begin with the prime meridian;
   b. are designated by being East or West from an origin;
   c. are of equal length;
   d. become shorter away from the equator;
   e. E. none of the above.
2. All of the following are true statements about longitude, except
   a. has its origin at the prime meridian;
   b. extend east and west to 180 degrees longitude;
   c. are relatively equal in length;
   d. could be determined by sailors using a device called the sextant;
   e. could not be determined by sailors until the introduction of the chronometer.
3. You are told that the earth rotates on its axis at a speed of about 1042 miles per hour. Given that the rotation occurs in 24 hours, what is the circumference of the earth?
   a. 40,000 miles;
   b. 25,000 miles;
   c. 2400 miles;
   d. 76,000 miles;
   e. none of the above.
4. How many degrees of a full circle can you travel eastward or westward from the zero (prime) Meridian before heading back toward the Prime Meridian?
   a. 60 degree.
   b. 90 degree.
   c. 360 degree.
   d. 180 degree.
   e. none of the above.
5. 0 degree longitude and 0 degree. latitude is located:
   a. over central Australia;
   b. in Brazil;
   c. in the Atlantic south and west of Africa;
   d. at the South Pole;
   e. none of the above.
6. To find longitude, a sailor needs to know
   a. the elevation of the sun above the horizon;
   b. the latitude at the prime meridian;
   c. local time and the time at another line of longitude;
   d. the relative space;
   e. none of the above.
7. Latitude and longitude is a spherical coordinate system with its origin at 0 degree latitude and 0 degree longitude. This point is in the Atlantic Ocean just below the African country of the

Ivory Coast. Locations are measured in degrees away from this origin in north, south, east and west directions. 23.34 degree S and 46.38 degree W is probably located in:

   a. Russia;
   b. Canada;
   c. South Africa;
   d. South America
   e. None of the above.

8. The circumference of the earth at the equator or along any line of longitude is approximately:
   a. 25,000 km
   b. 40,000 km
   c. 36,000 km
   d. 46,000 km.
9. It is 1:00 PM on Friday at 90 degree W. what time is it at 90 degree E?
   a. 7:00 PM Friday;
   b. 7:00 AM Friday;
   c. 7:00 AM Saturday;
   d. 1:00 AM Saturday;
   e. 1:00 PM Saturday.
10. It is 12 Noon, Monday at 90 degree. W. what time and day should it be at 75 degrees east longitude?
   a. 11PM, Monday;
   b. 11 AM; Tuesday;
   c. 1 AM; Monday;
   d. 11 PM; Tuesday;
   e. 6 AM; Monday.

Practice

1. Prepare a working model of the Solar system as a group work and demonstrate in the class.
2. Collect and prepare in a chart, the facts about the sun, planets, satellites, asteroids, comets and meteors and make a news reading of each heavenly body in the school assembly each one day.
3. Collect latest information on the "Planet 9" and present it in the classroom.

Reference

1. Geography by Surender Singh.
2. Geography by Vee Kumar publications.
3. Solar system. Nasa.gov.com

ICT CORNER

Time zone and Eclipses Conflicting Clocks

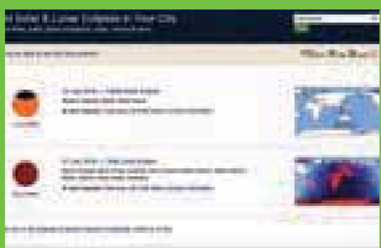
Through this activity you will identify time zones and Eclipses.

Steps

- Use the URL to reach the 'Time Zone Map' page or scan the QR code.
- Use the mouse and surf over the interactive map to observe the time variations and current time in a particular place.
- Select 'Eclipses' under 'Sun and Moon' menu to observe eclipses and transits of planets.
- Click 'See list of all eclipses & planet transits worldwide (1900 to 2199)' option form the list and use the interactive map to identify date and paths of eclipse and transits.

Step 1

Step 2



Step 3

Step 4

Website URL:

https://www.timeanddate.com/time/map/

*Pictures are indicative only.

B169_11_GEO_EM

Unit III

Lithosphere: Endogenic Processes

Chapter Outline

Learning Objectives:

- *Understand the structure and composition of the Earth.*
- *Develop an insight into the Continental Drift Theory.*
- *Describe the concept of Plate Tectonic movement.*
- *List and compare the characteristics and distribution of the earth's internal forces*
- *Explain rock types and rock cycle*

3.1 Introduction

Do you know that the Russians tried to dig through the centre of the Earth? It indeed is a daring attempt.

While the famous Voyager 1 satellite took 26 years to exit our Solar System (16.5 billion km away), almost the same amount of time (24 years) was taken for man to dig out a mere 12.3 km into the earth's surface.

Russia drilled Kola Super Deep bore hole between 1970 and 1994. The deepest

Figure 3.1 Kola Super Deep Borehole, Russia

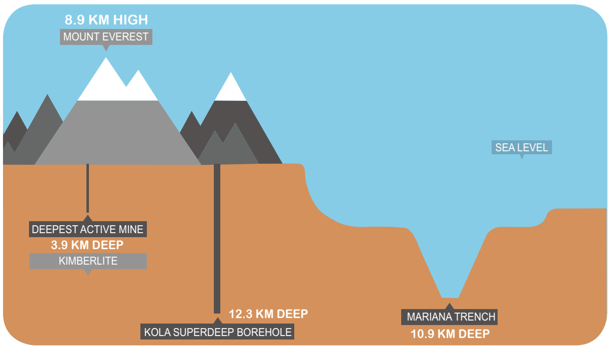


Figure 3.2 Extreme points of the earth

part of it, named 'SG-3 (Star Gate), extends 12.3 km into the Earth. Look at figure 3.2 and amaze the highest and deepest points of the earth.

The earth's surface is being continuously reshaped by both the internal (Endogenic forces) and external forces (Exogenic forces). The changes that the endogenic and exogenic forces bring about in the appearance of the surface of the earth are collectively known as geomorphic processes. (figure. 3.3)

The process by which the earth's surface is reshaped through rock movements and displacement is termed as diastrophism. Diastrophism includes both orogenic and epeirogenic processes.

Our knowledge of the earth is mostly limited to its surface. But the earth has a complicated interior. The earth is composed of lithosphere, atmosphere, hydrosphere, and biosphere.

The lithosphere is the outermost rigid rocky shell of the earth. It comprises the crust and the upper portion of the mantle. The word lithosphere is derived from the Greek words ***lithos*** meaning rocky and ***sphaira*** meaning sphere. The term **lithosphere** was introduced by Joseph Barrel, an American Geologist.

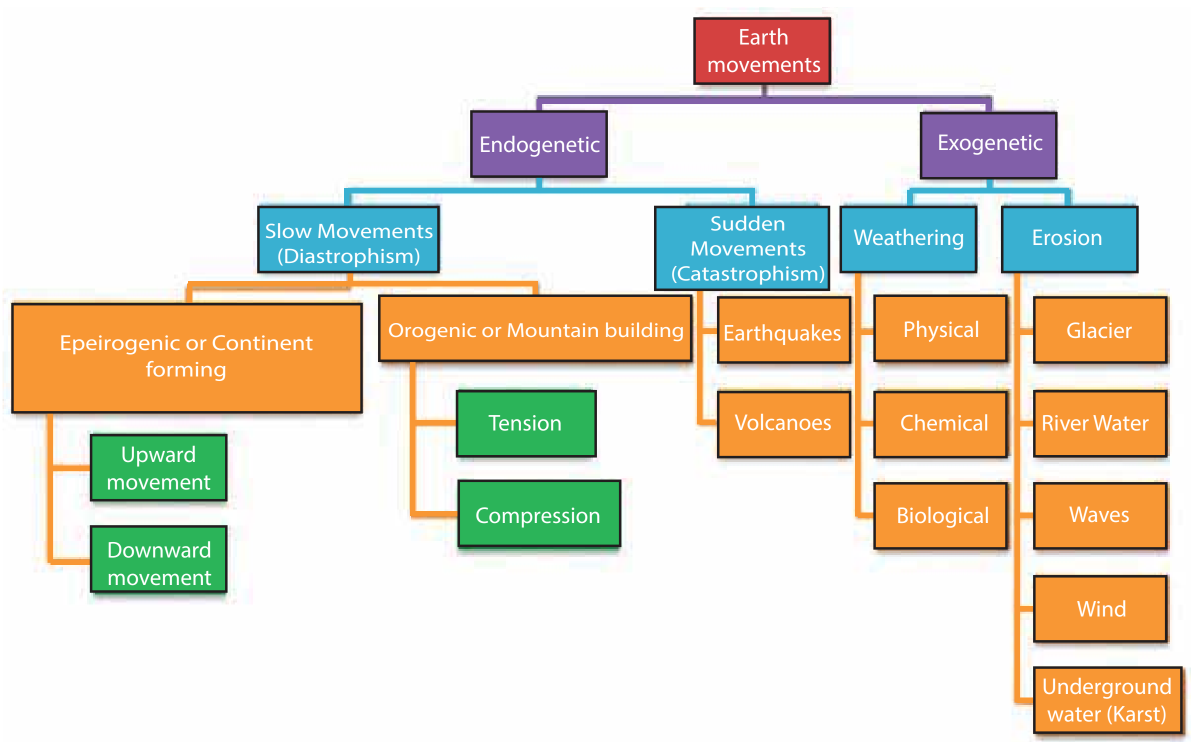


Figure 3.3 Earth's Forces

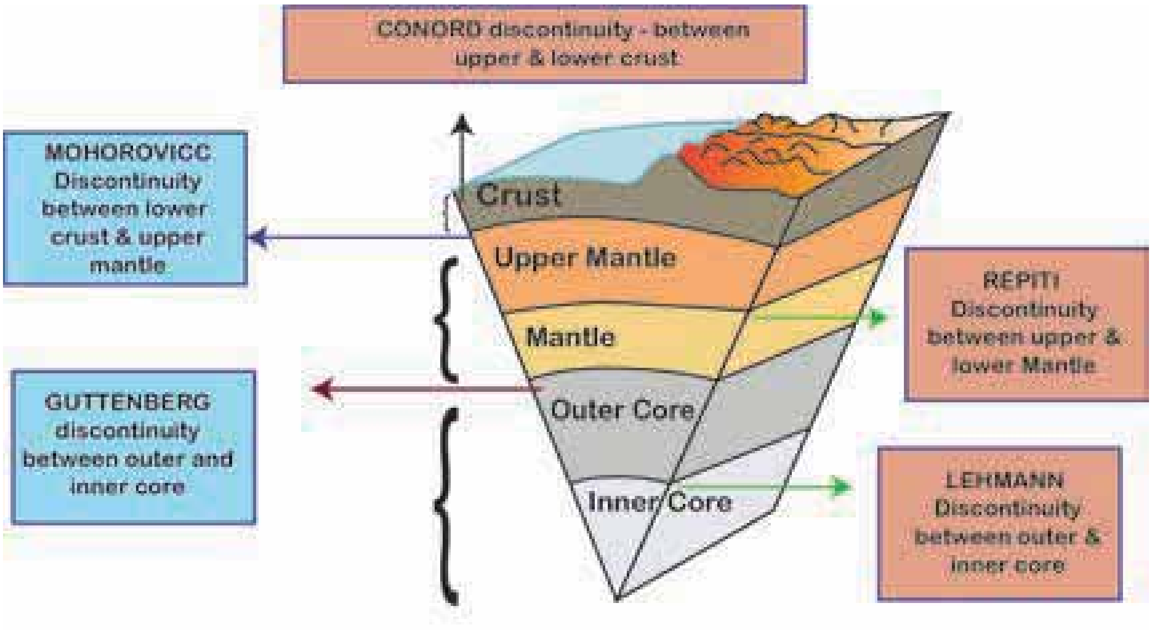


Figure 3.4 Layers of the Earth

3.2 Interior of the Earth

The interior of the earth is composed of many minerals both in the solid and liquid state. The temperature in general increases at the rate of 1° C for every 32 metres towards the earth's interior.

Look at the figure.3.4 the layers of the earth. Earth's interior can be divided into the crust, upper mantle, lower mantle, outer core, and inner core.

3.2.1 The Crust

The crust is further divided into upper crust (continental crust), composed of silica and aluminum (sial) and the lower crust (oceanic crust) made up of silica and magnesium (sima). The boundary between the upper crust and the lower crust is termed as 'Conorod boundary'. The thickness of the crust varies from oceanic areas to continental areas. Oceanic crust is thinner when compared to the continental crust. The mean thickness of oceanic crust is 5 km while the continental crust is around 30 km. The continental crust is thicker in the areas of major mountain systems. It is as much as 70 km thick in the Himalayan region. The density of the crust is less than 2.7 g/cm^3.

3.2.2 The mantle

The mantle is composed of silica, magnesium and iron. It lies between the lower crust and the outer core. It extends for about 2,900 km. It is divided into upper mantle and lower mantle. The mantle generally is in a solid state. The upper part of the mantle is called asthenosphere. The word *Asthen* in Greek means weak. It extends up to 400 km and it is the main source of magma. The Mohorovicic is the boundary which divides the lower crust and the upper mantle. The density of the mantle is 3.9 g/cm^3.

3.2.3 The core

The core forms the centre of the earth. Its density is 13.0 g/cm^3. Its temperature is about 5500° C to 6000° C. The core has two parts namely the outer core and the inner core. The boundary between the lower mantle and the outer core is called Guttenberg margin.

The outer core and inner core are separated by **Lehmann boundary**. The outer core is in the liquid state while the inner core is in the solid state. Generally, the core is composed of Nickel and Ferrous (Iron) which is called NiFe (Barysphere). The core is extended from 2,900 km to 6,370 km from the surface of the earth.

3.3 Continental Drift Theory

In 1912 Alfred Wegener (1880-1930) postulated that all the continents once were together forming a single continent. According to him, about 250 million years

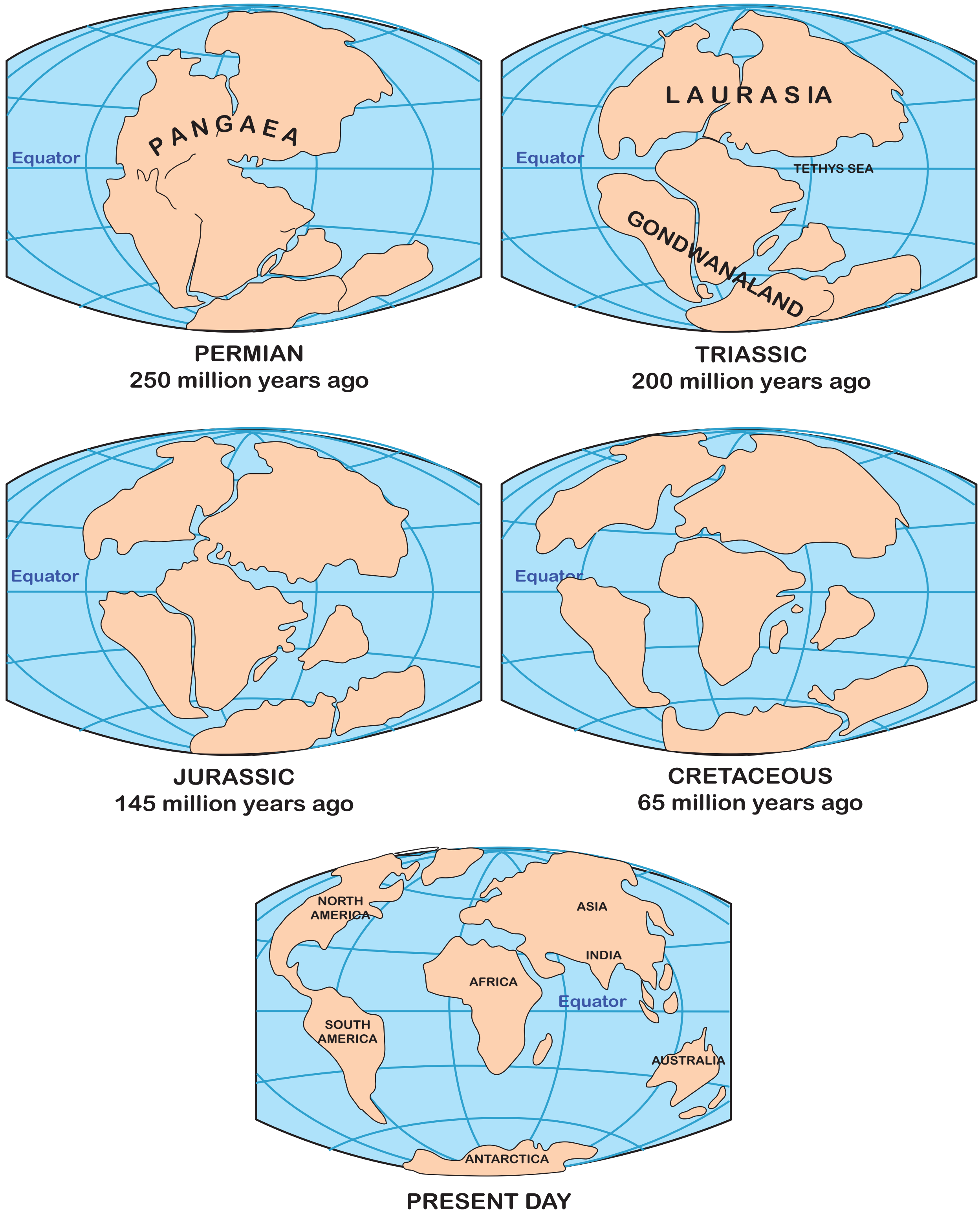


Figure 3.5 Continental Drift

ago, the earth was made up of a single landmass called *Pangaea* (meaning "all lands"), and a single ocean surrounding it called as Panthalassa. Over a long period of time, probably 220 million years ago, they drifted apart and gradually moved to form their present position. First, Pangaea broke into two landmasses namely Laurasia in the north and Gondwana in the south.

Laurasia further split into Eurasia and North America. Gondwana land split into Africa, South America, Antarctica, Australia, and India.

Wegener put forward certain evidences to support the continental drift theory. Let us deal with it in detail.

3.3.1 Evidences to support continental drift theory

The continental drift theory is supported by the following evidences.

1. Certain identical rare fossils have been found in different continents.

   The fossils of Mesosaurus (a small Permian reptile), for example, have been found only in Africa and South America.
2. The fossil of a Fern tree, about 360 million year old, has been found only in India and Antarctica.
3. Rocks of similar type, formation, and age have been found in Africa and Brazil.
4. Geological structure in Newfoundland matches with that of Ireland, Scotland and Scandinavia. Geological Structure of Appalachian Mountains matches with Morocco and Algeria in North Africa.
5. The corresponding edges of the continents fit together. For example, the western side of Africa and the eastern side of South America fit together.

DO YOU KNOW?

Enchanted rock in the Texas Hill Country is about a billion years old. The Hawaiian Islands are the youngest lava forms of the Hawaiian hotspot.

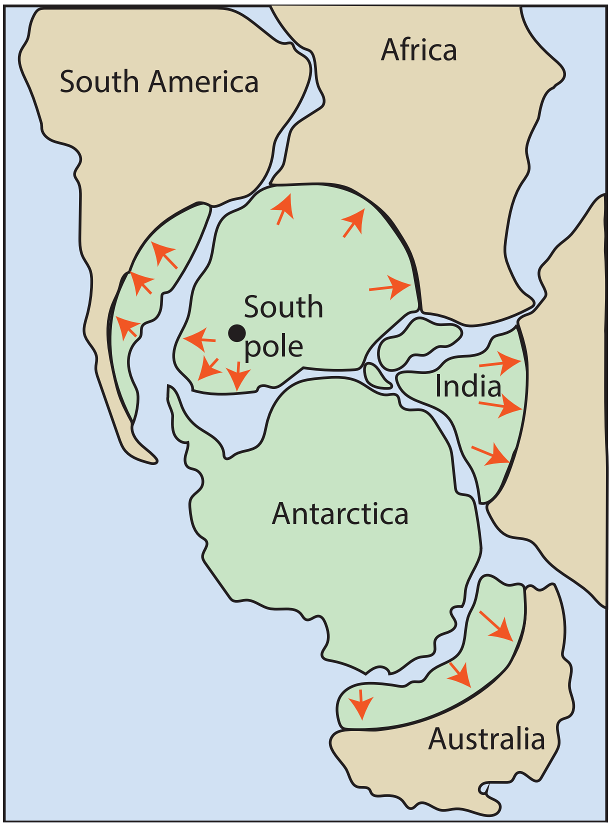


Figure 3.6 Evidence of continents split from the same land mass

3.4 Plate Tectonics

Have you heard about diving between two continents? It is possible in the Silfra rift of Iceland. Look at Figure.3.7. It is located in the Tingvellir National Park. It is in the boundary between the North American plate and the Eurasian plate. It is the visible boundary between these two plates.

Figure 3.7 Silfra rift, Tingvellir, Iceland

Web link for Silfra drift

https://www.youtube.com/watch?v=U3eT0qmPJbw

You have already learned the Continental drift theory. Now let us see what plate boundaries are.

3.5 Plate boundaries

Plate boundaries are the zones where two or more plates move about. Plate tectonics describes the distribution and motion of the plates. The earth's surface is composed of rigid lithospheric slabs technically called "plates". The word **tectonic** is derived from the Greek word ***tekton*** meaning builders.

> DO YOU KNOW?
>
> GNSS (Global navigation satellite System) measures the speed of plate movement. Rate of seafloor spreading ranges from 1 to 2 centimetres per year along the oceanic ridge in the northern Atlantic Ocean to more than 15 cm per year along the East Pacific Rise.

Lithospheric plates are sometimes called as crustal plates or tectonic plates. Earth's lithosphere is divided into a series of major and minor mobile plates. Eurasian plate, Indo-Australian plate, North American plate, South American plate, Pacific plate, African plate and Antarctic plate are the major plates. Arabian plate, Caribbean plate, Cocas plate and Scotia plate are the examples of minor plates. Plates move at the rate of 2 to 3 centimeters per year.

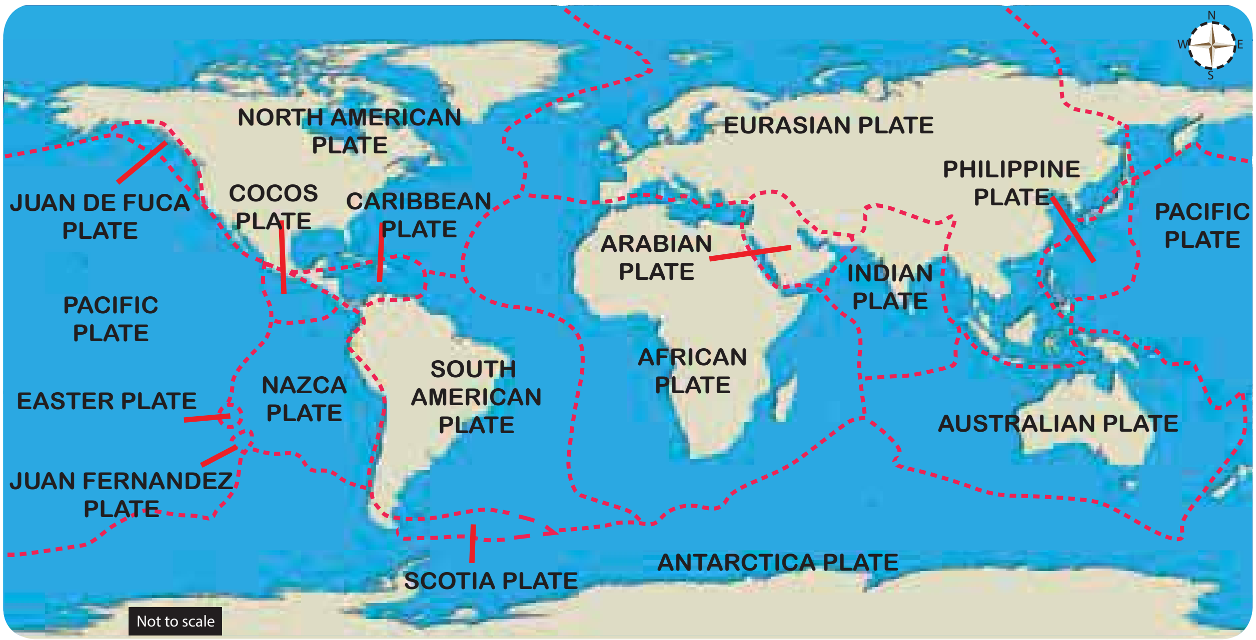


Figure 3.8 Distribution of tectonic plates

Student activity

Look at the map given below. Label the plates or number them. Identify and colour the oceanic plates.

1. Pacific plate	9. North American plate
2. African plate	10. South American plate
3. Eurasian plate	11. Juan de Fuca plate
4. Arabian plate	12. Indian plate
5. Australian plate	13. Antarctic plate
6. Caribbean plate	14. Philippine plate
7. Cocas plate	15. Nasca plate
8. Scotia plate	

1. Name the plates bordering the Indo-Australian plate.

____

2. Which sea lies between African plate and Arabian plate?

____

3. Which two continents, you think, may fit together?

____

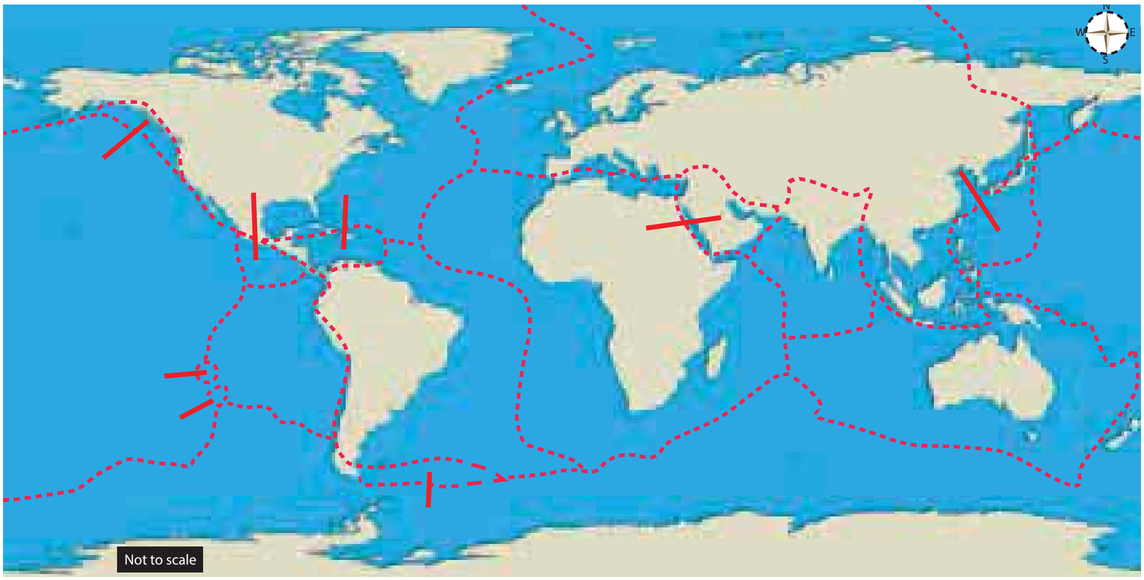


Figure 3.9 Tectonic plates

Plates are composed of the continental or oceanic landmass. The subduction of the oceanic plates results in the occurrence of earthquakes and volcanoes adjacent to trenches.

Plate margins mark the occurrence of the most significant landforms, including volcanoes, fold mountains, island arcs and deep-sea trenches. There are three principal types of plate boundaries. They are divergent, convergent, and transform boundaries.

3.5.1 Divergent plate boundaries

Divergent plate boundary is the margin where two plates move apart. For instance, the African plate and South American plate move apart and form a divergent plate boundary. Narrow oceans represent young divergent boundaries and wide oceans are indications of old ocean basins. Ocean ridges are the boundaries between plates of the lithosphere.

> **DO YOU KNOW?**
>
> Atlantic Ocean is widening at an estimated rate of 1 to 10 cm a year

A fissure is created when oceanic lithosphere separates along the oceanic plate boundary. The gap is filled by magma that rises from the asthenosphere. The magma cools and solidifies to create a new oceanic crust. Hence, the divergent plate boundary is termed as the constructive plate boundary. It is also called as accreting plate margin.

Let us see what happens in the divergent plate boundary. Firstly, submarine mountain ridge is formed through the fissures in the oceanic crust when the plates move apart.

The Mid-Atlantic Ridge is an ideal example of a submarine mountain ridge in the Atlantic Ocean. It is the longest mountain ridge in the world.

It extends for about 16,000 km, in a 'S' shaped path, between Iceland in the north and Bouvet Island in the south. It is about 80 to 120 km wide. It reaches above the sea level in some places thus forming the

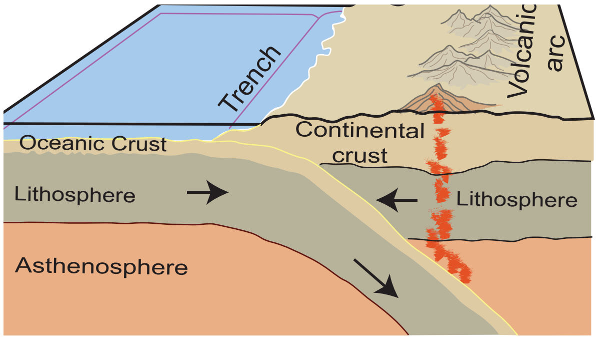


Figure 3.10 Divergent margin

islands such as the Azores, Ascension, St. Helena and Tristan da Cunha.

> **Web link: Mid Atlantic Ridge**
>
> www.britanica.com/place/atlanticocean

Secondly, rift valley is formed when two plates move apart. If a divergent boundary runs through the continent, the continent splits apart and rift valley is formed. The African Rift Valley of East Africa is an example.

3.5.2 Convergent plate boundary

Convergent plate boundary is the margin where two plates collide with one another. For instance, the South American plate and Nazca plate collide with each other. There are two kinds of surface features associated with the convergent margin. The first is the ocean trench that forms a line between the two colliding plates.

> **DO YOU KNOW?**
>
> Wadati-Benioff zones are nothing but Subduction zone

A trench is a narrow and deep depression of the ocean floor. It is formed when the oceanic plate slides down underneath continental plate as the oceanic plate is denser than the continental plate. For instance, Mariana Trench in the Pacific Ocean, is the deepest trench in the world. It is formed when the Pacific plate sinks down the Eurasian plate. It is about 10,994 metres (10.99 km) deep. Mariana Trench stretches for more than 2,540 km with a width of 69 km.

You could take Mount Everest and sink it in the Mariana Trench, the deepest point in the ocean, and still you have a km of depth to reach the surface of the ocean.

When a continental plate and an oceanic plate collide with each other, denser oceanic plate sinks below the lighter continental plate, subduction zone is formed.

A subduction zone is a boundary where one plate sinks under the other plate. It was first identified by Kiyoo Wadati and Benioff.

Secondly fold mountain is formed when two plates collide each other. For instance, the Himalayas were formed when the Indian plate collided with the Eurasian plate. The zone marking the boundary of the two colliding plates is known as suture line.

As the crust is less dense than the mantle, the newly formed magma will tend to rise to the Earth's surface, where it may form volcanoes. The area in the subduction zone where most earthquakes occur is known as the Benioff zone.

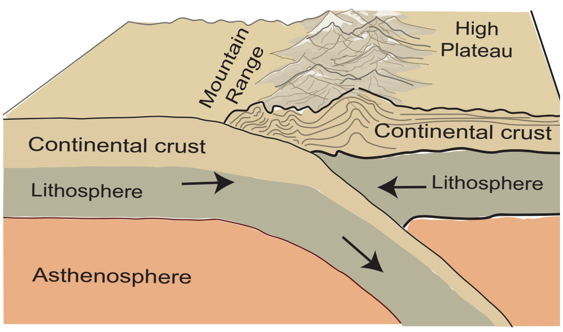


Figure 3.11 Convergent plate boundaries

3.5.3 Transform plate boundaries

Transform plate boundary is the margin where two plates move side by side. The lithosphere is neither destroyed nor created by the transform plate boundary. Hence it is called as the Conservative or passive plate boundary. The San Andreas Fault, California, is a transform boundary that separates the North American plate and Pacific Plates.

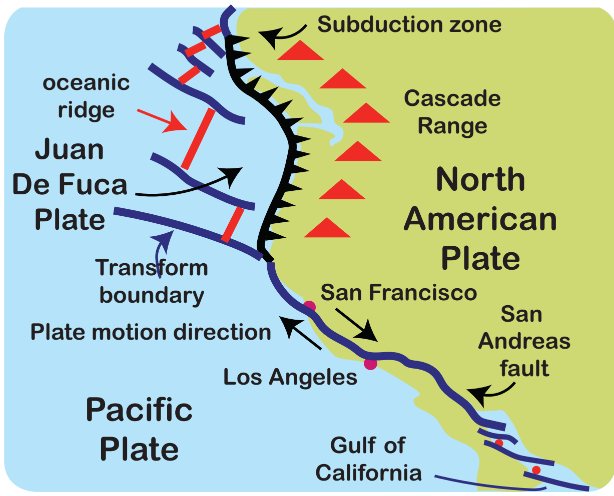


Figure 3.12 Transform plate boundary

3.6 Convection Cell

Now you may think why plates keep moving. The plate movements are caused by the convection cells. Convection cell is the circulation of the molten materials caused by the heat derived from the core. When looking at the figure.3.13 you will understand how and why plates move in different directions.

When the molten materials(magma) circulate in different directions, they push or pull the plates in different directions. Thus, the plates move towards each other, move away from one another and move side by side. The plate movements cause the formation of fold, fault, earthquake, and volcano to occur. Let us see the cause, effects, and distribution of the internal forces.

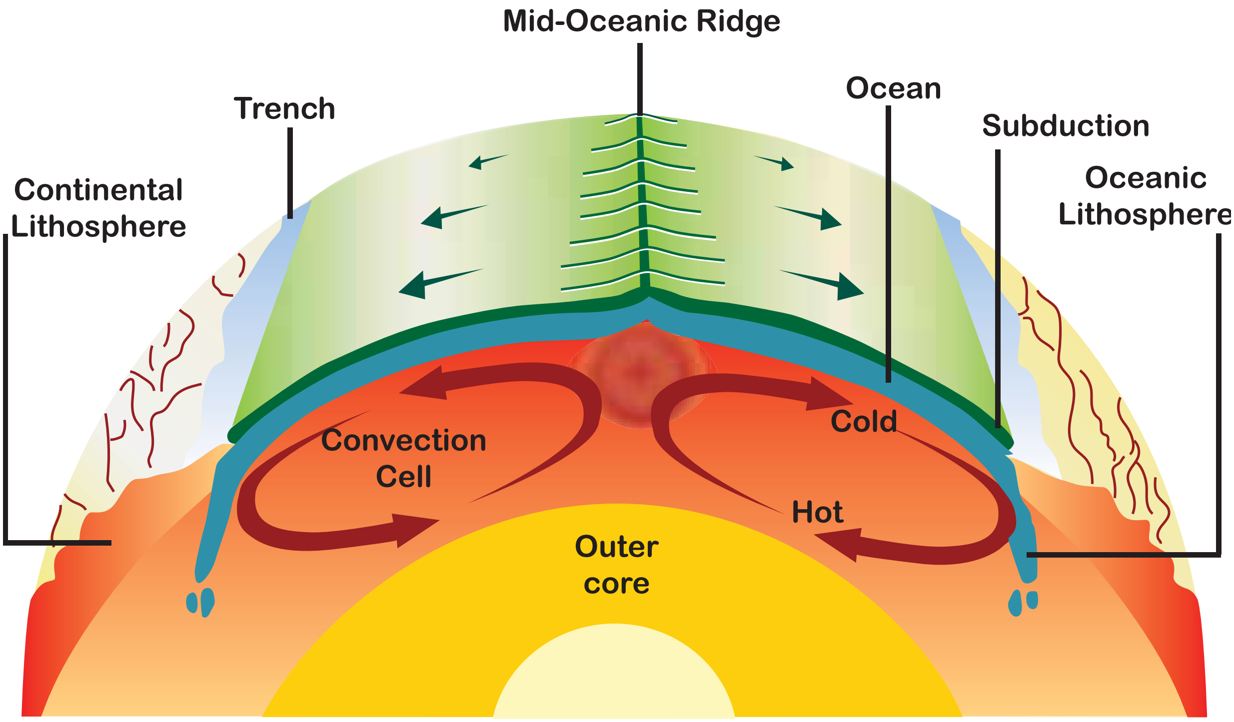


Figure 3.13 Convection Cell

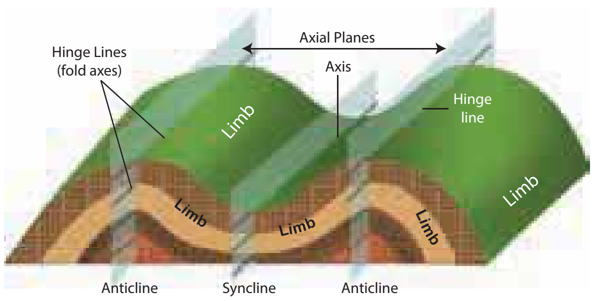


Figure 3.14 Parts of the Fold

3.6.1 Internal forces

The internal forces are also called as the tectonic forces. They generally occur in the plate boundaries. They are caused by convection cell and plate movement. They form fold, fault, earthquake and volcano.

3.7 Fold

Horizontal movements are produced by forces of compression and tension. Folding is the bending of rock strata due to compression. Folding on a large scale results in mountain building generally referred to as orogeny.

3.7.1 Parts of a Fold

Up thrown part of a fold is called anticline. Down thrown part of a fold is syncline. The side of the fold is a limb. The top of the fold is the crest. The plane which bisects the angle between two limbs is called the axis of fold or axial plane. The fold is formed by the plate movements.

3.7.2 Types of Folds

The type of fold depends on the nature of the rock, the intensity of compression forces, etc. The types of the fold can be many but we will deal with five of the following.

1. When compressional force is equal from both sides, the angle of the limb is same on both sides. Such a fold is called **symmetrical fold**.
2. When compressional force is more from one end, one limb is steeper than the other. Such a fold is called **asymmetrical fold**.

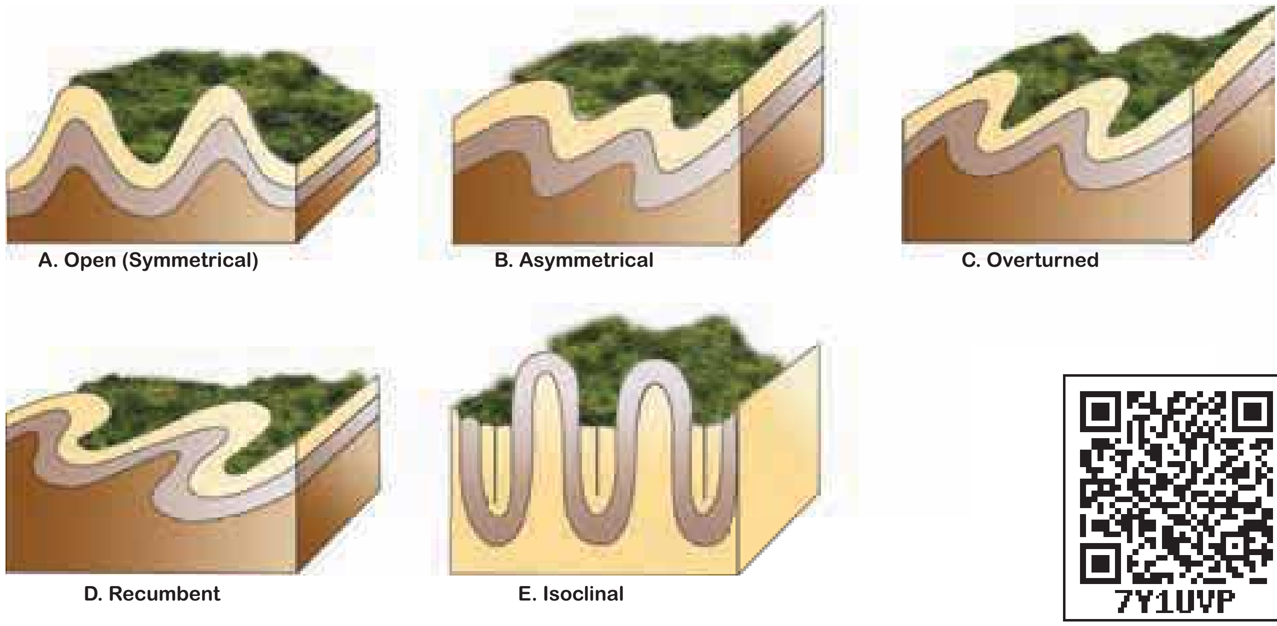


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Figure 3.15 Types of Fold

3. **Isoclinal folds** are similar to symmetrical folds, but these folds both have the same angle and are parallel to each other. 'iso' means 'the same' (symmetrical), and 'cline' means 'angle,' so this name literally means 'the same angle.' So **isoclinal folds** are symmetrical and aligned in a parallel fashion.
4. When one limb of the fold is pushed over the other limb of the fold, it is called as **over turned fold**. Limbs are seldom horizontal.

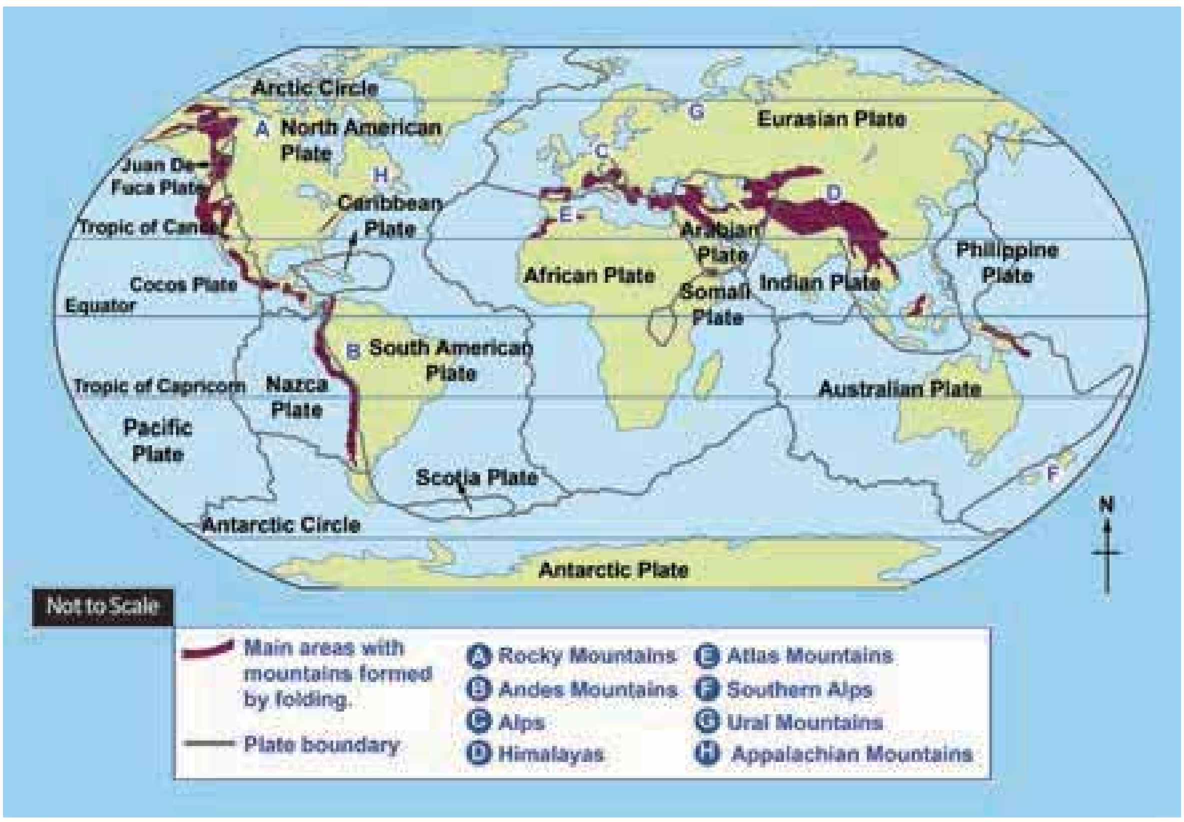

Figure 3.16 The Fold mountains of the world

Student activity

From the map given above, name the plates causing the formation of fold mountains given below.

S. No	Fold Mountain	Two Converging Plates
1.	The Andes	——→ ←——
2.	The Rockies	——→ ←——
3.	The Atlas	——→ ←——
4.	The Himalayas	——→ ←——
5.	The Alps	——→ ←——

5. When one side of the fold is pushed so much that it lies positioned over the other, such a fold is called **recumbent fold**.

When plates converge, the weak rocks and sediments lying between two plates get squeezed and folded. Parallel folds form long chains of fold mountain ranges with high peaks. The fold mountains are characterised by peaks and valleys. The tops of anticlines become the peaks and synclines become the valleys. Intermontane plateaus (plateau surrounded by the mountain ranges all sides) may be found between the high ranges. Example, Tibet.

3.8 Fault

A fault is a break in earth's crust where blocks of rock crust slide past each other.

Usually it occurs along plate boundaries, where the forces of plate motion compress, pull or shear the crust that breaks the crust. Energy release associated with rapid movement on active faults is the cause of most earthquakes.

The **fault plane** is the flat surface along which broken blocks of rock slide past one another. A **fault dip** is an angle between the fault plane and horizontal plane. Up thrown side represents the uppermost block of a fault. Down thrown side represents the lowermost block of a fault. Sometimes it becomes difficult to find out, which block has really moved along the fault plane. Hanging wall is the upper wall of a fault. Foot wall represents the lower wall of a fault.

A **fault scarp** is the steep wall like slope caused by faulting of the crustal rocks. Sometimes the fault scrap is so steep that it resembles a cliff.

3.8.1 Types of Faults

Based on how plates move about, the fault can be divided into as follow:

3.8.1.1 Normal Fault

Vertical displacement of the crust is called a normal fault. The normal fault is caused by tensional forces where plates diverge. One block lies above the other (hanging wall). The other block lies below the fault (footwall).

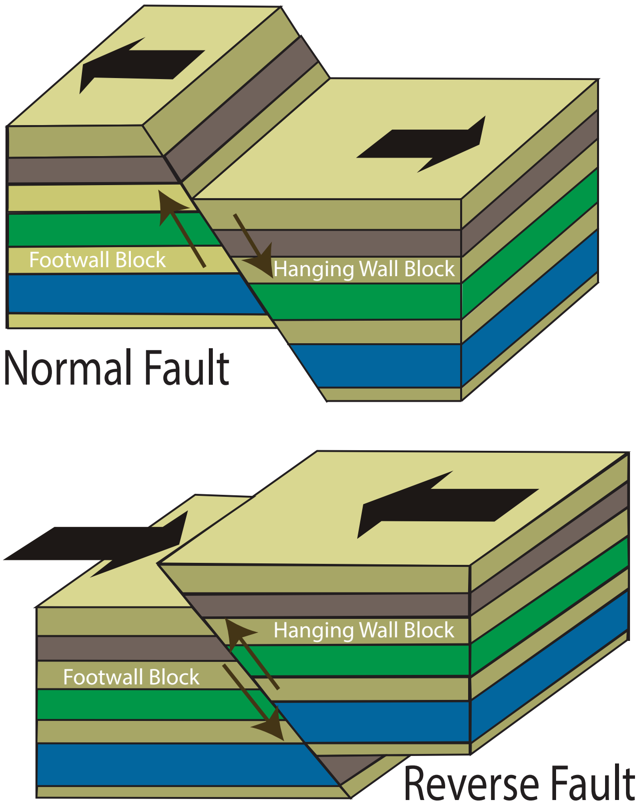

Figure 3.17 Normal fault and Reverse fault

When movement occurs along a normal fault, the hanging wall slips downward.

Landforms made by Normal fault are:

1. Rift Valley or Graben

When a narrow block of land drops or subsides between two parallel normal faults, rift valley (Graben) is formed. Graben originates from the German word meaning 'trough'. A Rift Valley may subsequently get filled by water and a river may flow through it. Normally, a rift valley is long, narrow and very deep. For example,

Figure 3.18 Narmada Rift Valley, India

i. Rhine rift Valley is flanked by two Block Mountains namely the Vosges and the Black Forest.

ii. The rift of River Narmada in India lies between the Vindhyas and Satpura block mountains.

iii. The great rift valley of Africa.

The Great Rift Valley of Africa is the longest rift valley in the world. It stretches for 6,400 km from Mozambique in the south to Syria in the north. The depressions have become lakes. The lakes

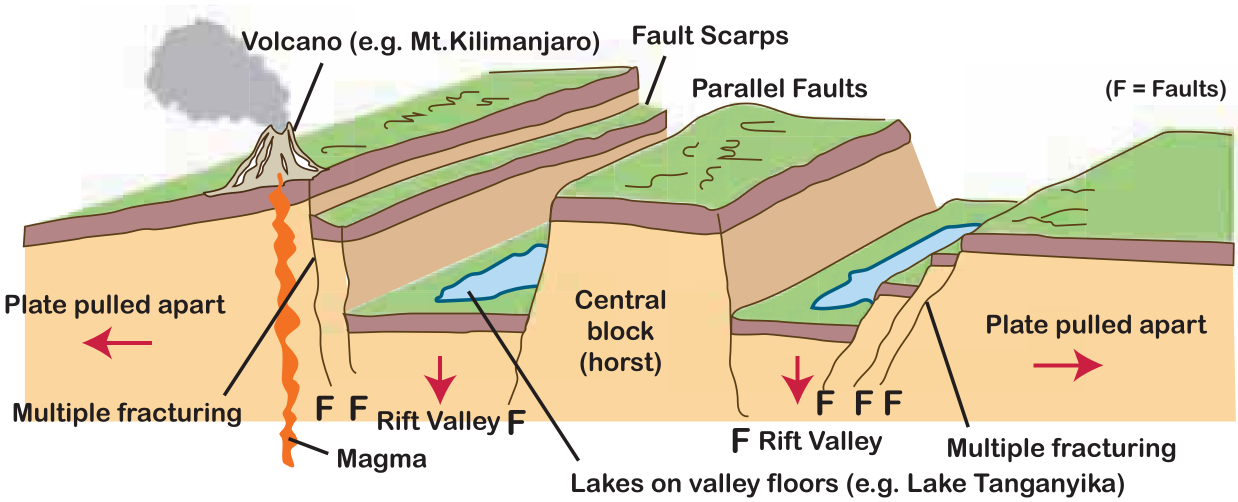

Figure 3.19 Rift valley and Block Mountain

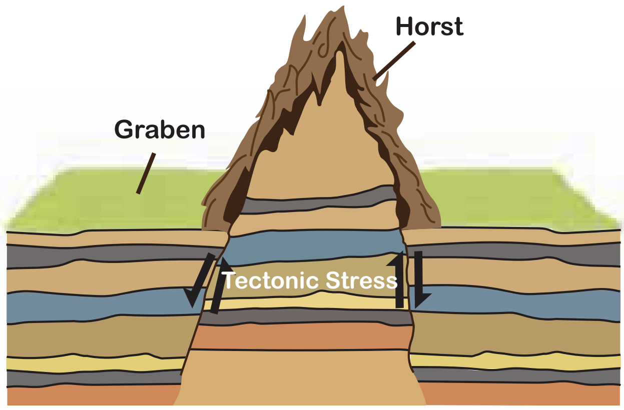

Figure 3.20 Horst (Left) and Vindhya Block Mountain (Right)

of Africa, Dead Sea of Israel and the Red Sea form the parts of the Great Rift Valley.

2. Horst

When a block of land between two faults is pushed up, block mountain or horst is formed. In this case, the central block is not only up thrown but the side blocks are also relatively downthrown so that the whole central mass appears like a dome.

In India, specifically the mountain ranges of Vindhya and Satpura found in the central western part of the India are block mountains.

3.8.1.2 Reverse Fault

A reverse fault is a horizontal displacement of the crust. It is formed where two fractured blocks move towards each other. It is caused by compressional forces along convergent plate boundaries. One side of the fault lies at an angle above the other.

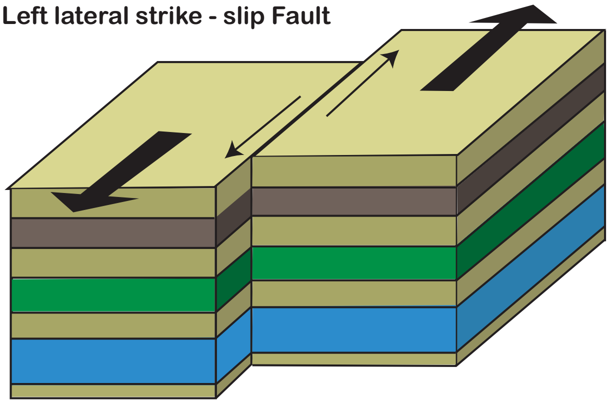

Figure 3.21 Transform fault

3.8.1.3 Shear Fault / Transform Fault/ Strike – Slip Fault

It is created by shearing along transform boundaries. Rocks on either side of fault slip past each other sideways with little up or down motion. It mostly occurs in the ocean basin and connects offsets in the mid ocean ridge.

3.9 Earthquake

Earthquake is a sudden shaking of the earth's surface. **Focus** is the location inside the earth where the earthquake originates. **Epicenter** is the point on the earth's surface vertically above the focus of an earthquake. Earthquake results from the sudden release of pressure which has slowly built up within the earth's crust. Energy is released in the form of shockwaves known as seismic waves. The seismic waves can broadly be classified into two types namely Body waves and surface waves.

I. ***Body Waves*** are the waves that travel through the interior of the earth. They are further divided into the following.

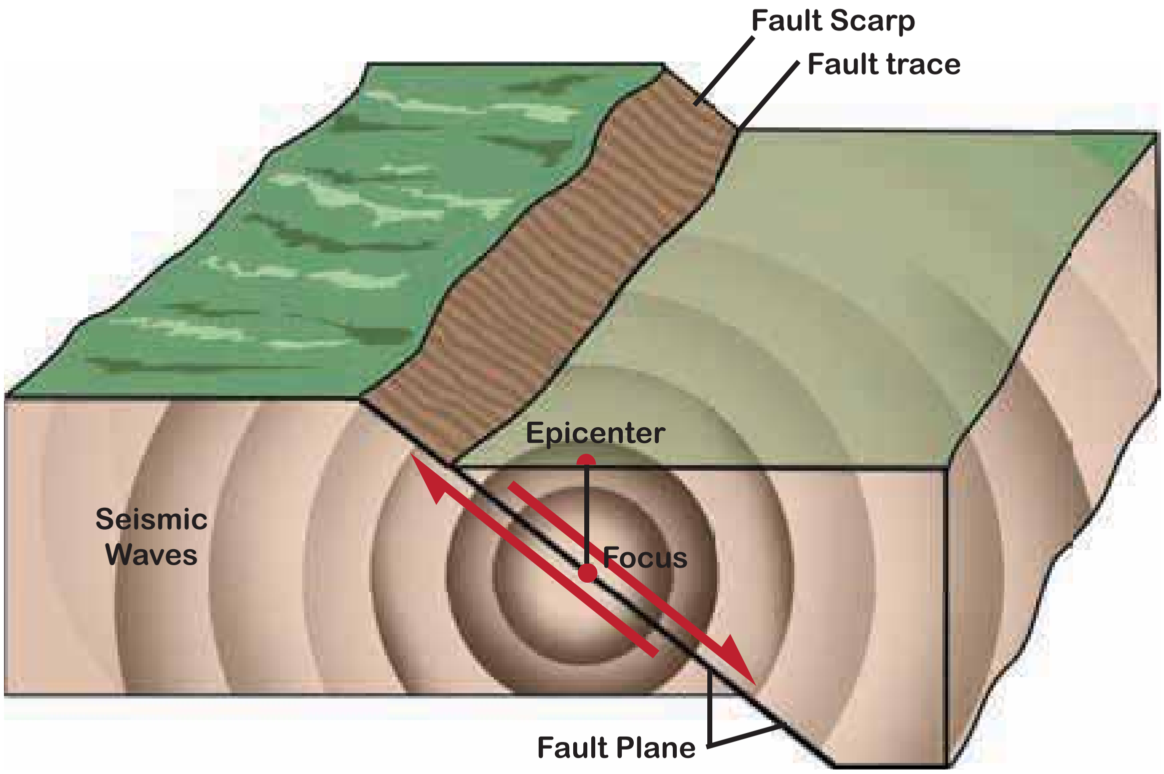

Figure 3.22 Parts of an Earthquake

a. ***P or Primary or Compressional waves*** are the fastest seismic waves (6 km/sec. in the upper crust). They cause the matter to oscillate forward and backward, parallel to the motion of the seismic wave front. P waves push (compress) and pull (dilate) the rock that they pass through. They pass through all medium.

b. ***S or Secondary or Shear waves*** are slower than the primary waves (3.5 km/sec. in the upper crust). They cause matter to oscillate side to side, perpendicular to the motion of the wave front. S waves shear the rock that they pass through. They pass through only solid medium.

II. ***Surface Waves*** are the waves that travel along the earth's surface. They are slower than body waves. They cause damage during earthquakes.

Love waves shake the ground side to side like S wave.

Rayleigh waves displace the ground like rolling ocean waves. The ground rolls forward and up and then down and backwards. This is similar to a p wave but with the extra up-down motion.

3.9.1 Measuring the earthquake

It is estimated that about 100,000 earthquakes occur but all cannot be felt. A few earthquakes may be severe causing huge damage to property. Earthquake magnitude is measured on the Richter scale (named after the seismologist who devised it), which rates them on a scale of 1 to 10. Earthquake intensity is measured on the modified Mercalli scale, which ranges from 1 to 12, depending upon the intensity. The seismograph is an instrument used to detect and record seismic waves created by the earthquakes.

3.9.2 Description of effects of earthquake in Richter scale

MODIFIED MERCALLI SCALE	RICHTER SCALE
I. Felt by almost no one. II. Felt by very few people.	2.5. Generally not felt, but recorded on seismometers.
III. Tremor noticed by many, but they often do not realize it is an earthquake. IV. Felt indoors by many, Feels like a truck has struck the building. V. Felt by nearly everyone: many people awakened. Swaying trees and poles may be observed.	3.5. Felt by many people
VI. Felt by all; many people run outdoors. Furniture moved, slight damage occurs. VII. Everyone runs outdoors. Poorly built Structures considerable damaged; Slight damage elsewhere.	4.5. Some local damage may occur.
VIII. Specially designed structures damaged Slightly, others collapse. IX. All buildings considerably damaged, many shift off foundations, Noticeable cracks in ground.	6.0. A destructive earthquake.
X. Many structures destroyed. Ground is badly cracked.	7.0. A major earthquake.
XI. Almost all structures fall. Very wide cracks in ground. XII. Total destruction. Waves seen on ground surfaces, objects are tumbled and tossed.	8.0. and up Great Earthquakes.

Table 3.1 The Mercalli and Richter scales

3.9.3 Causes of Earthquakes

There are many factors controlling the occurrence of the earthquake. Some of the major factors include:

1. Plate Tectonic Movements
2. Volcanic Eruptions.
3. Construction of large dams results in earthquake. Example. Koyna dam, Maharashtra.
4. Other Reasons: The nuclear explosions also release massive energy to cause tremors in the earth crust. When underground cave collapses, earthquake may occur.

3.9.4 Effects of the Earthquakes

1. Damage to buildings, roads, rails, factories, dams, bridges etc.
2. Landslides caused by earthquakes damage infrastructure.
3. Fires in the forest and urban areas.
4. Flash floods.
5. Tsunami - The high amplitude oceanic waves caused by submarine earthquake (measuring more than 7 on Richter scale). The seismic waves travel through seawater generates high sea waves. They cause severe loss of life and property. For instance, on 26th December 2004, a tsunami originating from a magnitude 8.9 earthquake in northern Sumatra killed over 1,50,000 people in countries surrounding the Indian Ocean.

3.9.5 *Distribution of earthquakes*

1. Circum-Pacific region: This region includes all the coastal areas around the Pacific Ocean. It extends through the coasts of Alaska, Aleutian Islands,

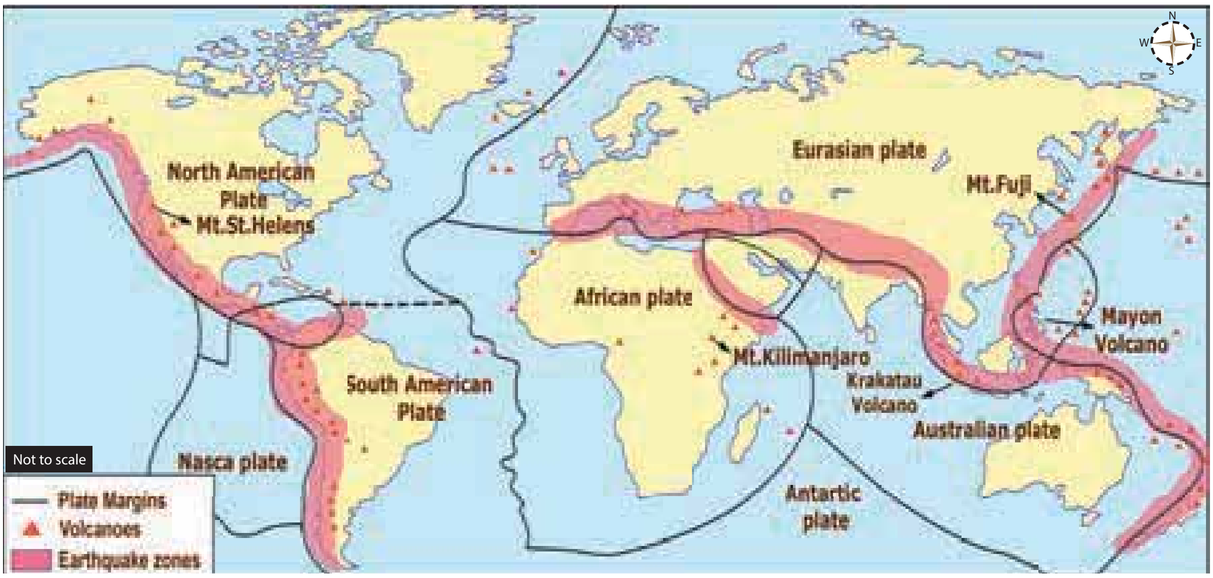

Figure 3.23 World Distribution of Earthquakes and Volcanoes

Japan, Philippines, New Zealand, west coast of North and South America. This zone accounts for 68% of all earthquakes on the surface of the earth.

2. Mediterranean-Himalayan region: This region extends from Alps mountain to the Himalayan Mountains and Tibet to China. About 31% of world's earthquakes occur in this region.
3. Other Areas: These include Northern Africa and Rift Valley areas of the Red Sea and the Dead Sea.

3.10 Volcano

A volcano is an opening in the earth's crust through which magma, gases and ash are released to the earth's surface. The molten rock material found in the interior of the earth is called magma. It can be noted that when magma reaches the earth's surface, it is known as lava (Figure. 3.25). Vent is an opening or mouth of a volcano. Fumaroles are the gushing fumes through the gap in the volcano. Crater is a saucer shaped depression in the mouth of a volcano. When the crater is widened, it is called as

CASE STUDY

Figure 3.24 Earthquake,Iran-Iraq border, 2017

On 12th November 2017, an earthquake with a magnitude of 7.2 on the Richter scale occurred on the Iran–Iraq border. Areas affected: Iran and Iraq.

Max. intensity: VIII (Severe)

Fault: Arabian and Eurasian plates. Casualties: 630 dead; above 8,100 injured; above 70,000 homeless. Depth: 19.0 km.

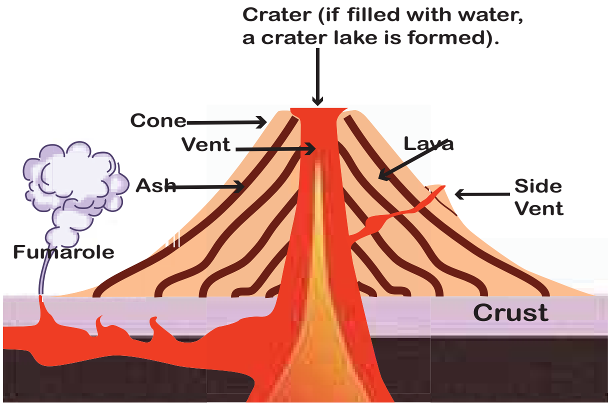

Figure 3.25 Volcano

Caldera. Volcanic ash consists of fragments of pulverized rock, minerals and volcanic glass, created during volcanic eruptions. Volcano generally erupts either through the vent (E.g. Mt. Fujiyama, Japan) or fissure (The Deccan Plateau, India).

Pumice is a volcanic rock produced when lava with a very high content of water and gases is discharged from a volcano.

3.10.1 Causes of Volcanic Eruptions

The following are the causes of volcanic eruptions:

Weak Zones in the Earth Crust: The parts of the earth where two tectonic plates collide against or drift apart from each other are considered very weak. Volcanoes may erupt in such zones, for example, African and Eurasian plates.

Magma Saturated with Gases: The magma, in the interior of the earth, is often found saturated with gases like carbon dioxide, and hydrogen sulfide. These gases together with water vapour make the magma highly explosive. Magma is forced out as lava on the surface of the earth due to the pressure exerted by these gases.

3.10.2 Types of Volcanoes

Based on the **frequency of eruption**, there are three types of volcanoes:

Fact File

Mt. Krakatau

The greatest volcanic explosion known to humans is perhaps Mt. Krakatau in August 1883.

Krakatau is a small volcanic island in the Sunda Straits, between Java and Sumatra.

The explosion could be heard in Australia, almost 4,000 km away.

The vibration set up enormous waves over 30 m high which drowned 36,000 people in the coastal districts of Indonesia.

DO YOU KNOW?

Cotopaxi in Ecuador is the world's highest active volcano.

1. **Active Volcanoes:** Volcanoes which erupt frequently are called active volcanoes. Generally, their vent remains open. Mount Etna of Italy, Cotopaxi in Ecuador are some examples.
2. **Dormant Volcanoes:** These volcanoes may not have erupted in the recent past but there is a possibility of eruption at any time. In other words, they may lie dormant awaiting active eruption anytime. Sometimes gases and steam come out of them. They cause great destruction to life and property once they become active again. Mt. Vesuvius of Italy and Mt. Fujiyama of Japan are examples.
3. **Extinct Volcanoes:** These volcanoes have exhausted their energy and have

not erupted during the known geological period. The vent of these volcanoes remains closed with solidified lava. The formations such as craters may be filled with water and crater lakes may be formed. The slopes of these landforms may be covered with vegetation. Popa in Myanmar and Mt. Kenya in eastern Africa are the examples of extinct volcano.

On the **basis of nature of eruption and form** developed on the surface, they are classified into following types:

1. **Shield Volcanoes:** These are made up of basalt, a type of lava that is very fluid when erupted. They become explosive when water gets into the vent. They develop into a cinder cone. Hawaiian volcano is an example of this category.
2. **Composite cone volcanoes:** They are also called 'strato volcanoes'. They are cone-shaped volcanoes composed of layers of lava, ash and rock debris. Mount Vesuvius and Mount St. Helens are examples of composite volcanoes.
3. **Cinder Cone Volcano :** It forms when magma is thrown out to the surface, cooled in to ash and cinders and settled around the mouth of volcano. It is less dangerous than other volcanoes.
4. **Lava Dome:** Unlike composite and shield volcanoes, lava domes are of significantly smaller structure. They are formed when the lava is too viscous to flow to a great distance. As the lava dome slowly grows, the outer surface cools and hardens as the lava continues to pile within. Eventually, the internal pressure can shatter the outer surface, causing loose fragments to spill down its sides.

3.10.3 Effects of Volcanic Activities

Destructive effects of volcano

Showers of cinders and bombs can cause damage to life and properties. Sometimes ash can precipitate under the influence of rain and completely cover large areas.

The volcanic gases pose potential hazard to people, animals; agriculture, while sulfur dioxide gas can lead to acid rain and air pollution.

Positive Effects of Volcanoes

Volcanism creates new landforms. Volcanic rocks yield very fertile soil upon weathering and decomposition.

The Kimberlite rock of South Africa, the source of diamonds, is the pipe of an ancient volcano.

In the vicinity of active volcanoes, waters in the depth are heated from contact with hot magma giving rise to springs and geysers. The Puga valley in Ladakh region and Manikaran (Himachal Pradesh) are promising spots in India for the generation of geothermal electricity.

3.10.4 Distribution of Volcanoes across the World

Most known volcanic activity and the earthquakes occur along converging plate margins and mid-oceanic ridges. The major regions of volcanic distributions are as follows.

1. Pacific Ring of Fire

Circum-Pacific region, popularly termed the ‘Pacific Ring of Fire’, has the greatest concentration of active volcanoes. Volcanic belt and earthquake belt closely overlap along the ‘Pacific Ring of Fire’. It is estimated to include two-thirds of the world’s volcanoes.

2. Mid Atlantic Region

The Mid Atlantic Region coasts has comparatively fewer active volcanoes but many dormant or extinct volcanoes, example. St. Helena, Cape Verde Islands and the Canary Islands. But the volcanoes of Iceland and the Azores are active.

3. The Great Rift valley of Africa

In Africa some volcanoes are found along the East African Rift Valley. Kilimanjaro and Mt. Kenya are extinct volcanoes. The only active volcano in West Africa is Mt. Cameroon.

4. Mediterranean Region

Volcanoes of the Mediterranean region are mainly associated with the Alpine folds. Example, Mt. Vesuvius, Mt. Stromboli (known as the Light House of the Mediterranean Sea).

5. Other Regions

Elsewhere in the interiors of continents of Asia, North America and Europe active volcanoes are rare. There are no volcanoes in Australia.

Volcanoes in India

There are no volcanoes in the Himalayan region of India. However, Barren Island, lying 135 km north-east of Port Blair became active in 1991 and 1995.

However, the other volcanic island in Indian Territory is Narcondam (Andaman and Nicobar Islands) It is probably extinct. Its crater wall has been completely destroyed.

3.11 Rocks

Rock is the solid mineral material forming the surface of the earth. Petrology is the science of rocks. The age of the rock is determined based on Carbon-14 dating.

3.11.1 Rock Types

Based on their origin, the rocks are classified as follows:

1. Igneous Rocks

Igneous rocks are formed out of magma and lava and they are known as primary rocks. If the magma cools slowly at great depths, mineral grains increase in their size. Sudden cooling (at the surface) results in small and smooth grains. The igneous rocks are the oldest of all the rocks. Granite, pegmatite, basalt, etc are some of the examples of igneous rocks. There are two types of igneous rocks: intrusive rocks (Granite) and extrusive rocks (Basalt-Deccan Traps).

Granite is less dense and is lighter in colour than basalt rocks.

3.11.2 Intrusive Igneous rocks

Intrusive Igneous rocks are formed when magma rises and cools within the crust. The intrusive activity of volcanoes gives rise to various forms. We see them one by one as follow.

1. Batholiths

Batholiths are large rock masses formed due to cooling and solidification of hot magma inside the earth. It is granitic in origin.

2. Laccoliths

Laccoliths are large dome-shaped intrusive rock connected by a pipe-like conduit from below. These are basically intrusive counterparts of an exposed domelike batholiths. The Karnataka plateau is spotted with dome hills of granite rocks. Most of these, now exfoliated, are examples of laccoliths.

3. Lapoliths

When the magma moves upwards, a saucer shape, concave shaped body called Lapolith is formed.

4. Sill

Sill is a solidified sheet-like horizontal lava layer inside the earth. The near horizontal bodies of the intrusive igneous rocks are called sill or sheet, depending on the thickness of the material. The thinner ones are called sheets while the thick horizontal deposits are called sills.

5. Dyke

When the magma makes its way through cracks and the fissures developed in the land, it solidifies almost perpendicular to the ground. It gets cooled in the same position to develop a wall-like structure. Such structures are called dikes.

These are the most commonly found intrusive forms in the western Maharashtra area. These are considered the feeders for the eruptions that led to the development of the Deccan traps.

2. Sedimentary Rocks

Sedimentary rocks are also called as detrital rocks. They are formed as a result of denudation. These deposits through compaction turn into sedimentary rocks. They occupy only 5 percent of the earth. They are layered or stratified of varying thickness. Example: sandstone, shale etc. Ice deposited sedimentary rocks is called Till. Wind-deposited sediments are called Loess.

Depending upon the mode of formation, sedimentary rocks are classified into

1. Mechanically formed sedimentary rocks: sandstone, conglomerate, limestone, shale, loess, etc.
2. Organically formed sedimentary rocks: geyserites, chalk, limestone, coal etc.
3. Chemically formed: halite, potash, etc.

3. Metamorphic Rocks

The word metamorphic means 'change of form'. The metamorphic rocks form under the action of pressure, volume and temperature (PVT) change.

Metamorphism is a process by which the already consolidated rocks undergo recrystallisation and reorganization of materials within original rocks. Gneiss, slate, schist, diamond, marble, quartzite

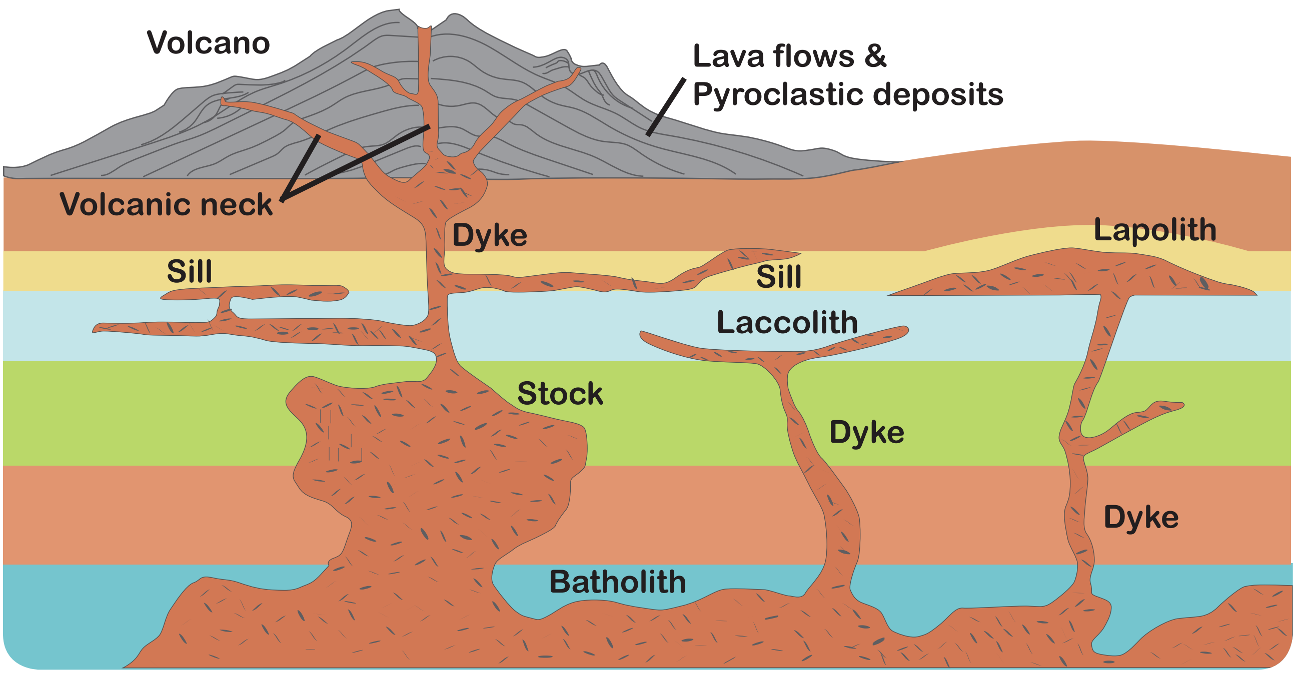

Figure 3.26 Intrusive Volcanic structure

etc. are some examples of metamorphic rocks. The igneous and metamorphic rocks together account for 95 percent of the earth.

3.12 Rock Cycle

Rock cycle is a continuous process through which old rocks are transformed into new ones. Igneous rocks can be changed into sedimentary or metamorphic rocks. The fragments derived out of igneous and metamorphic rocks form into sedimentary rocks.

Igneous and sedimentary rocks can change into metamorphic rocks. The crustal rocks (igneous, sedimentary and metamorphic) may be carried down into the mantle (interior of the earth) through subduction process and the same melt and turn into magma, the original source for igneous rocks. In this way the rock cycle is a continuous process.

Table 3.2 Metamorphosis processes

Igneous/ Sedimentary rock	Influence	Metamorphosed rock
Granite	Pressure	Gneiss
Clay, Shale	Pressure	Schist
Sandstone	Heat	Quartzite
Clay, Shale	Heat	Slate or Phyllite
Coal	Heat	Anthracite or Graphite
Coal	Heat and Pressure	Diamond
Limestone	Heat	Marble

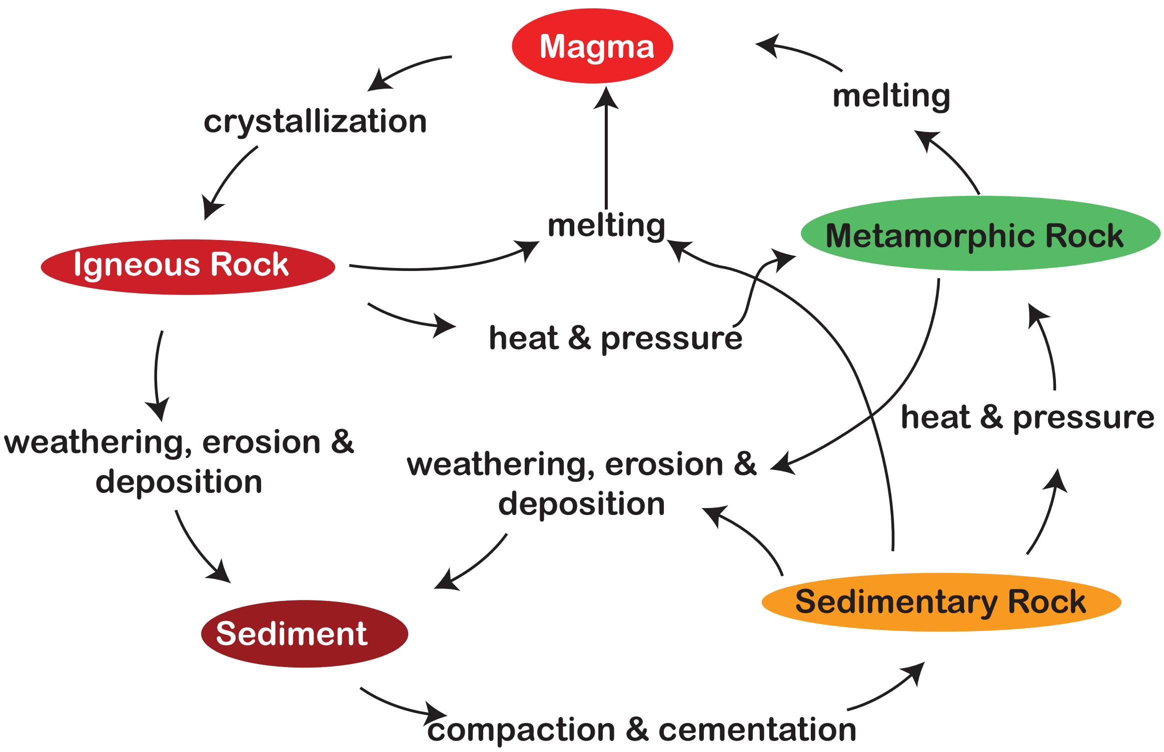

Figure 3.28 The Rock Cycle

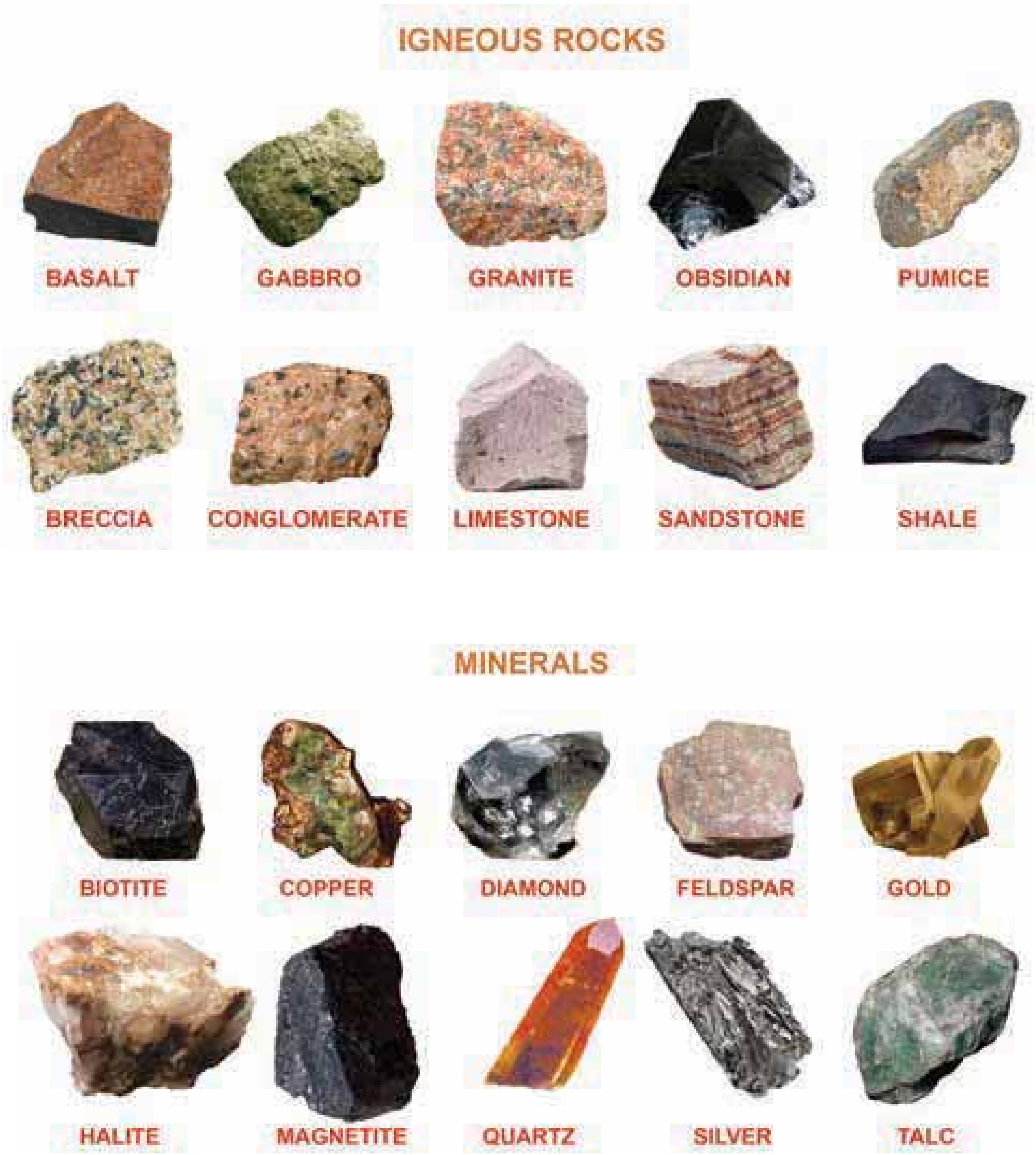

Figure 3.29 Rock forming Minerals

Students' activity

Place the appropriate number given in the diagram in the bracket

Lacolith ( )

Batholith ( )

Dyke ( )

Sill ( )

Chamber ( )

Phacolith ( )

Lapolith ( )

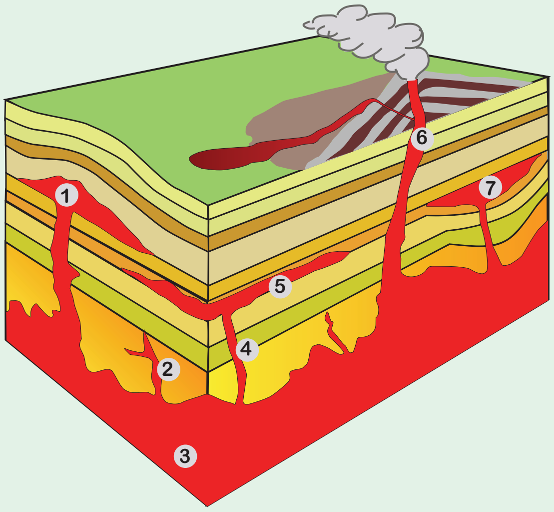

Figure 3.27 Intrusive Volcanic Structures

GLOSSARY

1. **Orogeny:** structural deformation of lithosphere due to interaction between tectonic plates.
2. **Conorod boundary:** Margin between the upper crust and the lower crust.
3. **Shearing fault:** the fault is created by shearing along the plate boundary.
4. **Laccoliths:** are large dome-shaped intrusive rock connected by a pipe.
5. **Lapolith:** When the magma moves upwards, a saucer shape, concave shaped body called lapolith.
6. **Syncline:** down slope of a fold
7. **Crest:** the top of the fold.
8. **Catasrophism:** sudden movements of the earth caused by plate movements.
9. **Metamorphism:** the process by which both igneous and sedimentary rocks get changed into metamorphic rocks.
10. **Rock cycle:** a continuous process through which old rocks are transformed into new ones.

Evaluation

7YAQXC

I. Multiple choice questions

1. The term "Lithosphere" was introduced by
   a. Alfred Wegener
   b. Joseph Barrel
   c. Alexander Von Humbolt
   d. Kiyoo Wadati
2. The boundary between the upper crust and lower crust is termed as ______
   a. Guttenberg margin
   b. Lehmann Boundary
   c. Conorod boundary
   d. Mohorovicic boundary
3. Who postulated the continental drift theory?
   a. Kober b. Holmes
   c. Taylor d. Wegener
4. Odd one out

a. The Eurasian plate
b. The North American plate
c. The Pacific plate
d. The African plate

5. One among the given is the deepest trench in the world.
   a. The Mariana Trench
   b. The Sandwich Trench
   c. The Puerto Rico Trench
   d. The Sunda Trench
6. It is a type of fold where one limb is steeper than the other.
   a. Symmetrical fold
   b. Asymmetrical fold
   c. Over turned fold
   d. Recumbent fold
7. The longest rift valley in the world is
   a. The Narmada rift valley
   b. The African rift valley
   c. The Baikal rift valley
   d. The Rhine rift valley
8. One of the following zones accounts for 68% of the earthquakes on the surface of the earth.
   a. The Mediterranean – Himalayan zone
   b. The Circum Pacific zone
   c. The Mid Atlantic zone
   d. The African rift valley zone
9. One among the given is the world's highest active volcano.
   a. Mt. Vesuvius
   b. Mt. Stromboli
   c. Mt. Cotopaxi
   d. Mt. Krakatau
10. Solidified sheet-like horizontal lava layer inside the earth is called as
   a. Dyke
   b. Batholith
   c. Sill
   d. Lacolith

II. Brief answer

1. Define Diastrophism.
2. Why is the inner core solid?
3. Distinguish between Mohorovicic boundary and Lehman boundary.
4. Write the significance of the Ring of Fire.
5. List the types of volcano based on their frequency of eruption .

III. Short answer

1. Write a short note on the Convection cell.
2. Name the types of plate boundary.
3. Why do plates keep moving?
4. Name the types of fold.
5. Draw a volcano and label its parts.

IV. Detailed answer

1. Describe the Interior of the Earth with a diagram.
2. Explain continental drift theory.
3. Explain the types of plate boundaries.
4. Draw a diagram and describe the stages of the rock cycle.
5. On the outline map of the world, mark the distribution of volcanoes and describe briefly about them.

V. Practice

1. Prepare in the cardboard sheet jigsaw puzzle of fitting plates in their respective boundaries.
2. Prepare a working model of the active volcano and demonstrate in the class.
3. Make a model of types of Fold and Fault using available resources, label them, and present to the class.

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4. https://www.youtube.com/watch?v=PDrMH7RwupQ

ICT CORNER

Lithosphere Morphing Boundaries

Through this activity you will identify the land masses formed by Endogenic processes.

Steps

- Use the URL to land on 'Google Earth' or scan the QR code from your smartphone.
- Open "Google Earth" app and type "Everest" in the search box to explore the folded mountain structure created by tectonic collision.
- Type volcano name in search box and explore the landscape formed by its eruption.
- Roll over the globe using your mouse and zoom in and zoom out to explore the land mass and its tectonic plate extensions.

Step 1

Step 2

Step 3

Step 4

Google Earth's URL:

https://earth.google.com/web/

*Pictures are indicative only.

B169_11_GEO_EM

Unit IV

Lithosphere: Exogenic Processes

Chapter Outline

Learning Objectives:

- *Understand how external forces reshape the surface of the earth.*
- *Distinguish between physical weathering and chemical weathering.*
- *Identify the different types of mass wasting and its characteristics.*
- *Distinguish between the actions of various gradational agents.*

At Mahabalipuram, Chennai, the 6 meter high and 5-metre wide rock estimated to weigh over 250 tons is known locally as Krishna's Butter Ball. Its original Tamil name is "Vaanirai Kal" which literally translates to "Stone of The Sky God”

Look at the figure above Krishna's Butter ball inserted on the top and let's discuss:

- What, do you think, made this rock stone to get this shape?
- Guess how many years it might have taken to get such a shape.
- Think about how it is standing balanced?

4.1 Introduction

Let’s recall that you have learned in the previous chapter about geomorphic processes - Endogenic processes in detail. Now we deal with the exogenic processes. The forces which act on the earth’s exterior are called as exogenic forces or external forces. The action of exogenic forces results in wearing down the rock and hence, they are considered as land wearing forces.

4.2 Exogenic Processes

The processes which occur on earth's surface due to the influence of external forces are called as exogenic processes. Weathering, mass wasting and denudation are the major exogenic processes. The elements of nature capable of doing these exogenic processes are termed as gradational agents. For instance, the wind, river, glacier, waves and ground water.

4.3 Weathering

Weathering is the process of disintegration and decomposition of rocks. It is due to the action of climate, plants, animals and other living organisms which cause the rocks to break down physically, chemically and biologically.

There are three types of weathering. They are physical weathering, chemical weathering and biological weathering.

4.3.1 Physical weathering

Physical Weathering is the disintegration of rock mainly induced by elements of weather. It produces smaller, angular fragments of the same rock. It is caused by the change in temperature, pressure, water and wind. Physical weathering is further divided into different categories. They are thermal weathering, frost wedging and exfoliation.

4.3.1.1 Thermal weathering

In arid and semi-arid areas, the temperature increases, heat up and expand the rocks during the day and contract the rock materials when cooling at night. Under extreme temperature conditions, due to alternate expansion and contraction, the rocks crack and eventually split. The thermal weatherings are of two types. They are;

(a) Granular disintegration and

(b) Block disintegration

Alternate expansion and contraction of minerals of varying properties in the rocks due to temperature changes, makes

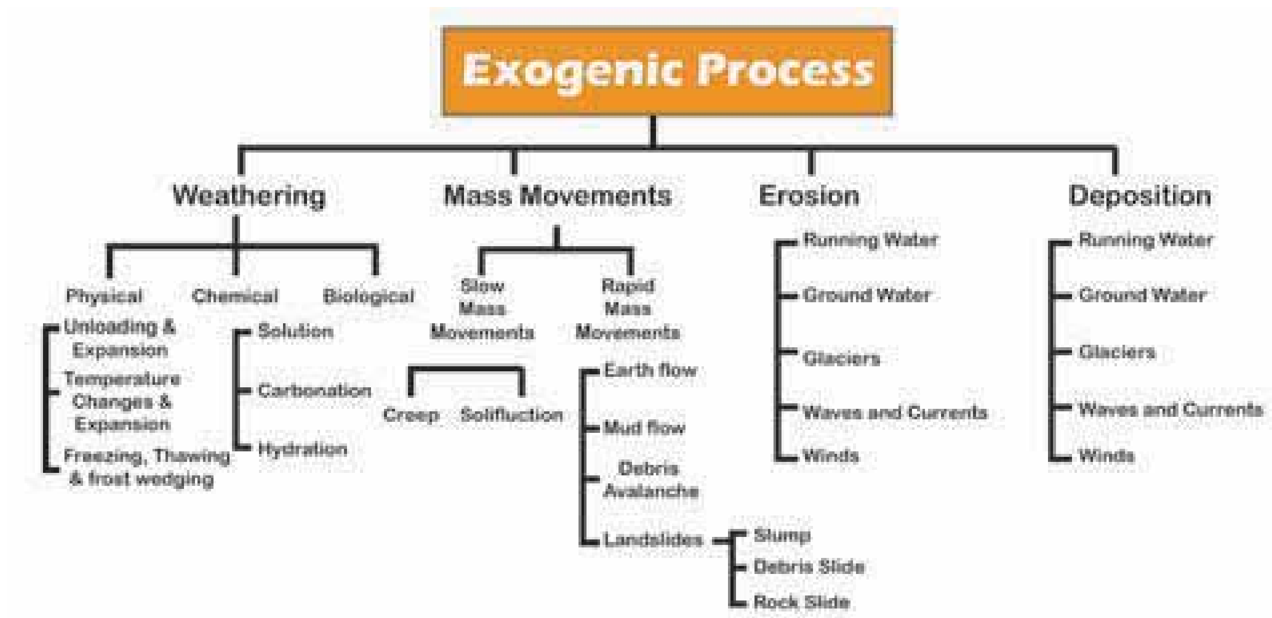


Figure 4.1 Exogenic processes

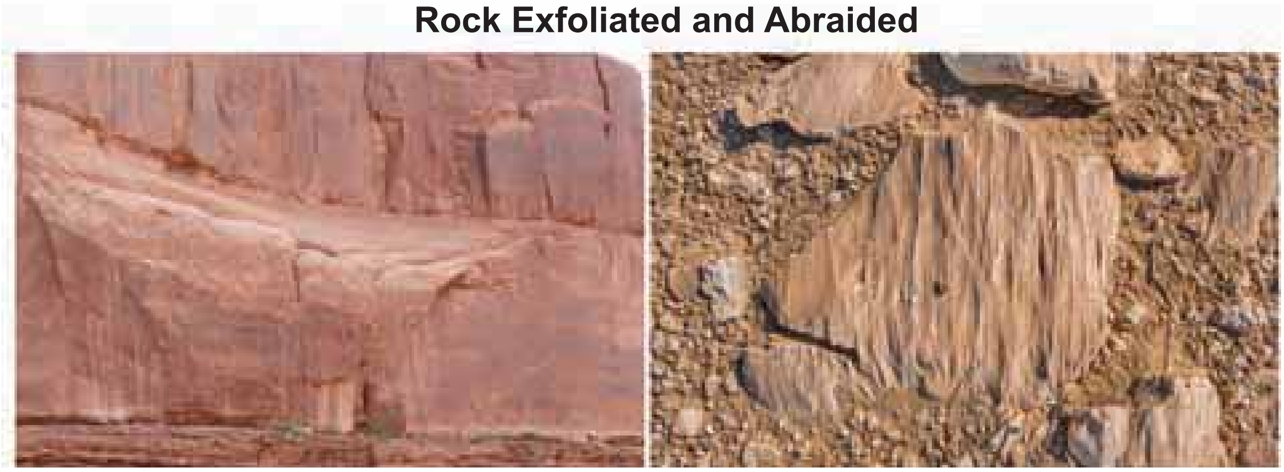


Figure 4.2 Exfoliated Rock(left) and Granular (right)

the rocks break down into small pieces (Figure 4.2). Due to this, the breakup of rocks occurs, grain by grain. This is known as **granular disintegration**.

Block disintegration occurs in rocks such as granite rock. So in the areas of jointed igneous or layered sedimentary rocks due to the great diurnal range of temperature, the rocks may break up along the joints and cracks into a large rectangular shaped blocks.

4.3.1.2 Frost Wedging

Almost all liquids contract when frozen, but when water freezes it becomes larger in size or takes up more space. As water expands it puts great pressure on rocks. When water enters into the cracks of rocks and freezes, the pressure exerted on the rock is enough to wedge the walls of the crack farther apart, thus expanding and deepening the crack. Thus, frost wedging results in weathering of rock.

4.3.1.3 Exfoliation

Rocks generally heat or cool more on the surface layers. The alternate changes in temperature could cause their outer layers to peel off from the main mass of the rock in concentric layers just as the skin of an onion. The process by which curved layers of rock breakaway from the rock beneath them leaving behind dome shaped monoliths is called exfoliation (Figure 4.2). It is also called as 'onion weathering'. Exfoliation occurs commonly in the arid areas.

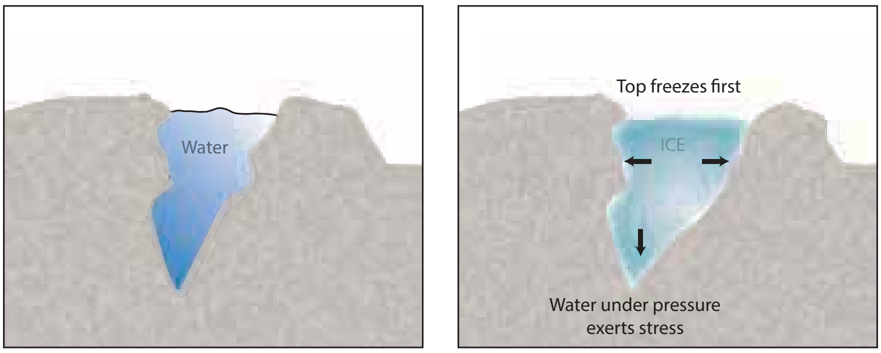


Figure 4.3 Frost Wedging

4.3.2. Chemical Weathering

Chemical weathering is the decomposition of rock. For example it creates altered rock substances, such as kaolinite (china clay) from granite. The types of chemical weathering are as follows:

i. **Solution**: Some soluble minerals in the rock get dissolved when come in contact with water. Over a long period minerals get washed away from rock and sometimes leading to the formation of caves.

ii. **Oxidation**: When oxygen combines with water and iron, it weakens the rock and breaks it. Example, rusting of iron.

iii. **Hydrolysis**: It is the chemical breakdown of a rock substance when combined with water and forms an insoluble precipitate like clay mineral. The most common example of hydrolysis is feldspar found in granite changing to clay.

iv. **Carbonation:** Carbonation is the mixing of water with carbon dioxide to make carbonic acid. This acid reacts with minerals in the rocks. This type of weathering is important in the formation of caves.

v. **Hydration**: It is the absorption of water into the mineral structure of the rock. Hydration expands volume and also results in rock deformation. A good example of hydration is the absorption of water by anhydrite, resulting in the formation of gypsum.

4.3.3 Biological Weathering

Biological weathering is the alteration of rock by the action of plants, animals, and man. Burrowing and wedging by organisms like earthworms, termites, rodents, etc., help in exposing the rock surfaces to chemical changes with the penetration of moisture and air. Human beings by removing vegetation for agriculture and other activities also help in mixing and creating new contacts between air, water, and minerals in the rock materials. Plant roots make a great pressure on the rock materials mechanically breaking them apart.

Figure 4.4 biological weathering

4.4 Mass wasting

Mass wasting is the movement of a large mass of rock, soil and debris downward by the pull of gravity. It is also called a mass movement or slope movement. It may happen suddenly or slowly. Generally, mass wasting is classified by the type of material involved (mud, soil, and rock) and type of motion (**fall**-free-falling pieces, **slide**-material moves along the rock slope and **flow**–material mixed with water).

4.4.1 Types of Mass Wasting

Following are the types of mass wasting:

Rock falls

Rock falls occur when pieces of rock break from a cliff. Frost wedging may also eventually loosen large blocks causing them to fall. The accumulation of rock debris at the base of a steep slope is called **talus**.

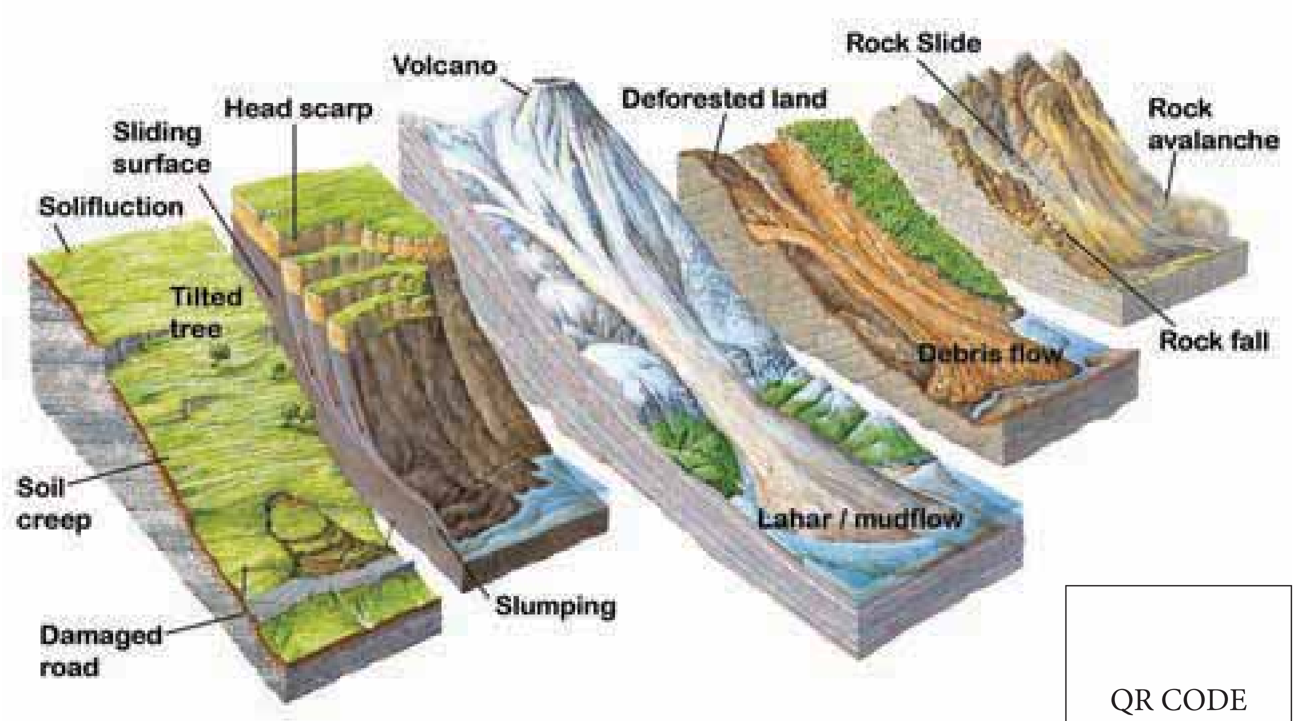


Figure 4.5 Mass movement

QR CODE

Figure 4.6 Rock fall

Rockslides

Rockslides usually follow a zone of weakness. Presence of water increases slippage. Collisions down the slope generally break the rock mass into rubble that eventually results in rockslides.

Landslides

Landslides occur when a large piece of rock breaks off and slides down hill. It is often initiated by earthquakes and very heavy rain.

Slump

Great mass of bed rock moves downward by rotational slip from a high cliff is known as slump. Most common reason for slumping is erosion at the base of the slope which reduces the support for overlying sediments.

Debris Slide

Debris slide is more extensive and occurs on a larger scale than slump but there is a little amount of water. The materials involved in debris slide are a mixture of soils and rock fragments.

Debris flows

Debris flow is defined as mass wasting event in which turbulence occurs throughout the mass. Debris flow includes earth flows, mudflows, and debris avalanches. Debris flow occurs when the rock or soil mass loses coherency when lots of water is involved. Debris becomes mixed up completely and flows as liquid mud. It often carries large boulders which can be very destructive. When earth material moves down a hillside as a fluid-like mass, it is called an **earth flow**. These flows typically occur in humid areas on steep slopes with thick, clay-rich soil that becomes saturated with water during storms.

Figure 4.7 Debris flow

A mudflow

Mudflow is a liquid mass of soil, rock debris and water that moves quickly down a well defined channel. They occur most often in mountainous semiarid environments. A mudflow originating on a volcanic slope is called a **lahar**.

Debris avalanche

The deadliest type of debris flow is **the debris avalanche**. It is a rapidly churning mass of rock debris, soil, water, and air that moves down steep slopes. The trapped air may increase the speed of an avalanche by acting as a cushion between the debris and the underlying surface

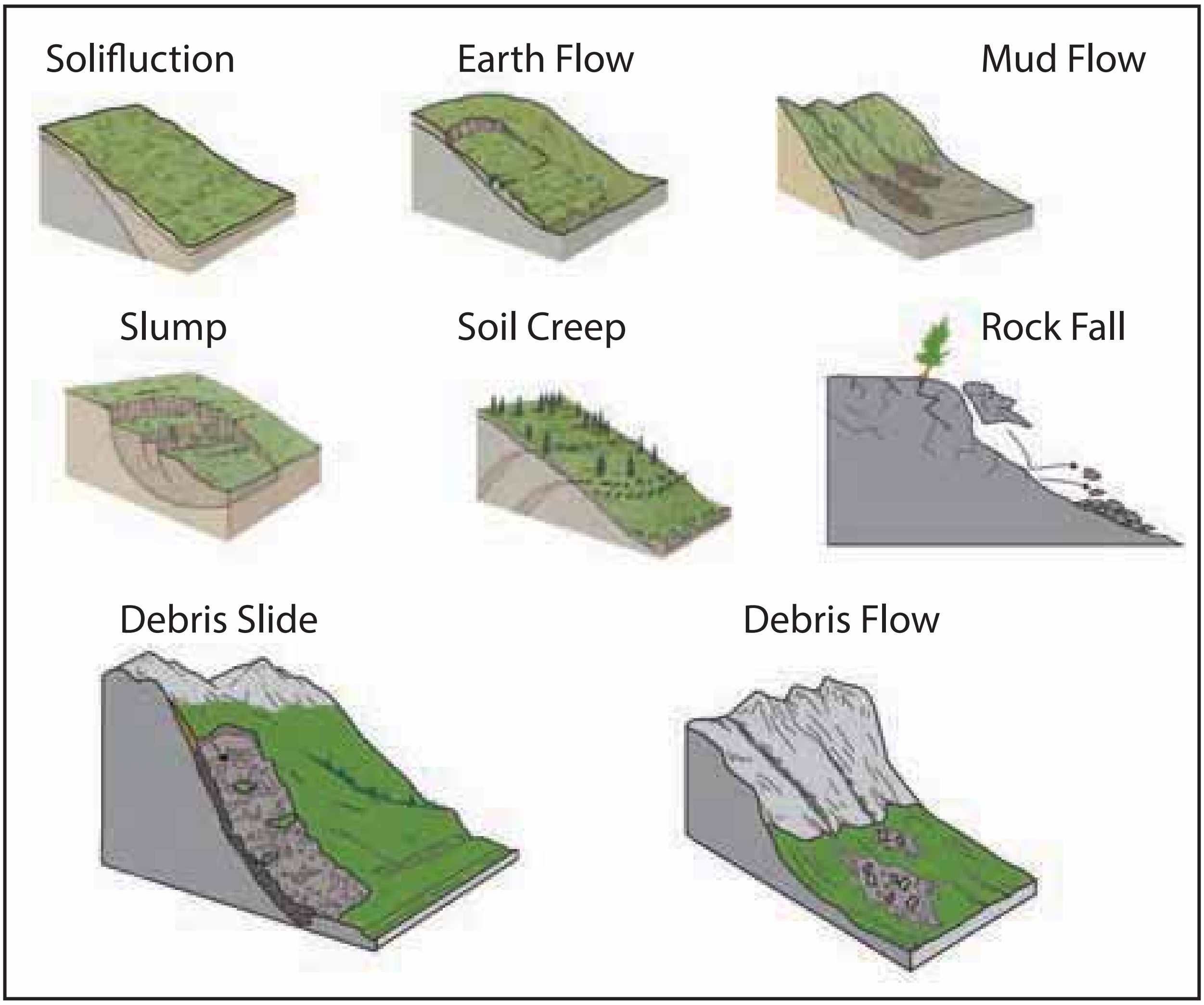


Figure 4.8 Mass Movement

Creep

Creep is a slow and gradual movement of soil downhill. Its velocity is typically less than a centimetre per year. Freezing and thawing contribute the soil creep by progressively moving soil particles down the hill. Creep is manifested at the surface by things like tilted utility poles, fences and trees Vegetation helps reduce the rate of soil creep.

4.5. Gradational Processes

Gradation is the process by which the earth's surface gets leveled. It can be further divided into degradation, the process of eroding the earth's elevated surface and aggradations, the process of filling up the earth's depressions.

4.5.1 Gradational Agents

The forces which act on the surface of the earth are termed as Gradational agents. Water, wave, wind, ice are the important gradational agents. Let us now discuss the gradiational agents one by one.

4.6. The River

The streams have a huge capacity to erode the rock over which they flow. In fact, the formation of the river channel is the result of the erosional capacity of the stream. The erosional capacity of the stream depends on its volume of water and velocity of flow. The river performs three types of work. They are erosion, transportation and deposition.

1. **Erosion**: The breaking of rocks by the river in along its course is called erosion. Erosional work of a river is performed mechanically and chemically. River erosion is carried out in the following ways:
   - i. **Hydraulic action**: It refers to the physical force of the moving water which breaks the rocks in its course.
   - ii. **Corrasion (abrasion)**: It refers to the breaking of rock in the bed and on the bank by fragments carried by the stream.
   - iii. **Corrosion(solution)**: It refers to the dissolving process of soluble minerals by the splashing of stream water.
   - iv. **Attrition**: It refers to the eroded materials carried by the stream strike against each other.
2. **Transportation**: Stream carrying the fragmented materials broken by the stream is called transportation. After erosion, the eroded materials get transported alont with the running water. This transportation of eroded materials is carried in four ways:
   - i. **Traction**: The heavier and larger rock fragments like gravels, pebbles etc are forced by the flow of the river to roll along its bed. These fragments can be seen rolling, slipping, bumping and being dragged. This process is called as traction and the load transported in this way are called traction load.
   - ii. **Saltation**: Some of the fragments of the rocks move along the bed of a stream by bouncing continuously. This process is called as saltation.
   - iii. **Suspension**: The holding up of small particles of sand, silt, and mud by the water as the stream flows is called suspension.
   - iv. **Solution**: Some parts of the rock fragments dissolve in the river water and transported. This type of transportation is called solution transportation.
3. **Deposition**: When the velocity of the stream decreases, the stream deposits sand, silt and other fragments. It is

called as the deposition. When a river moves in a gentle slope, its speed reduces and river begins to deposit its load. The river starts depositing larger materials first and smaller and finer materials are carried further down to the mouth of the river.

4.6.1 Stages of the River

The course of a river includes the upper stage, the middle stage, and the final stage. Each stage of the river is dominated by a kind of work. Let's discuss the stages of a river, the main work and the landforms made in each stage.

1. The Upper Stage

The upper stage of a river is also called the youthful stage or mountain stage. The velocity and speed of the stream are very high because the slope here is steep. The vertical erosion is the most dominant work here. The valley is formed here. The place where a river starts is called a **source**. In the mountain stage, the number of small streams originates from different locations. They are called **Tributaries**. The place where two rivers join is called as **the confluence**. The mountain which has two river systems draining on either side of the slope is termed as **the water divide**.

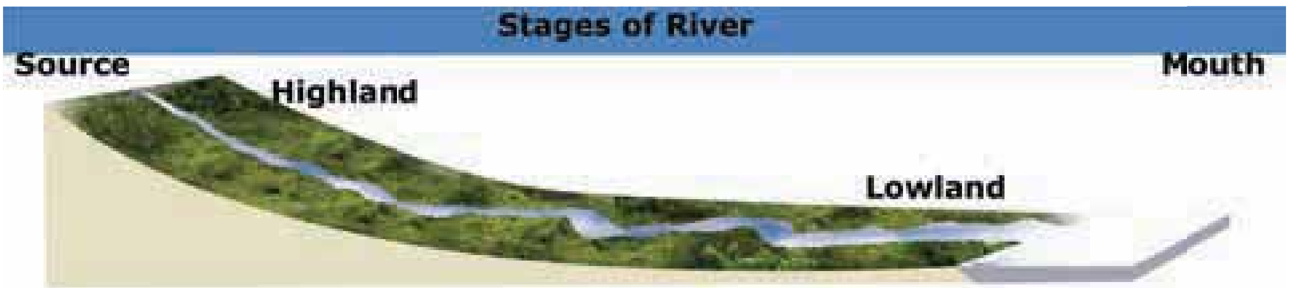
2. The Middle Stage

Middle stage is the matured stage of a river. Vertical erosion or deepening of the valley is significantly reduced. Lateral erosion is the dominant work. Due to the lateral erosion of this stage, the widening of the valley occurs. The volume of the river water increases and the slope of river is moderate. The depth of the river is deep here.

3. The Lower Stage

This is the final stage of a river where the valleys are extremely broad and it has generally gentle slope. The valley becomes almost flat which is called a peneplain. Most of the peneplain forms low residual

> **Students activity**
>
> Look at the diagram, read the table of content carefully and fill in the columns with suitable words.



	Upper Stage	Middle Stage	Lower Stage
Erosion			
Gradient			
Depth			
Velocity			
Width			
Volume			

hills with steep slopes which are called as Monadnocks. The main work of the river in this stage is the deposition. The depth of the river is shallow here. When the main river splits into many small rivers, they are called as the distributaries. The place where the river ends is called mouth of the river. (for example: Sea coast, Lake.)

4.6.2 Landforms by the Erosional Work of River

The significant landforms resulting from erosion by rivers include gorge, canyon, V-Shaped Valley, waterfall, pothole, structural bench, river terrace, river meander, ox-bow lake, peneplain, etc.

Gorges are formed due to active down cutting of the valleys. So, a Gorge is a narrow and deep river valley which has steep slopes.

Figure 4.9 Gorge

Canyons are extended form of gorges. Canyons represent very deep, narrow but long valleys. The steepness of the valley sides depends on the nature of the rocks. The Grand Canyon of the Colorado River in the state of Arizona, USA having a length of 482.8 kilometers and depth of 2088.3 meter is the largest canyon in the world. The Canyon of Gandikota is situated on the Pennar River in Andhra Pradesh is known as the Grand Canyon of India.

V-Shaped Valley The valleys made by the rivers are erosional landforms. The valley is formed in the youthful stage of the river erosion. Due to the steep slope and large volume of water, the river cuts its bed vertically forming narrow and deep river valley. This is called as V-shaped valley.

Rapids and waterfalls

Rapids are stream sections with extremely strong currents, numerous obstacles, and steps in their streambeds. A waterfall is a vertical drop in a streambed. Both water fall and rapids are formed by vigorous erosion. Series of a waterfall in a river is called as Cascade.

Plunge pool

A plunge pool is a deep depression in a stream bed at the base of a waterfall. It is created by the erosional forces of falling water at the base of a waterfall.

DO YOU KNOW?

Angel Falls, in Venezuela, is Earth's highest waterfall (979 m).

Hogenakal falls, Dharmapuri, Tamil Nadu some times is called as **the Niagara of India.**

CASE STUDY

Figure 4.10 The Canyon of Gandikota, the Pennar River in Andhra Pradesh

Gandikota, Kadapa district of Andhra Pradesh is known for its spectacular gorge formed by river Pennar that cuts through the Erramala hills. This handsome piece of Nature's architecture is known as the **Hidden Grand Canyon of India**. Magnificent Gandikota fort is located majestically on top of this gorge. Belum Cave found here is the second largest cave system in the India. In fact, geologists have also found **surplus deposits of Quartz** in the stalactite and stalagmite formations of the cave. Adjacent to Gandikota fort, lies a magnificent lake that is believed to have been established by emperor Sri Krishnadevaraya using water from the Pennar river.

Grooves

Long and narrow depression at the base of a waterfall made by river runoff is called a groove. The grooves are created by water eroding soil from a hill or mountain in a short period of time.

The swirling movement of the water falling into the plunge pool is called **eddying**.

Interlocking spurs

An **interlocking spur**, also known as an **overlapping spur**, is a projecting ridge that extends alternately from the opposite sides of a V-shaped valley. A river with a winding course flows down the interlocking spur.

Web link:

More at https://www.livehistoryindia.com/geological-wonders/2017/05/24/gandikota-the-grand-canyon-of-india-2)

Figure 4.11 Hogenakal waterfalls, Dharmapuri, Tamil Nadu

Pot Holes

The kettle-like small depressions in the rocky beds of the river valleys are called potholes. They are always cylindrical in shape. Potholes are generally formed in coarse-grained rocks such as sandstones and granites.

River Terraces

The narrow step like flat surfaces on either side of the valley floor are called river terraces. They represent the level of former valley floors.

Figure 4.12 Interlocking spurs

4.6.3 Landforms by the deposition of river

1. Alluvial fan

Alluvial fans are often found at the foot of arid or semiarid mountain ranges where intermittent streams flow. An alluvial fan is a fan shaped deposit of gravel, sand and other smaller particles of sediment.

Alluvial fans are found in Kosi river, Himalayan region, Death Valley National Park and along the sides of the Colorado River at Grand Canyon National Park, U.S.

Figure 4.13 Alluvial Fan

2. Peneplains

Peneplains represent low featureless plain having undulating surface and remnants of convex-concave residual hills.

3. Meander

A **meander** is a winding curve or bend in a river. **Meanders** are the result of both erosional and depositional processes. They are typical landform of the middle and lower course of a river. This is formed by vertical erosion, lateral erosion, and deposition within the floodplain.

4. Oxbow lake

Oxbow lake is a free standing body of water formed when the meander is cut off from the main river. This landform is so named because it resembles horse shoe

5. Levees: Raised bed and a bank of the river due to frequent flooding and deposition of the sediments is called levees.

6. Flood Plain

A flood plain is a flat area of land adjacent to a river. It stretches from the bank of its channel to the base of the enclosing valley walls which experiences flooding during the period of high discharge.

7. Estuary

The word "estuary" is derived from the Latin word *aestuarium* meaning tidal inlet of the sea, which is derived from the term *aestus*, meaning tide. An estuary is a partially enclosed coastal body of brackish water with one or more rivers flowing into it, and with a free connection to the open sea.

The inflow of both sea water and fresh water provide high levels of nutrients both in the water column and in sediment. Hence, it makes estuaries among the most productive natural habitats in the world. Narmada river estuary is located in Gujarat.

8.Delta

Delta is found in the old stage of a river. It is the triangular shaped landform made up of alluvial deposition in the mouth of the river. It is named after the fourth Greek alphabet called delta. Example, The Ganges Bhramaputra delta is the largest delta in the world.

Types of Delta: Delta is classified into the following based on the shape and kind of the load deposited by the river.

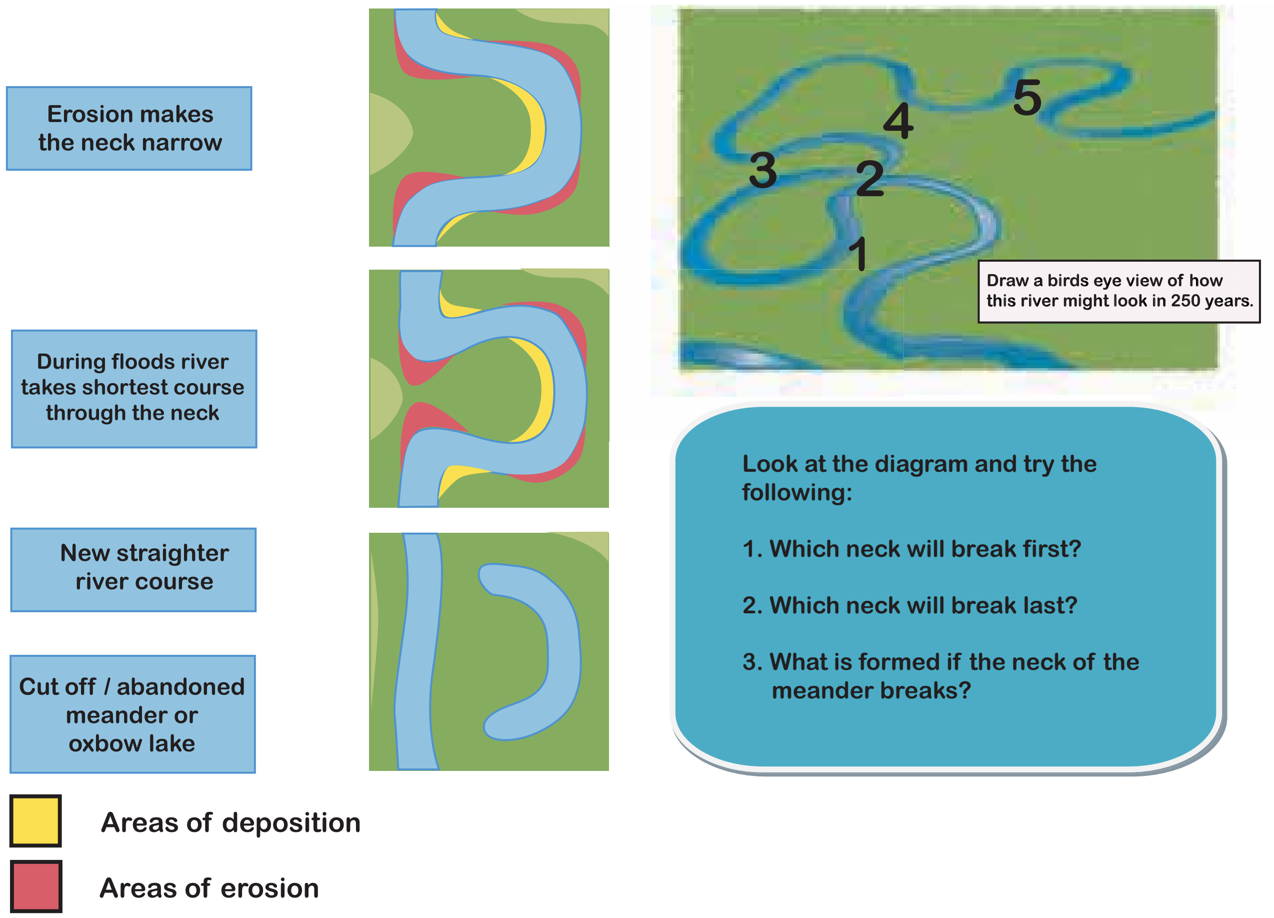


Figure 4.14 Meander

1. **Arcuate Delta**: A bowed or curved **delta** with the convex margin facing the body of water. It is also known as fan-shaped **delta**. Example, River Nile Delta in Egypt and Ganga Delta in India.
2. **Estuarine Delta :** it is formed at the mouth of submerged rivers depositing down the sides of the estuary. Example, Seine River of France.
3. **Birds foot Delta:** They are formed due to deposition of finer materials by river water. Deposited alluvial material divides the river into smaller distributaries. Such delta is also called as finger delta. Example, Mississippi river delta, the USA.
4. **Lacustrine Delta:** It is formed when a river flows into a lake. Example, Lough Leanne river delta, Ireland.
5. **Truncated Delta:** Sea waves and ocean currents modify and even destroy deltas deposited by the river through their erosional work. Thus, eroded and dissected deltas are called truncated deltas.
6. **Abandoned Delta:** when the river shifts its mouth, the delta already made is left abandoned. Such a delta is called abandoned delta. Example, Yellow river delta, China and the Western part of Ganga delta made by Hoogly river, India.
7. **Cuspate delta** is a tooth shaped delta formed when a single distributary

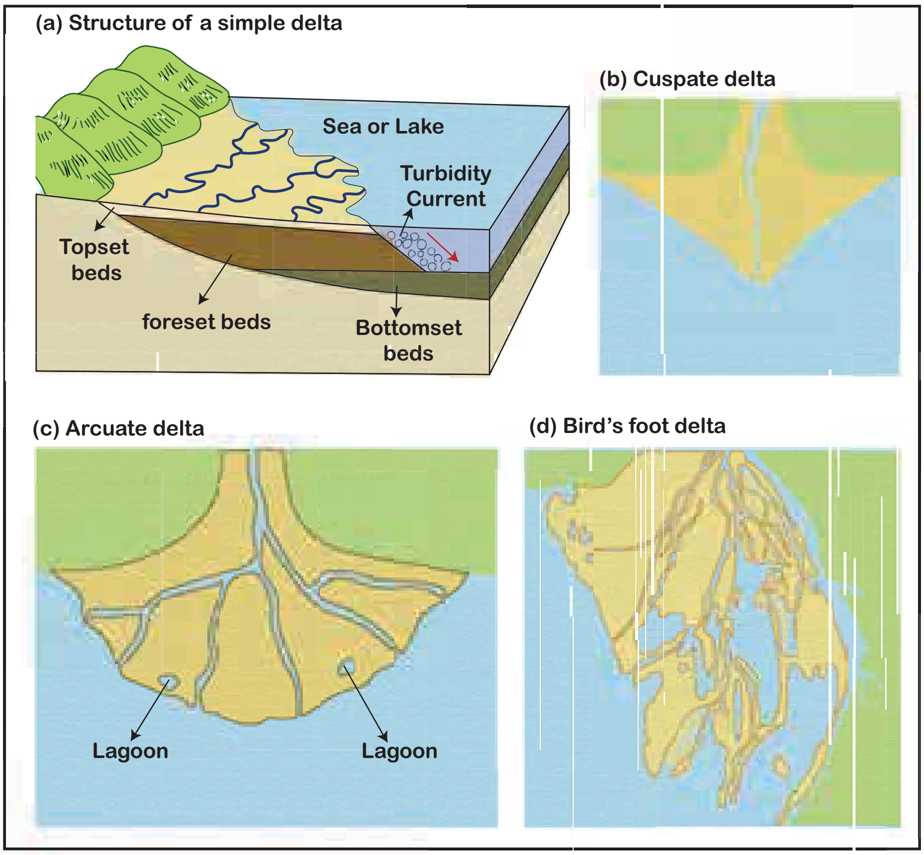
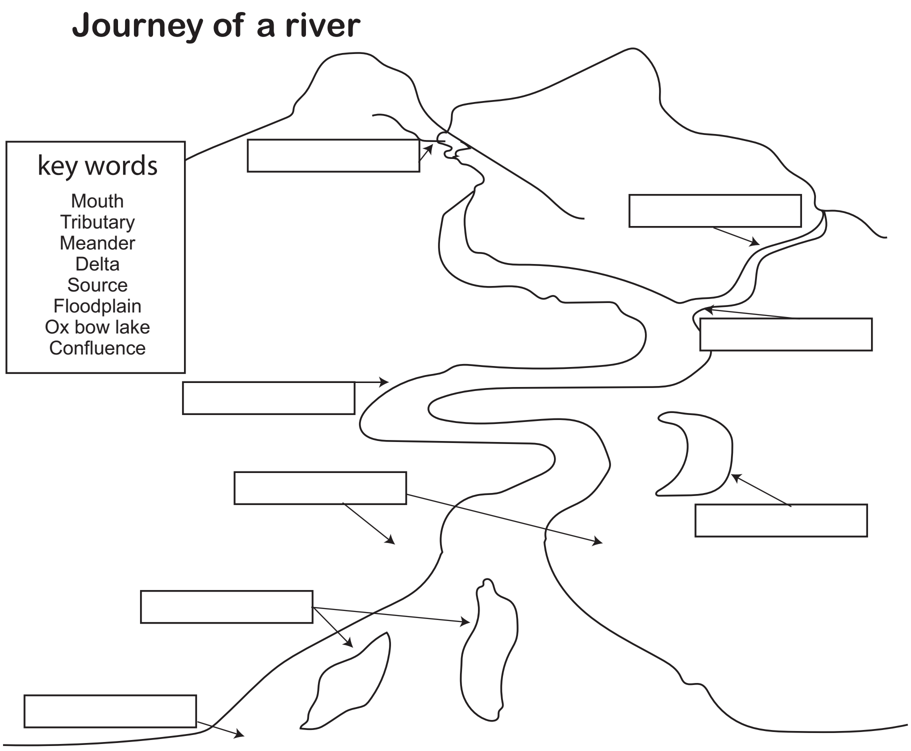


Figure 4.15 Types of Delta

Students activity

Label the following diagram of landforms made by the river.



flows through and deposits its load on its either side. Example, Tiber River of Italy

4.7 Glacier

A glacier is a huge mass of ice that moves slowly along the mountain slope. The term “glacier” comes from the French word *glace* which means ice. Glaciers are often called “rivers of ice”. It forms where the accumulation of snow exceeds its ablation over many years.

The places where the snow lies for the whole year are called **snowfields**. The imaginary line above which there is a permanent snowfield is known as **the snow line**. The snowfields are always situated above the snow line. The snow line differs according to latitude, amount of snowfall, the direction of the wind and the physical features of the region. Snow starts melting below the snow line. Under the pressure of the upper layers, the lower layers of the snow field begin to melt causing the mass of snow to move down slope as glacier. Glacier moves at an average speed of 1meter per day. Over 96 percent of the glaciers occur in Antarctica and Greenland.

DO YOU KNOW?

The world’s largest glacier is the Lambert Glacier in Antarctica, more than 96 km wide and 435 km long and 2,500 metres deep..

4.7.1 Types of Glaciers

The Glaciers are of three types. They are;

1. Continental Glaciers
2. Ice Caps
3. Mountain and Valley Glaciers

1. Continental Glaciers

The continental glaciers are found in polar regions. In these areas, all the precipitation is in the form of snow. The snow that falls from year to year gradually gets accumulated. As a result, these regions are covered by an extensive ice mass. This is known as ice sheet or continental glacier. It is estimated that the maximum thickness of the ice sheets of Greenland is 3,400 meter, while the maximum thickness of the ice sheet of Antarctica is 4776 meter. Sometimes, the ends of the ice sheet projects outwards over the sea. The waves of the sea strike against them and break the ice sheets into blocks of floating ice known as Icebergs.

2. Ice Caps

It is the covering of snow and ice on the oceans of poles. The ice caps can cover vast areas with the extensive accumulation of snow and ice. Example, Svartissen ice cap in Northern Norway.

3. Mountain and Valley Glaciers

These are also known as Alpine glaciers. They flow like tongues of ice down through the mountain valleys from the ice caps. The piedmont glaciers form continuous ice sheets at the base of mountains. The valley glaciers or Alpine glaciers are found in higher regions of the Himalayas and on all such high mountain ranges of the world.

4.7.2 Characteristics of Glaciers

A moving ice mass or glacier possesses certain characteristics of movement, speed, and surface structure. The rate of movement of the glacier is very slow.

The rate of movement or the speed of a glacier depends upon the size of the glacier and the slope of the valley. Sometimes, the surface of the glacier forms cracks known as **Crevasses**. Crevasses are the deep fissure of variable width in the surface of a glacier. These crevasses are dangerous to the Mountaineers.

Figure 4.16 crevasses

4.7.3 Action of glaciers

The glacier performs three actions namely erosion, transportation and deposition.

A glacier erodes its bedrock by the action of (1) Plucking and (2)Abrasion

(1) Plucking

The glacier plucks big pieces of rocks from the valley floor and creates large grooves or hollows. These pieces are dragged along the valley floor as the glacier moves. The boulders and rocky floor are grounded by mutual contact.

(2) Abrasion

Pure ice is capable of wearing down massive rocks when equipped with angular rock fragments. The glacier can groove, scratch, and chisel the rock surface. It has a powerful abrasive effect.

As a result, a glacier during its lifetime creates various landforms which may be classified into erosional and depositional landforms.

4.7.4 Erosional landforms of Glaciers

The landforms created by glaciers are mainly found in the mountainous regions. The chief erosional landforms by the glaciers are as follow:

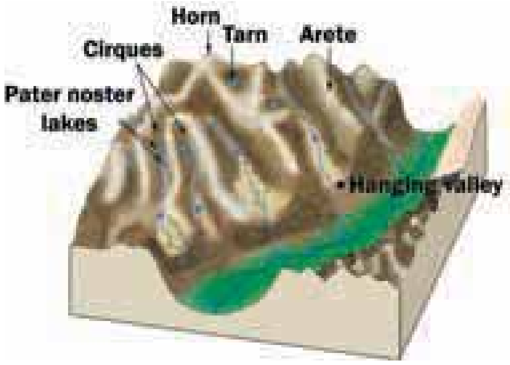


Figure 4. 17: Erosional landforms of Glaciers

1. U-Shaped Valley

U-Shaped Valley is a typical glacial feature. Since glacial mass is heavy and slow moving, erosional activity is uniform in all directions. A steep-sided curved bottom valley has a U shaped profile.

2. Hanging Valley

Hanging valley is formed when tributary glaciers are unable to cut as deeply as main ones and remain "hanging" at higher levels than the main valley as discordant tributaries. These tributary valleys appear hanging over the main valley and enter the main valley at some height.

3. Cirque and Tarn

A Cirque or Corrie is an amphitheater-shaped hollow basin cut into a mountain ridge. It has a steep-sided slope on three sides, an open end on one side and a flat bottom. When the ice melts, the Cirque may develop into a Tarn Lake and the whole thing appears like a big armchair.

4. Aretes

It is a steep-sided, sharp-tipped saw toothed ridges which have undergone glacial erosion from two sides. These comb like ridges are called as arete.

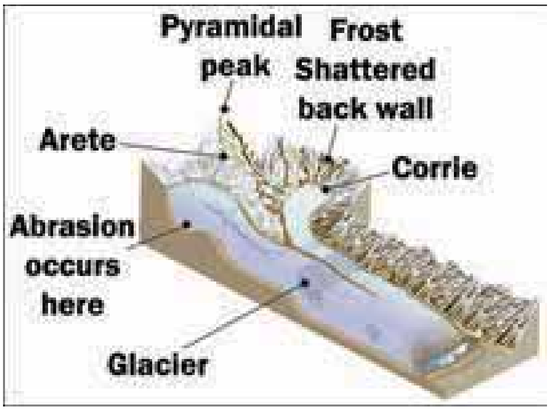


Figure 4.18 Glaciated features

5. Horn

If the summit of the Arete is roughly inclined, it gives rise to pyramidal peaks which are known as horns. Example, Matterhorn of Alps-Switzerland.

6. Roche Moutonnees or Sheep Rock

Roche Moutonnees or sheep rock is a glaciated bedrock surface, usually in the form of rounded knobs. The upstream side of a roche moutonnee has been subjected to glacial scouring that has produced a gentle, polished, and striated slope and the downstream side has been subjected to glacial plucking that has resulted in a steep, irregular and jagged slope.

7. Nunataks

A rock mass surrounded by ice is called Nunatak. It stands out as an island in the ice.

8. Fjord

The fjord is formed as a steep-sided narrow entrance like feature at the coast of a glaciated region where the stream meets the coast. Fjords are common in Norway, Greenland and Newzealand.

4.7.5 Depositional landforms of glaciers

When the glaciers melt or recede they deposit the rock material, brought by them, forming hillocks of various shapes and sizes. The depositional landforms of the glaciers are;

1. Moraines

Moraines are the piles of dirt and rock that are deposited by a glacier as it moves across the landscape. These debris fields exist in places where glaciers have moved through in the past. There are many kinds of glacial moraines that form. Moraines are generally classified based on their location.

a) Lateral Moraines

Lateral moraines are ridges of debris that run parallel to the sides of a glacier. This is often accompanied by scraping of the valley sides which means the debris from the moraine creates high ridges above the glacier.

b) Ground Moraines

Ground moraines are glacial depositions formed on the floor of glacial valley. Ground moraines can be deposited in between lateral moraines in the case of many alpine glaciers.

c) Medial Moraines

Medial moraines are ridges of debris that are left down a valley floor at the middle of two glaciers. Both glaciers merge together and their debris combine to form a consistent moraine field along their borders. They are actually the merging of two lateral moraines which continue as medial moraines.

d) Terminal or End Moraines

Terminal or end moraines are left by the end of a glacier. The slower a glacier moves the bigger the moraine will be as the glacier has more time to accumulate outside debris.

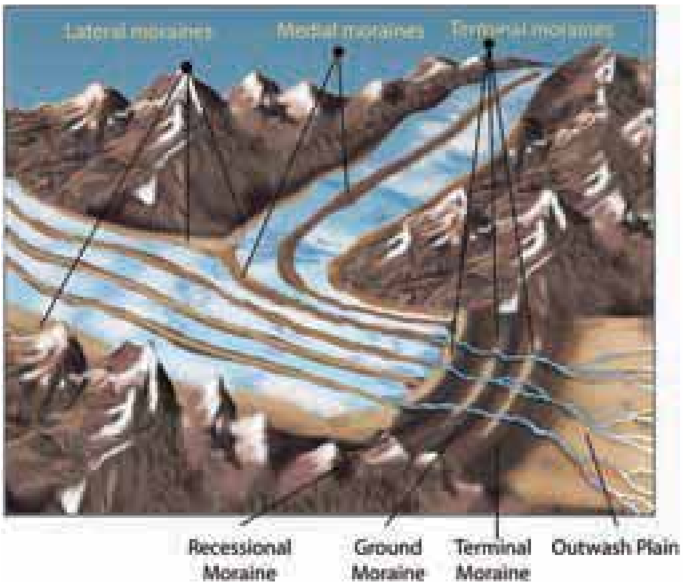


Figure 4. 19 Types of Moraines

e) Recessional Moraines

This recessional moraine runs across the landscape behind a terminal moraine. They are caused by times when the glacier slows or stops in its movement. It is formed because the receding glacier pauses in certain places for a long time before continuing its movement.

2. Outwash Plain

When the glacier reaches its lowest point and melts, it leaves behind a layered deposition of rock debris, clay, sand, gravel, etc. This layered surface is called as an Outwash Plain.

3. Esker

It is a winding ridge of depositions of rock, gravel, clay, etc, running along a glacier in an outwash plain. The Eskers resemble the feature of an embankment and are often used for laying roads.

4. Drumlins

It is an inverted boat-shaped deposition in an outwash plain caused by deposition.

5. Kames

Kames are the number of ridges formed along the ice front.

4.8 Ground water (Karst Topography)

The word "karst" literally means "rocky mountain" comes from a region in former Yugoslavia that includes Croatia and Slovenia. The word is derived from the Slavic word Kras.

What does Groundwater do?

Any limestone, dolomite or gypsum region showing typical landforms produced by the action of groundwater through the process of solution and deposition is called as Karst Topography (Karst region in the Balkans).

4.8.1 Erosional Landforms due to Groundwater

Following are the erosional landforms formed due to the action of groundwater.

1. Sinkholes

A sinkhole is an opening more or less circular at the top and funnel-shaped towards the bottom. When as sinkhole is formed solely through the process of solution, it is called as a solution sink.

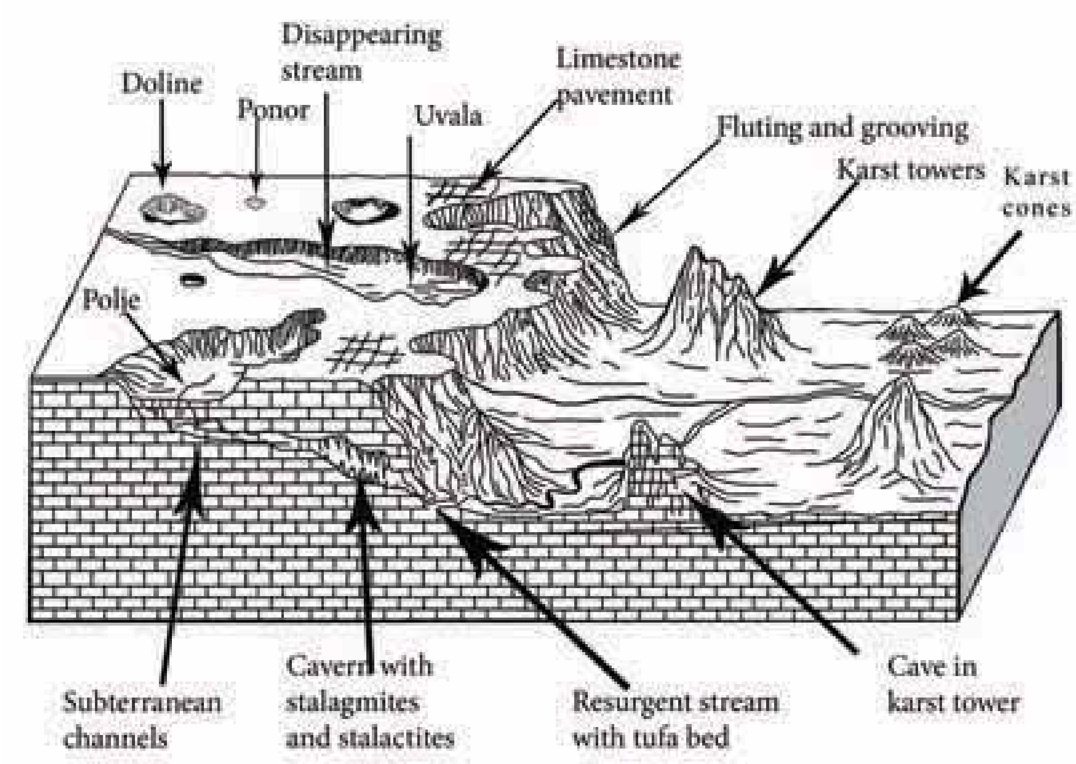


Figure 4.20 Karst features

2. Doline

A doline is a closed depression draining underground in karst areas. It can be cylindrical, conical, bowl or dish shaped. The diameter ranges from a few meter to many hundreds of meters. The name doline comes from dolina, the Slovenian word meaning *valley*.

3. Lappies

Lappies are the irregular grooves and ridges formed when most of the surfaces of limestone are removed by solution process.

Figure 4.21 Lappies

4. Uvala

Series of smaller sinkholes coalesce into a compound sinkhole is called uvala.

5. Polje

Polje is an elongated basin having a flat floor and steep walls. It is formed by the coalescence of several sinkholes. The basins often cover 250 square km and may expose "disappearing streams." Most of these basins have steep enclosing walls that range from 50 to 100 meter in height, giving rise to the name "blind valley."

6. Caves

Caves normally have an opening through which cave streams are discharged. Caves

HOTS

How was the world's biggest cave, son doonge of vietnam formed.

having an opening at both the ends are called tunnels.

Figure 4.22 Curtains

4.8.2 Depositional Landforms due to Ground water

The following depositional features are formed within caves.

1. Curtains

Rain water drips from long crack in a cave roof forms a continuous strip of calcites. It is called as curtains.

2. Stalactite

Drops of water containing dissolved limestone seep down through cracks in the cave roof. Drops of water lose carbon dioxide and deposit calcite. Overtime deposition of calcite forms pillars hanging down from the roof of the cave. It is called as stalactite and where the stalactite stretches towards the sides are known as Helactites.

3. Stalagmite

Deposition of calcite forming icicles growing upward from the cave floor is called as stalagmite.

Stalactites are calcium carbonate deposits hanging as icicles while Stalagmites are calcium carbonate deposits which rise up from the floor.

Figure 4.23 Stalagmite, stalactite, and pillar

4. Pillar

When both the stalagmite and stalactite join together, it is known as pillar.

4.9 Wind

The wind is the main geomorphic agent in the arid region. Wind in arid region has greater speed which causes erosional and depositional activities in the desert. The landforms which are created by erosional and depositional activities of wind are called as Aeolian Landforms.

Action of the wind

The action of the wind is carried in the following ways;

1. **Deflation**: Removal of sand and dust particles by wind. It forms depression in the desert. When depression is filled with water, it is called as Oasis.
2. **Abrasion**: Action of wind in which sand particles carried by the wind strike against the rock.
3. **Attrition**: Sand particles carried by the wind striking each other is known as attrition.

4.9.1Erosional Landforms of Wind

1. Deflation Hollows

When deflation causes a shallow depression by persistent movements of wind, they are called as deflation hollows.

2. Mushroom Rock

A mushroom rock, also called rock pedestal, or a pedestal rock, is a naturally occurring rock whose shape, as its name implies, resembles a mushroom.

In deserts, a greater amount of sand and rock particles are transported close to the ground by the winds which cause more erosion in the lower part of the rock than the top. These result in the formation of rock pillars shaped like a mushroom with narrow pillars with broad top surfaces.

Figure 4.24 Oasis (Top)
Mushroom rock (Bottom)

3. Yardang

Yardangs are extensively grooved, fluted, pitted and irregular rock ridges or reliefs of about 1 to 10 meters high running parallel to the prevailing winds. They are caused by differential erosion. When the sand-laden wind corrades zones of softer or weaker rock between harder vertical ridges from old lake sediment where soft, consolidated rock and bedrock surfaces are eroded into alternating ridges and furrows. Large-scale yardangs are found in Egypt (near Kom Ombo, north of Lake Aswan).

HOTS

Why is mushroom rock eroded more at the bottom than the top?

Zeugen

Zeugen is a landscape of alternate horizontal ridges and furrows made by the action of wind abrasion. It may be as high as 30 m height.

Figure 4.25 Zeugen

4.9.2 Depositional Landforms of Wind

1. Sand dunes

Dry hot deserts are good places for sand dune formation. According to the shape of a sand dune, there are varieties of sand dune forms like Barchans, Seif dune, etc. The barchan is one of the classic desert landforms. It is a crescent-shaped dune with the horns of the crescent stretching out in the leeward direction. Barchan dunes may reach more than 27 meter in height. Seif dunes are long ridges of sand. In general they are aligned in the direction of the prevailing wind. The slip face of seif dunes are probably formed by eddies. The depressions between seif dune ridges are swept clear of sand by the winds. The ridges run for long distances, sometimes several kilometres.

Figure 4.26 Sand Dunes

2. 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. These depositions are called as Loess.

3. Pediplains

When the high relief structures in deserts are reduced to low featureless plains by the activities of wind, they are called as Pediplains.

4.10 Waves (Coast)

Horizontal movement of sea water caused by the wind, rotation of the earth, etc., are called waves.

4.10.1 How do Waves Erode?

Waves carry out the erosive work in the following ways.

1. **Abrasion**: The waves striking against the coast with eroded materials is

called abrasion. Abrasion is also called as the corrasion.

2. **Hydraulic action**: The waves force water and air into the cracks in the rock. The parcel of air can be compressed by the surging water and the waves retreat, air expands explosively, weakening the joints and cracks and causing the rock to break. This is called the Hydraulic action.
3. **Corrosion**: The action of dissolving soluble rocks by waves is termed as the corrosion or solution.
4. **Attrition**: Eroded materials like boulders and rocks knock together to wear out into smaller particles. This is called attrition.

Terms related to coast

- **Sea shore** is the zone of land between high tide and low tide
- **Shore line** is boundary between land and water.
- **Backshore** is the beach zone starting from the limit of frequent storm waves to the cliff base.
- **Foreshore** is the portion of the beach subject to wave action during non-storm conditions.
- **Offshore** is the shallow zone of the continental shelf
- **Coastline** is the boundary where the land meets the sea
- **Swash** is the waves washing up the beach.

4.10.2 Landforms by the Erosion of Waves

Erosional landforms dominate rocky coasts but are also found in association with predominantly depositional landforms.

1. **Sea cliff** is steep rocky coast rising almost vertically above seawater is called sea cliff.
2. **Wave Cut Platform**: Rock cut flat surfaces in front of a cliff are called wave-cut platform. They are slightly concave upward. It is also formed when blowhole is collapsed.

Figure 4.27 Sea cliff and wave cut platform

3. **A sea cave** is a hollow excavated by waves in a zone of weakness on a cliff. The cave depth is greater than the entrance width.

Sea caves usually form at points of geological weakness, such as bedding planes, joints, and faults. A 90 meter long sea cave is found in the Loliem beach in Canacona in Goa. The world's most extensive cave is 1.5 km long Matainaka cave in New Zealand.

Figure 4.28 Sea Cave

4. **A blowhole** may form in the roof of a sea cave by the hydraulic and pneumatic action of waves, with fountains of spray

emerging from the top. If blowholes become enlarged, they may collapse.

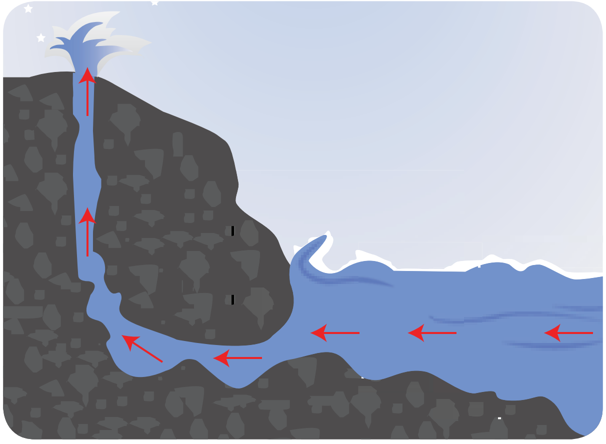


Figure 4.29 Blow hole

5. **Arch** is formed when the sea cave is cut right through by wave action. The arch is termed as sea tunnel if it is comparatively longer.
6. **The stack** is a steep and often vertical column of rock in the sea near a coast, formed by wave erosion.

It is formed when the natural arch is collapsed. It is also called chimney rock, needles, columns, pillars, skerries, etc,

7. **Stump** is the worn out stack.

4.10.3 Transportation Work of Waves

The eroded materials are transported by the waves in different ways. The materials involved in the transportation by sea waves include silt, sand, gravel, cobble, pebble and boulder.

4.10.4 Landforms by the deposition of waves

Depositional landforms developed by the sea waves include the beach, bar, lagoon, spit, tombolo, barrier island, etc. Let us see one by one in detail.

1. **Beach** is an elongated stretch of sands, pebbles, gravels, etc deposited along the coast. It can be a sandy beach or pebble beach. Praia da Cassino beach in Brazil is the world's longest beach stretching for 200 km from the Rio Grande to the border with Uruguay. Marina beach, Chennai is the second longest beach in the world.
2. **The Bar** is a stretch of sand deposition off the shoreline. The larger form of a bar is called barrier.
3. **The Lagoon** is enclosed seawater between the bar and the coast. For example,

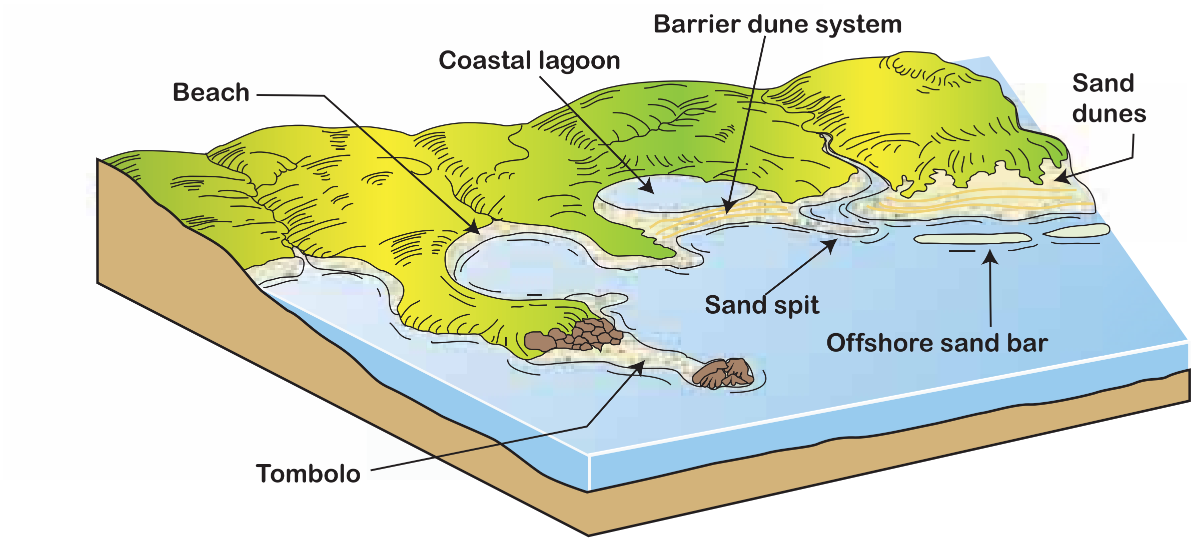


Figure 4.30 Depositional features of Waves

Pulicat lake, located in the Tamil Nadu and Andhra Pradesh is a lagoon.

4. **Spit** is a long, narrow ridge of sand or pebble with one end connected to the coast and the other end running into the sea. For example, Rameshwaram, Tamil Nadu.
5. **A Tombolo** is a bar connecting an island with the coast.

A-Z GLOSSARY

1. **Streambed:** A chanel in which a stream flow or formerly flowed
2. **Cataracts** - water fall with volume of water.
3. **The Ice Caps:** It is the covering of Snow and Ice on the oceans of poles.
4. **Offshore** is the zone shallow bottom of the continental shelf.
5. **Source of a river:** place where river starts.
6. **Water Divide:** relief having two river systems.
7. **Oasis:** depression in the desert filled with rain water.
8. **Desert:** waste land unfit for human use at the moment.
9. **Snow line:** an imaginary line below which snow starts melting.
10. **Delta:** A triangular shaped fertile land built by river at the mouth.

Evaluation

I. Multiple Choice Questions

7YTI1M

1. Which of the following is the chemical weathering process?
   a. Exfoliation
   b. Frost Wedging
   c. Carbonation
   d. Thermal expansion
2. Feldspar found in Granite changing to clay is the most common example of
   a. Oxidation
   b. Carbonation
   c. Solution
   d. Hydrolysis
3. Which district in Tamil Nadu has the highest frequency of landslide?
   a. Nilgiris
   b. Erode
   c. Dharmapuri
   d. Coimbatore
4. The swirling movement of the falling water into the plunge pool is called
   a. Plunge pool
   b. Groove
   c. Rapids
   d. Eddying
5. A winding curve or bend in a river
   a. Ox-bow lake
   b. Flood plain
   c. Meander
   d. Levees
6. A bowed or curved delta with the convex margin facing the body of water, also called as fan delta.
   a. Arcuate Delta

b. Bird's foot Delta
c. Abandoned Delta
d. Truncated Delta

7. Coleroon (Kollidam) river is a distributary of
   a. The Bhavani River
   b. The Palar River
   c. The Pennar River
   d. The Cauvery River
8. An amphitheater-shaped hollow basin cut into a mountain ridge by glacier.
   a. Arete
   b. Cirque
   c. Horn
   d. Fjord
9. The formation of irregular grooves and ridges when most of the surfaces of limestone are removed by solution process.
   a. Lappies
   b. Polje
   c. Cave
   d. Nunataks
10. One among the given is formed when the arch is collapsed.
   a. Stack
   b. Cave
   c. Blow hole
   d. Wave cut platform

II. Very short answer

11. Define exogenic processes.
12. What is an exfoliation?
13. How are rock flow, slide and fall different from one another?
14. List the types of Delta.
15. How is Spit different from Tombolo?

III. Short Answer

16. Compare physical weathering and chemical weathering.
17. Explain how a cave changes into stack.
18. Explain how a meander changes into an Oxbow lake.
19. Distinguish between Barchans and Seif dune.
20. Explain Moraine and list out its types.

IV. Detailed answer

21. List the landforms made by the river and explain any two landforms with diagrams.
22. Describe the erosional landforms of wind with diagrams.
23. Elucidate the landforms made by the wave erosion and draw the appropriate diagram.

V. Practice

24. Make a diorama of landforms made by the wind as a group work and show to the class explaining how each landform is made.
25. Group Work: Make a working model of a river course with all the landforms using available materials and demonstrate it in the class.

Reference

26. Wikipedia
27. Physical geography: fundamentals of the physical environment V. Ettwein and M. Maslin
28. Introducing Physical Geography, John Wiley & Sons.
29. Fundamentals of Geomorphology *Richard John Huggett*

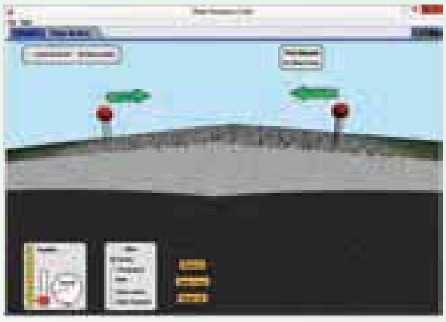
Web Reference

1. **Web link:** Read More at https://www.livehistoryindia.com/geological-wonders/2017/05/24/gandikota-the-grand-canyon-of-india-2

ICT CORNER

Lithosphere Change is Constant

Through this activity you will to learn the land formed by Exogenic processes.



Steps

- Use the URL to reach 'Plate Tectonics' simulation page.
- Download JAVA binary file from the page and install it .Click 'Play' button to run the JAVA applet.
- 'Plate tectonics' crust page will open. Modify temperature, composition and thickness of the crust and measure the density and depth using the scale provided.
- Select 'Plate Motion' page and drag the crust form to converge or diverge motion and observe the exogenic process.

Step 1

Step 2

Step 3

Step 4

Website URL:

https://phet.colorado.edu/en/simulation/plate-tectonics

*Pictures are indicative only.

B169_11_GEO_EM

Unit V

Hydrosphere

Chapter Outline

Learning Objectives:

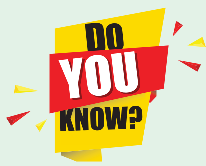
- *To understand the importance of hydrosphere*
- *Acquire knowledge on evolution of ocean and ocean relief features*
- *Appreciate the ocean movements and their influence on the earth's climate*

5.1 Introduction

"நீர்இன்று அமையாது உலகெனின் யார்யார்க்கும் வான்இன்று அமையாது ஒழுக்கு"

"World cannot survive without water and morality cannot exist without rain"

As thirukkural quotes, water is the most important resource in the world. Over 90% of the world's supply of fresh water is in Antarctica. You must know that 85% of the world population lives in the driest half of the planet. Now we shall learn about the hydrosphere in detail.



70% of human brain is water.

Water is the most common substance found on earth. It is an important constituent of all life forms on the earth. Hydrosphere is one among the four spheres of the earth. The hydrosphere includes the water on the surface of the earth, the water below the surface called ground water and the water in the atmosphere above earth's surface. Oceans, rivers, lakes and glaciers form part of surface water. There is substantial amount of water under the surface of the earth. The atmosphere has water in all the three forms. The total amount of water on the earth does not change over time. Water is constantly in motion within the spheres of the earth which is being transformed and reused all over the earth. The earth's hydrosphere, thus, acts as a closed system.

5.2 Distribution of Land and Water in the Earth

Earth is covered by land and water. About 70.8% of its area (361million sq km) is covered by water and 29.2% (148 million sq km) of its area by land. About 96.5% of water is salty found in seas and oceans. Fresh water occupies only 2.5%. Saline ground water and saline lakes together form 1%.

5.3 Fresh water

Fresh water is defined as water with a salinity of less than1% compared to that of the oceans (i.e. below 0.35%). Water with salinity between 0.35‰ and 1‰ is typically referred to as marginal water because it is marginal for many uses by humans and animals.

Considering the distribution of fresh water 68.6% of it is locked in Glaciers and icecaps. About 30.1% is stored as ground water and the remaining 1.5% is available as surface water.

Surface water includes ice and snow on the land and sea, water in the lakes, rivers, swamps and marshes, moisture in soil, atmosphere and biosphere. Rivers and lakes are the major sources of fresh water around the world, and are vital to the communities they serve.

Rivers: Rivers generally have a source on a mountain either from a glacier, a spring or a lake. River Ganga has its source from Gangotri glacier in the Himalayas. River Cauvery has its source from a spring in Talacauvery located in Kodagu district of Karnataka. River Nile has its source near Lake Victoria in Uganda. The river flows through confined channel between two banks and ends up at the mouth which is either on a sea or lake. When rivers drain their water into a lake or an inland sea, it is said to be an inland drainage.

The Nile River in Africa is the longest river in the world. The Nile River flows through Egypt, Uganda, Ethiopia, Kenya, Tanzania, Democratic Republic of the Congo, Rwanda, Burundi, Sudan and Eritrea drains and into the Mediterranean Sea forming a delta to the north of Cairo city.

The river Amazon in South America, is the second longest river, and has the largest drainage basin of any river. The Amazon River flows through Peru, Colombia, and Brazil and drains into the Atlantic Ocean forming an estuarine delta.

The Yangtze River, which flows in China, is the longest river in Asia, and the third longest river in the world. The longest river system in the United States, the Mississippi-Missouri system is considered the fourth longest river in the world.

DO YOU KNOW?

263 rivers either cross or demarcate **international political boundaries.**

The total volume of water in rivers in the world is estimated at 2,120 km³. Asia excluding Middle East, has the largest run off of 13,300 km^3/year followed by North America with 12,000 km^3 per year.

DO YOU KNOW?

A nationwide water resources information system, "Generation of Database and Implementation of Web Enabled Water Resources Information System (India-WRIS) in the country" contain all aspects of water resources and related data provide data and information in public domain through India-WRIS Web GIS portal.

Lakes: Lakes are larger bodies of water with outlet through a river or stream. Lakes may have their origin through tectonic activity, volcanic activity, river, glacier and wave action or sometimes meteoric origin. Caspian Sea, Lake Baikal and Wular Lake have been formed by earth movements. Lake Baikal is the deepest freshwater lake in the world. Caspian Sea is the largest salt water lake in the world.

Fact File

Tmc ft, is the abbreviation for one thousand million cubic feet (1,000,000,000 = 1 billion), commonly used in India with reference to volume of water in a reservoir or river flow.

Activity: List the major rivers from the map, find their source and mouth.

Name of the river	Source	Countries through which they flow	Sea or ocean it drains into	Type (Delta or estuary)
Amazon. R				
Nile .R				
Yangtzekiang. R				
Ganga. R				

Lagoon lakes are formed by wave deposition. Chilika Lake is the largest lagoon lake in India. Lonar Lake in Maharashtra is believed to be formed by depression created by meteor impact which hit during Pleistocene Epoch.

Lake Toba on the island of Sumatra is the largest resurgent caldera on Earth.

Sambhar Lake in Rajasthan is the largest salt water lake in India.

Finland is known as land of thousand lakes.

Wetlands: Wetlands are areas of marsh, fen, peat land or water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres. **Marshes** are shallow wetlands around lakes, streams, or the ocean where grasses and reeds are common, without trees. **Rann of Kutch** in India is a salt marsh. A **swamp** is a wetland with lush trees and vines found in a low-lying area beside slow-moving rivers. **Pallikaranai** wetland is a fresh water swamp adjacent to the Bay of Bengal situated in the southern part of Chennai.

Groundwater

Groundwater is the most valuable resource for any country. The rain water that falls on the earth either runs off as surface water or percolates into the ground to recharge the groundwater. The permeable rocks that can hold water and allow water to pass through them are called **aquifers.** The upper part of the saturated zone of the aquifer is called the **water table**. The level of water table fluctuates according to seasons (Figure 5.1).

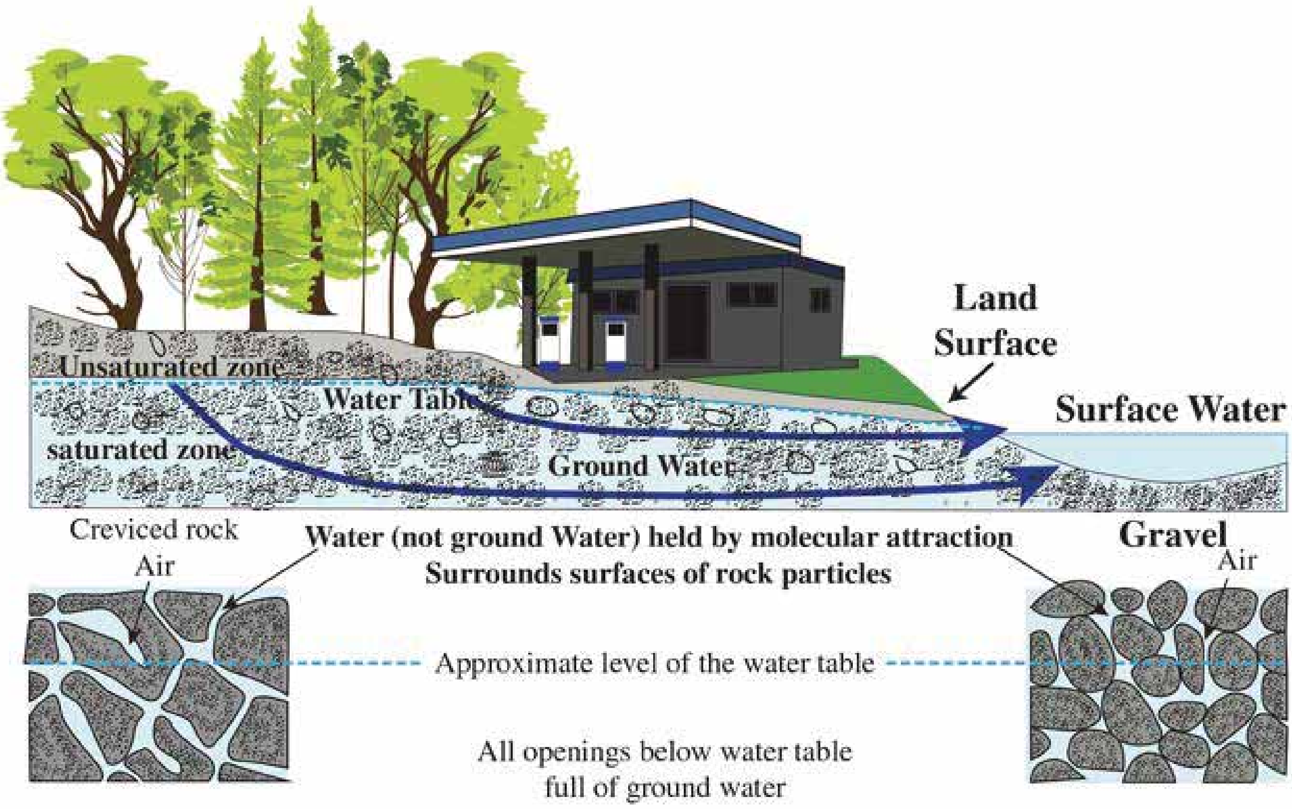


Figure 5.1 Ground water

DO YOU KNOW?

Saltwater intrusion

If excessive water is taken from the aquifers along the coast, the sea water enters the coastal aquifer. This process is termed as saltwater intrusion.

5.4 Cryosphere

Cryosphere includes the water in frozen state. Glaciers, ice sheets, ice caps, lake and river ice, permafrost, seasonal snow and ice crystals in the atmosphere together form cryosphere. Earth's climate is highly influenced by the extent of cryosphere as it controls the energy budget of the earth (Figure 5.2).

Perennial ice cover is found in Greenland and Antarctica as ice sheets, as mountain glaciers and as permafrost in higher latitudes. **Permafrost** is the condition prevailing when water freezes above and below the ground, (including rock or soil) for more than two consecutive years. Most permafrost regions are located in high latitudes, but alpine permafrost may exist at high mountains in much lower latitudes.

Fact File

Mount Kilimanjaro (5895m) in Tanzania, Africa, located closer to the equator has permafrost.

Seasonal snow and ice crystals are confined to middle latitudes and high mountains in lower latitude. **Sea ice** is frozen ocean water. Its formation, growth and melting are all confined to the ocean. An **ice shelf** is a thick, floating slab of ice that forms where a glacier or ice flows

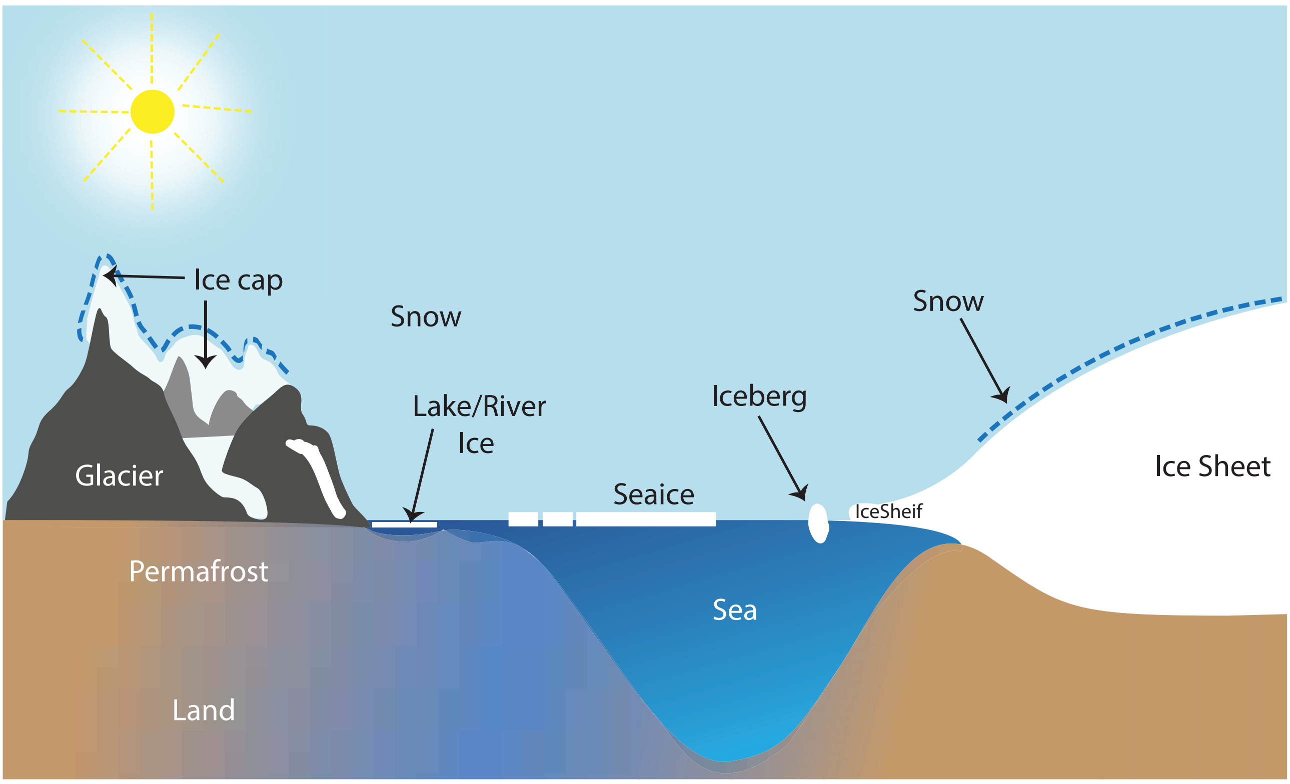


Figure 5.2 Cryosphere

down a coastline. The world's largest ice shelves are the Ross Ice Shelf and the Filchner-Ronne ice shelf in Antarctica. **An iceberg** is ice floating in open water that has broken off from glaciers or ice shelf.

Interaction of cryosphere with other spheres

Cryosphere is a climate indicator. Cryosphere with its high albedo influences the energy balance of the whole planet. Changes in cryosphere will alter land cover, surface temperature, soil moisture, air temperature, radiation, air circulation, clouds, precipitation, sea level, sea surface temperature, salinity, ocean current, fauna, flora and microbes. There is a complex interaction and balance among the spheres of the earth which makes life to flourish in the earth. If there is a change in one sphere it affects the other spheres as well. Nature maintains this balance. Understanding this complex interactions and living in harmony with nature will help to mitigate the environmental problems faced by the earth.

DO YOU KNOW?

Carbon is removed from the atmospheric cycle by cryosphere during the formation of ice and is released when the ice melts.

5.5 Oceans and Seas

The water in the oceans and seas is termed as marine water. Continuous water body that surrounds the continents, created by earth's internal force is known as Ocean. The term ocean takes its origin from the Greek word ***'Oceaonus'*** meaning enormous river encircling the earth. The area of the World Ocean is 361 million square kilometre. The earth has at present five major oceans: The Pacific Ocean, the Atlantic Ocean, the Indian Ocean, the Arctic Ocean, and the Southern ocean (Figure 5.3). All these oceans are interconnected to form one **Global Ocean or World Ocean**. This nature of water to level up quickly has made it as a reference point to measure the height of the land features and the depth of the sea features.

Fact File

Mean Sea Level (MSL) is the average height of the surface of the sea for all stages of the tide. MSL is reference point to measure the height of land features and depth of the sea features.

Sea is a body of saline water (generally a division of the world ocean) partly or fully enclosed by land. **Marginal sea** is a sea partially enclosed by islands, archipelagos, or peninsulas and extension of oceans towards land. They are generally shallow. Andaman Sea, Arabian Sea, Bay of Bengal, Java Sea, Persian Gulf and Red Sea are marginal seas of the Indian Ocean.

Bay is a water body surrounded on three sides by land and the fourth side (mouth) wide open towards an ocean. **Gulf** is a large body of water, with a narrow mouth, that is almost completely surrounded by land. The world's largest gulf is the Gulf of Mexico. **Sound, creek, bight** and **cove** are bays which vary in size and depth.

Strait is a narrow channel of water, connecting two larger bodies of water. Palk Strait connects Gulf of Mannar and Bay of Bengal. **Isthmus** is a narrow strip of land connecting two larger land masses. Isthmus of Suez connects Africa and Asia.

Enclosed seas are seas that reach very deep into the continent stay connected with one or the other ocean of the world through straits. Mediterranean Sea is the best example for enclosed sea. **Partly Enclosed Seas** are those types of seas that are connected to the oceans by a very wide opening and have similar characters of the adjacent ocean. A series of islands may also occur between a partly enclosed sea and the ocean to which it is connected. Caribbean Sea is a perfect example.

Landlocked Seas are completely surrounded by landmass on all sides without any natural outlet. They are actually hyper saline lakes. Dead Sea and Caspian Sea are good examples of landlocked seas. Jordon River and Volga River flow into Dead Sea and Caspian Sea respectively.

Fjord is a long indented bay with steep slope that has been created by the submergence of U shaped glacial valley. Example: sogne Fjord in Norway (203 km).

Ria is an indented bay with gradual slope formed by the submergence of V shaped river valley. George River in Sydney is the best example for Ria.

5.6 Oceans of the world

1. **The Pacific Ocean**

Pacific Ocean is the largest ocean in the world. It is bigger than all continents put together. Portuguese explorer Ferdinand Magellan in 1521 named the ocean Pacific Ocean meaning 'peaceful' because he felt the ocean to

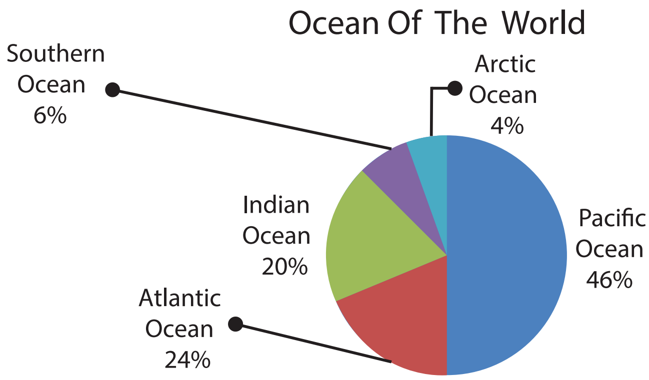


Figure 5.3 Distribution of the Oceans

be calm after sailing from the Atlantic Ocean through the stormy and dangerous Strait of Magellan. Average depth of this ocean is 4,280 meters.

> **DO YOU KNOW?**
> There is life cycle for oceans too! It is known as Wilson cycle.

2. **The Atlantic Ocean**

Atlantic Ocean is the second largest ocean of the world. The Atlantic Ocean's name refers to Atlas of Greek mythology. The North Atlantic Ocean was formed by the break-up of the supercontinent Pangaea and the south Atlantic was formed when the Gondwana land broke in the geological past.

> **Fact File**
> The Suez Canal, an artificial sea-level waterway in Egypt, connecting the Mediterranean Sea to the Red Sea through the Isthmus of Suez was officially opened on November 17, 1869.

3. **The Indian Ocean**

   The Indian Ocean is the third-largest in the world. It is named after India. Its calm open water has encouraged the sea trade earlier than the Atlantic or the Pacific Ocean.

4. **The Southern Ocean**

   The Southern Ocean is the world's fourth largest ocean. The Southern Ocean is the youngest ocean and was formed 30 million years ago when South America moved away from Antarctica, opening the Drake Passage (Figure 5.4). This ocean has the boundary where cold, northward flowing water from the Antarctic mixes with warmer sub Antarctic water. During summer in southern hemisphere over half of the Southern Ocean is covered with ice and icebergs.

5. **The Arctic ocean**

   The Arctic Ocean is shallower and smaller than the other four oceans. It is completely surrounded by Eurasia and North America. It is covered by ice completely in winter. The Arctic Ocean's surface temperature and salinity vary seasonally as the ice cover melts and freezes alternatively. Its salinity is the lowest on an average of the five major oceans. Bering Strait connects the Arctic Ocean with the Pacific Ocean while the Greenland Sea and the Labrador Sea connects it with the Atlantic. The deepest point is Litke Deep in the Eurasian Basin, at 5,450 m.

Fact File

The International Hydrographic Organization (IHO) is the inter-governmental organisation that surveys and produces charts for the world's seas, oceans and navigable waters.

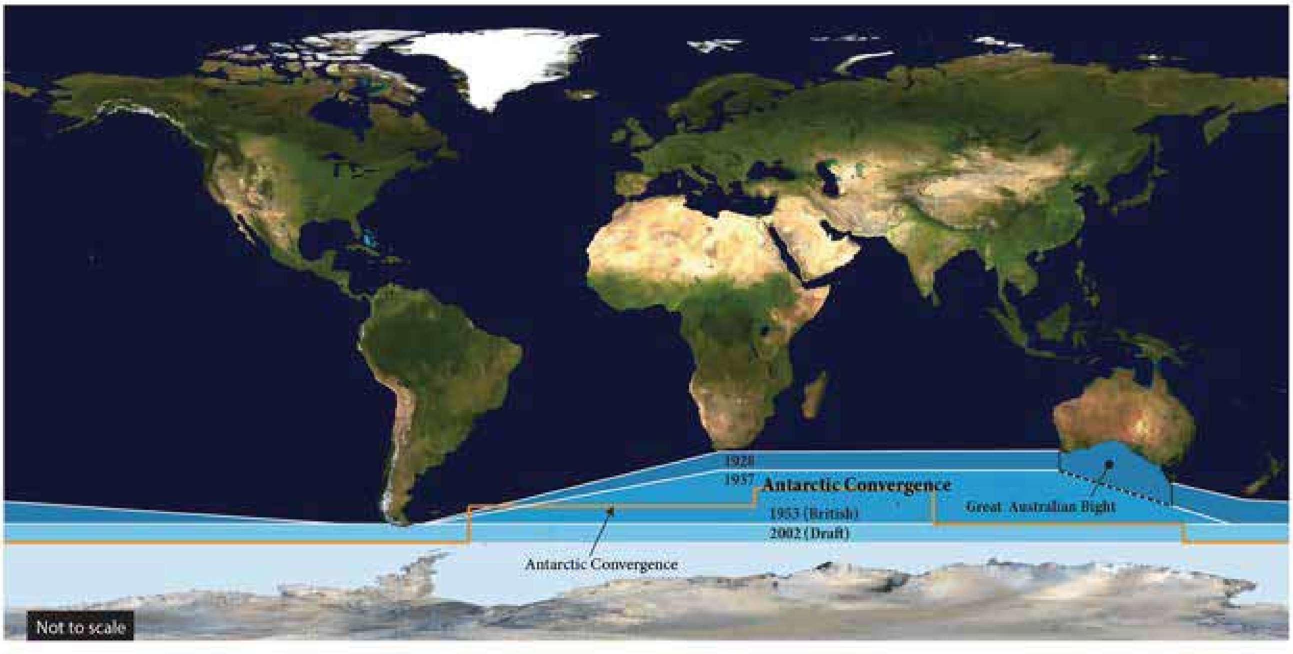
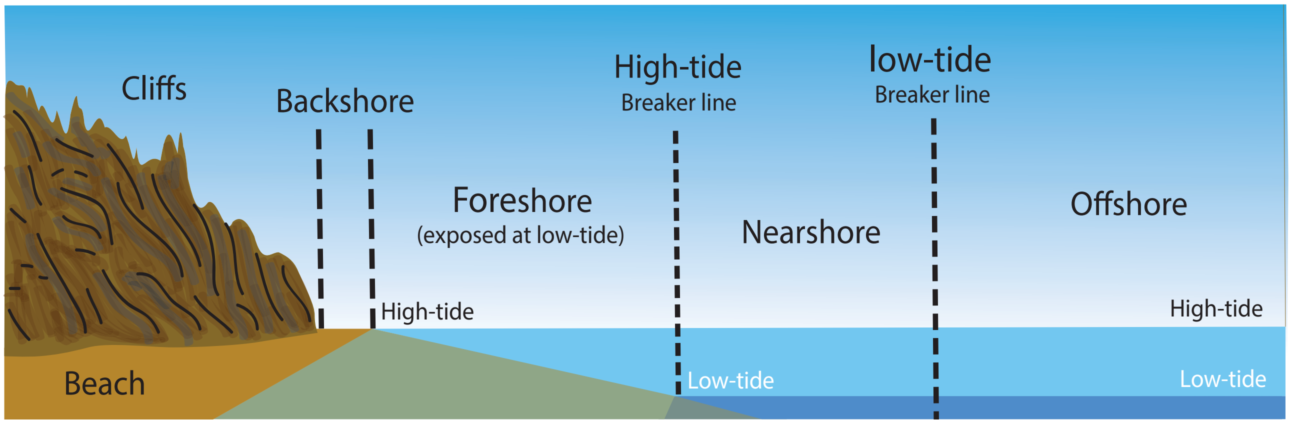


Figure 5.4 Extension of Southern Ocean

Student's Activity: Shoreline Terminology

Answer the following after careful examination of the diagram
Foreshore lies between ________________ and ________________
The seaward region beyond the low-tide breaker line is known as ________________



5.7 Maritime zones

The low-tide line forms the base line for marking maritime zones. Water landward of the baseline in defined as **internal waters** over which the state has complete sovereignty. A country's **territorial sea** extends up to 12 nautical miles (22.2 km) from its baseline (Figure 5.5). The **contiguous zone** is a zone of water extending from the outer edge of the territorial sea up to 24 nautical miles (44.4 km) from the baseline.

An **Exclusive Economic Zone** (EEZ) extends from the base line to a maximum

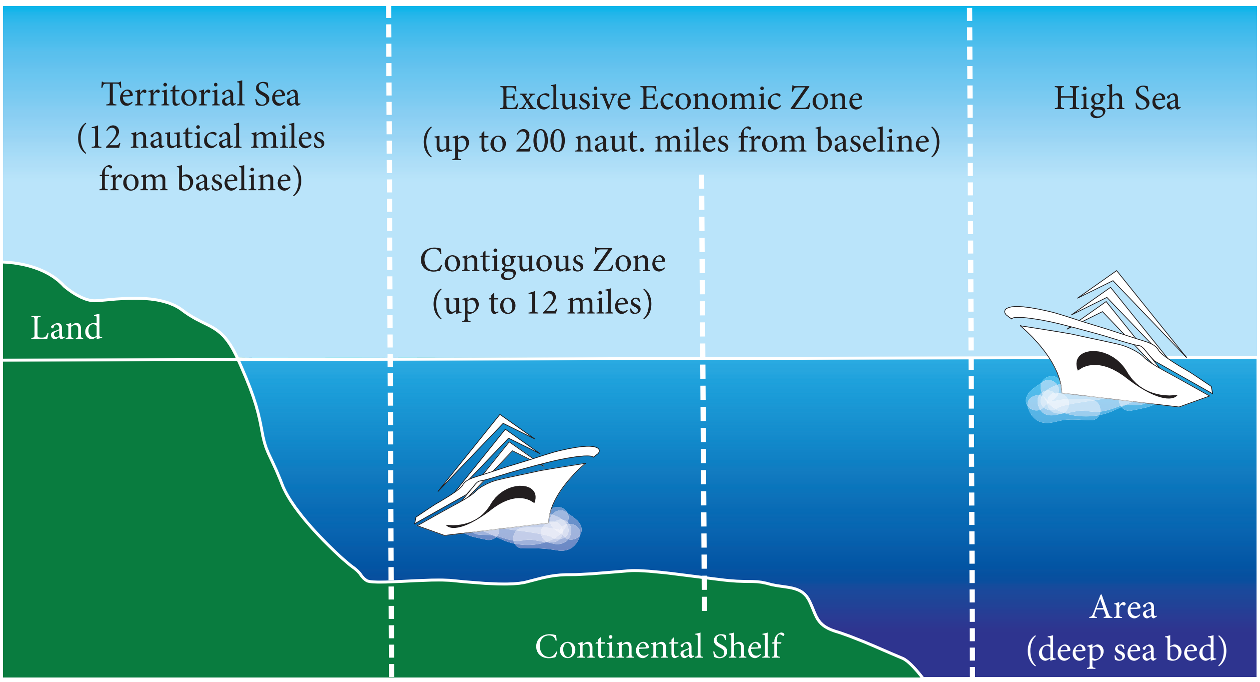


Figure 5.5 Maritime Zones

of 200 nautical miles (370.4 km). A coastal nation has control of all economic resources within its exclusive economic zone, including fishing, mining and oil exploration. Everything beyond EEZ is called **International Waters or the High Seas**. No nation has sovereign rights over this area.

> **Fact File**
>
> A nautical mile is based on the circumference of the earth, and is equal to one minute of latitude which is equivalent to one sixtieth of a degree of latitude. A nautical mile is a unit of measurement defined as 1,852 metres. Nautical miles are used in Navigational charts.

5.8 Relief of ocean

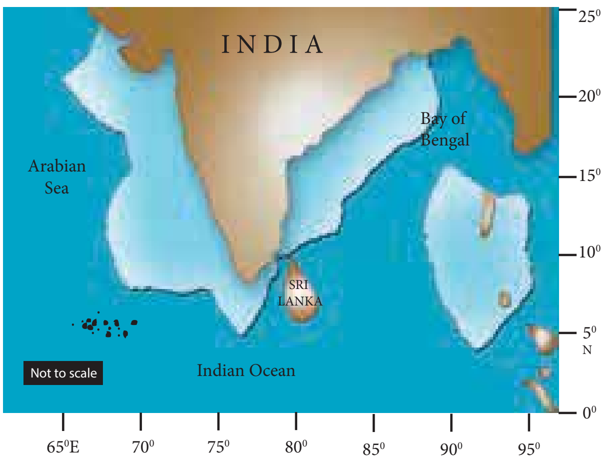
The bottom of the ocean has a variety of landforms just as it is seen on the earth's surface. There are large mountain ridges, deep depressions, flat plains, basins and volcanoes. The configuration of an ocean floor is shown with the help of a

> **Fact File**
>
> Indian National Centre for Ocean Information Services (**INCOIS**) with its Marine Satellite Information Services uses the remotely sensed sea surface temperature (SST) to identify the locations of fish aggregation. The details of the Potential Fishing Zones (PFZ) are then disseminated to the fishermen once in every three days along the Indian Coast by displaying the details in the Lighthouse in their respective regional language (Figure 5.6).

'**Hypsometric curve**' or '**Hypsographic curve**'. It is a graph denoting the proportion of a landmass standing above or below the sea level (Figure 5.7).

Continental shelf

Continental shelf is the seaward extension of land that lies under the sea water. It occupies 7% of the sea floor. The continental shelf slopes gently away from the land and is covered with shallow seas with an average depth of 200



North Indian Ocean with Arabian Sea and Bay of Bengal .The dashed Lines demacrate India's EEZ,Which covers about 2 million sq,km, Which is roughly 60% of India's land area.India's coastline including islands is about 7000 km long.

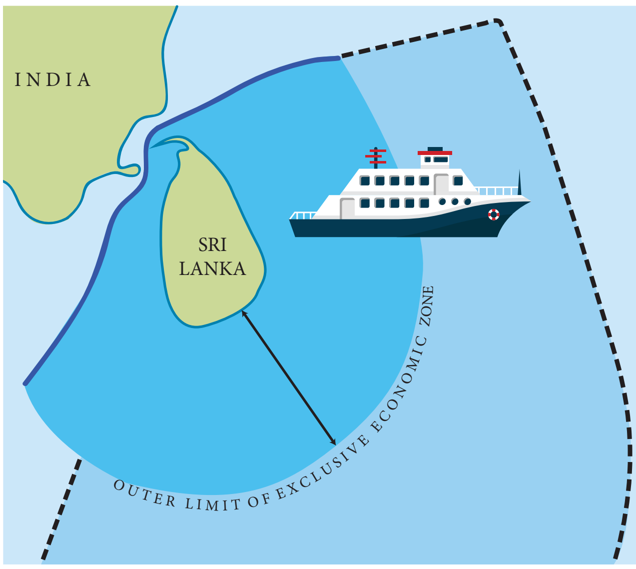


Figure 5.6 India's Exclusive Economic Zone

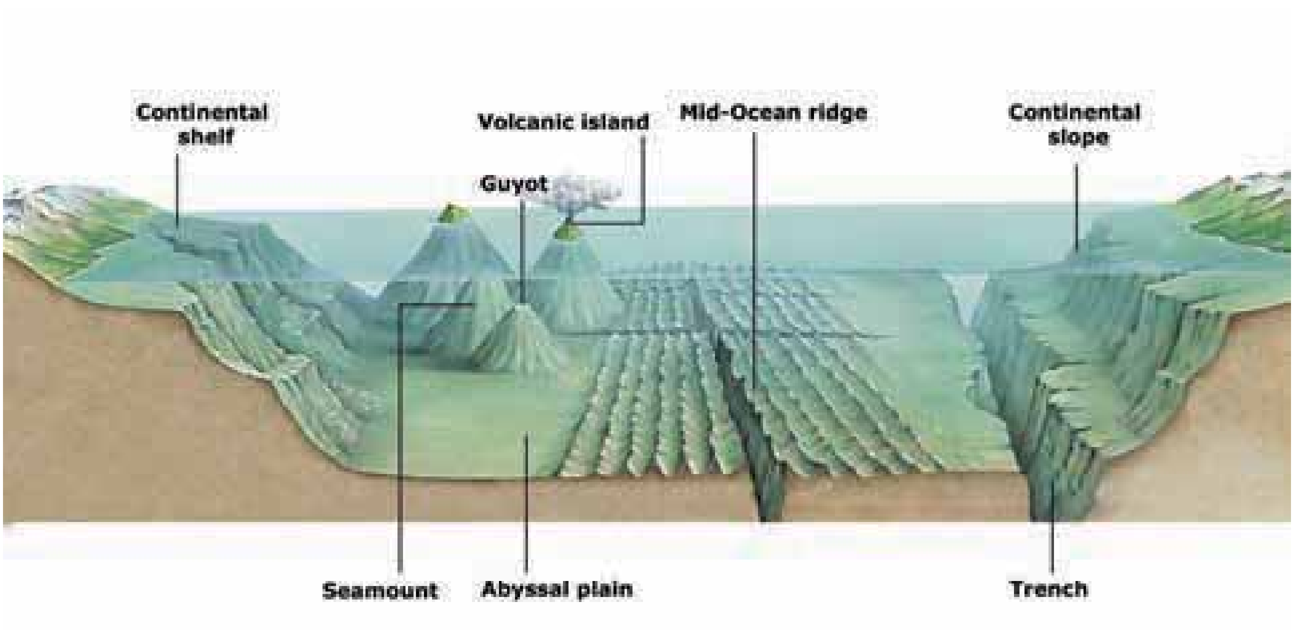


Figure 5.7 Major relief features of Ocean Floor

fathoms. The width of the continental shelf varies according to the nature of the rock beneath the crust. If the crust is dynamic then the shelf would be narrow and vice versa. Continental shelves are formed due to either any one or combination of the factors like fluvial deposits, marine erosion, tectonic forces, and the fluctuations in sea level in the past. Continental shelves are well known for oil, natural gas, mineral deposits and coral reefs. World famous fishing grounds like Grand Bank are situated here. The world's widest continental shelf (1210 km long) is located along the coast of Siberia, in Russia.

Continental shelf on the east coast of India is formed by deltas of the Ganga, the Godavari, the Krishna and the Cauvery. On the West coast of India the continental shelves are formed due to faulting and consequent submergence.

Continental Slope

The zone of steep slope extending from the continental shelf to the deep sea plain or abyssal plain is called continental slope. The slope angle varies from 5° to 60°. It occupies 9% of sea floor. This is the region in oceans where landslides, turbid currents, large sediment slumps, under water canyons, gorges cut by the currents and rivers occur. The deposit from the continental shelves immediately falls down here. The origin of continental slope is believed to be due to erosional, tectonic and aggradational processes.

Continental rise

The area between the continental slope and the sea floor is known as the continental rise. This part is noted for the accumulation of sediments similar to the alluvial fans near the foot hills in the land. It represents the boundary between continents and abyssal plain. It constitutes about 5% of the oceanic area.

Abyssal plain

The Abyssal plain is the vast area of flat terrain in the bottom of the oceans. It is

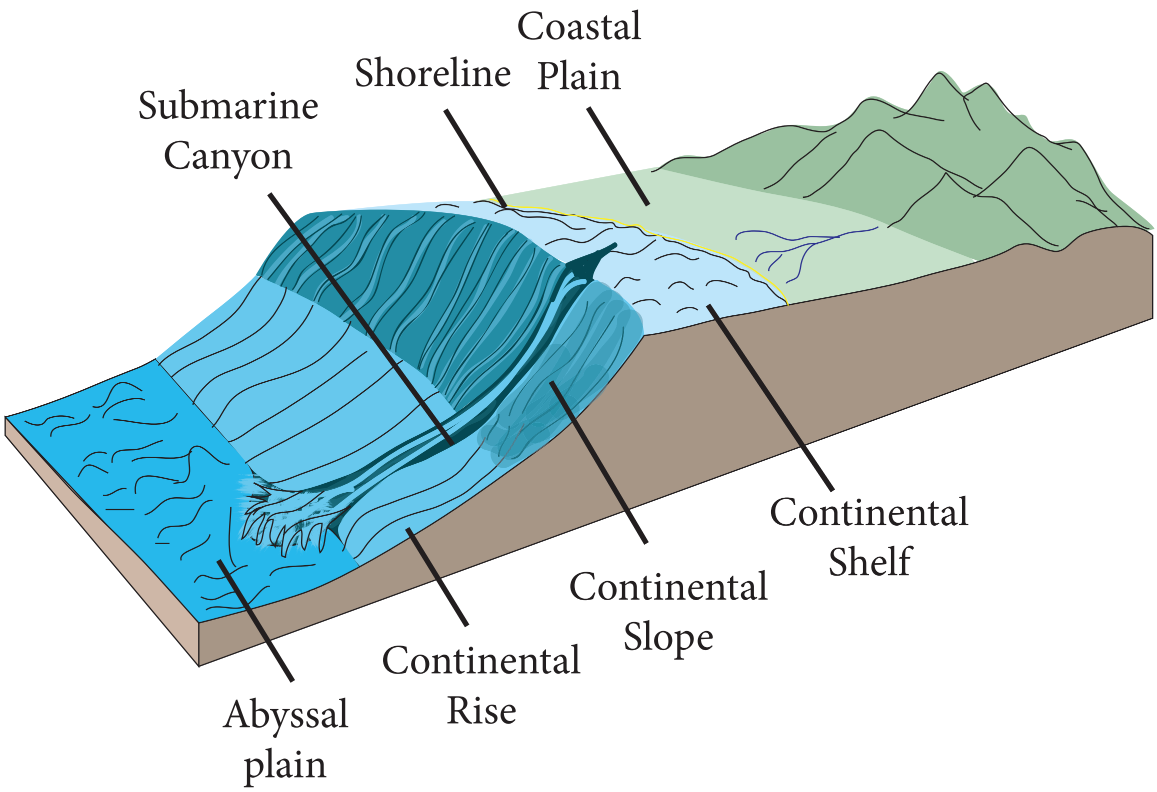


Figure 5.8 Ocean relief

the largest part of ocean relief covering more than 50% of the total area. There is an accumulation of very fine sediments on the floor. The sediments are combinations of fine particles of clay and microorganisms. As in the case of sedimentary rocks of earth's surface these sediments are in layers and are used to trace geological events in the past.

Mid oceanic ridges

The mid-ocean ridges are submarine mountains. They are continuous and are connected to form a single global mid-oceanic ridge system. They are formed by the tectonic forces acting from within the earth. Mid oceanic ridges are located on the divergent plate boundaries where magma flows through the fissure to form new oceanic crust. They form the longest mountain range in the world extending for more than 56,000 km long and has a maximum width of 800–1,500 km.

Ocean trench

The long, narrow, steep-sided depressions formed by tectonic forces beneath the abyssal plain are called Ocean trenches. Oceanic trenches actually extend 3 to 4 km below the level of the abyssal plain. There are 26 oceanic trenches in the world: 22 in the Pacific Ocean, 3 in the Atlantic Ocean and only one in the Indian Ocean. The Challenger Deep in the Mariana Trench, (10,994 m) in the Pacific Ocean is the deepest part of the earth. A trench forms along the convergent boundary where one plate subducts below the other (Figure 5.9).

Island

An island is a landmass surrounded by water on all sides. Islands may be formed on the continental shelf or as oceanic islands. Most of the oceanic islands are volcanic in origin. Group of islands

Major Ocean Trenches of the world

Name of the Trench	Location	Depth (in Metres)
Challenger in Mariana Trench	North Pacific	10,994
Aldrich or Tonga Trench	South Pacific	10,882
Kurile Trench	North Pacific	10,554
Tizar Romanche Trench	South Atlantic	7,761
Sunda Trench	East of Indian Ocean	7,450

Source: Geology.com

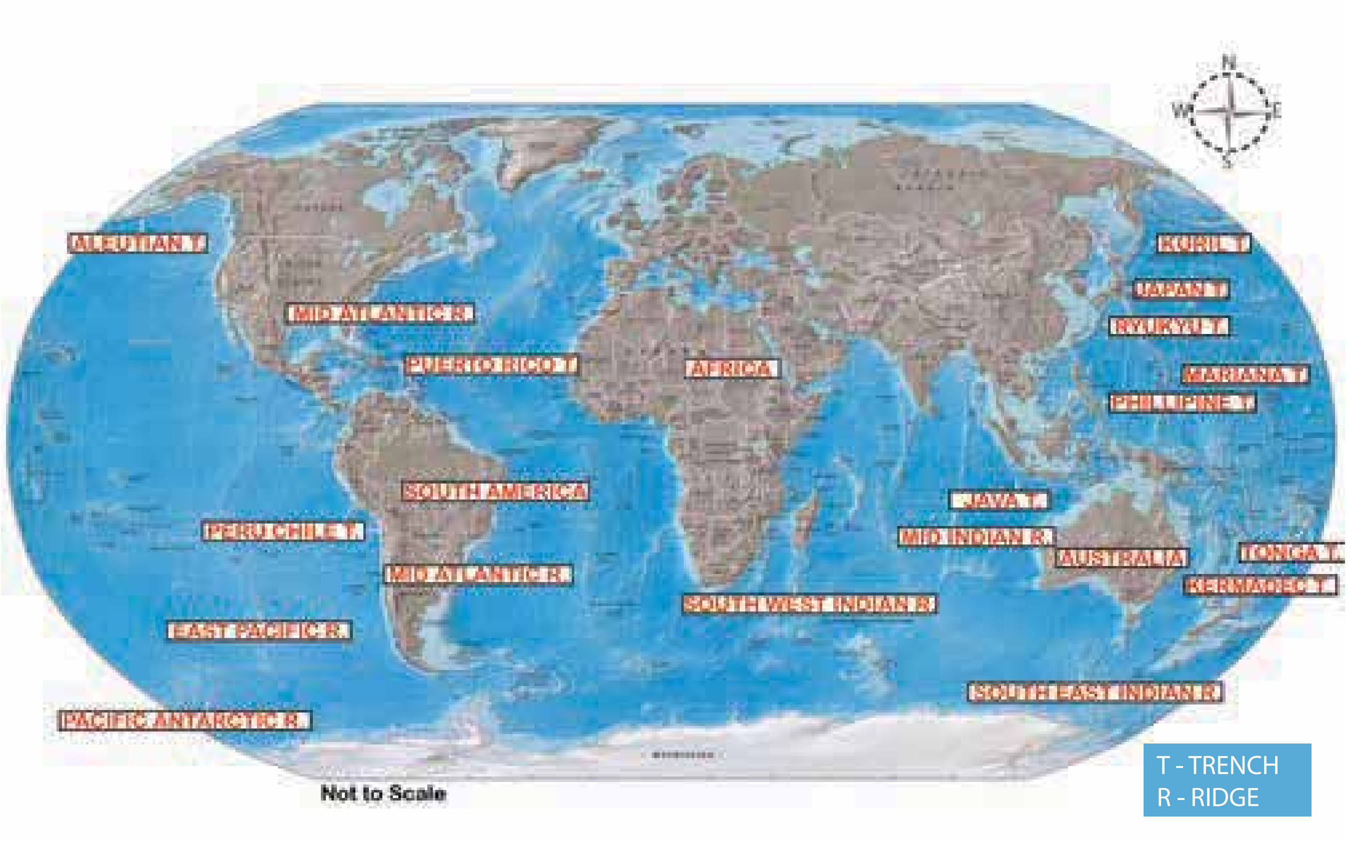


Figure 5.9 Ridges and Trenches of the world

Fact File

Ocean deep is grouped into two categories based on their size.

Very deep but less extensive depression are called deeps. Long narrow linear and more extensive depressions are called ‘trenches’.

formed by subduction of ocean plate are known as **archipelago**. Islands of Japan form an archipelago.

Marine organisms, the coral polyps colonize the tropical warm water and form islands known as **coral islands**. Lakshadweep Island in Indian Territory is made of corals. Andaman Nicobar islands are of volcanic origin.

Guyots

Flat topped volcanic hills submerged under the sea water are called **guyots**. It is a part of an underwater chain of volcanic mountains produced by slow plate movement.

Seamounts

Seamounts are conical, volcanic hills submerged under ocean water. It does not reach to the water's surface. It is an isolated rise with an elevation of thousand metres or more from the surrounding sea floor and with a limited summit area. It occupies 4.39 percent of ocean region. Seamounts and guyots are most abundant in the North Pacific Ocean.

Bottom relief of Pacific Ocean

Continental shelf of the Eastern Pacific Ocean is very narrow due to the presence of trenches while those on the western coast are wide. Continental shelf adjoining coasts of Australia and Indonesia varies in width from 160 to 1,600 km. In the Pacific Ocean, the abyssal plains are very vast. Absence of mid oceanic ridges is the main reason for deep sea plains. Prominent submarine ridges of the Pacific Ocean are **Albatross plateau**, **Cocas ridge** and **Aleutian ridge.** Tasmania basin (New Zealand) and east pacific basin are major basins of Pacific Ocean. Pacific Ocean has about 25,000 islands. There are number of archipelagos both in north and south Pacific Ocean. The Hawaii islands were formed by hotspot. The challenger deep in Mariana trench is the deepest part of Pacific Ocean (10994m).

Bottom relief of Atlantic Ocean

In the North Atlantic Ocean, extensive continental shelves are found around the shores of Newfoundland (Grand bank) and British islands (Dogger Bank). In the South Atlantic Ocean, a very extensive continental shelf is found between Bahia Blanca and Antarctica (Figure 5.10).

The most striking relief feature which is the 'S' shaped Mid–Atlantic ridge which extends for 16,000 km from Iceland in the north to Bouvet Island in the south. The ridge separates the Eurasian Plate and North American Plate in the North Atlantic, and the African Plate from the South American Plate in the South Atlantic. **Iceland** and **Faroe** are the few peaks of the Mid-Atlantic ridge.

The mid-Atlantic ridge divides the Atlantic Ocean into two major basins, i.e., East and West Atlantic basins. Other basins are Spanish basin, north and south Canary basin, Guinea basin, Brazilian basin and Labrador basin. **Puerto Rico Deep** (8,380 m) is the deepest of all deeps in the Atlantic Ocean. Other deeps are **Romanche Deep** and **South Sandwich Trench.**

The West Indies is an island archipelago near the main land of North America. British Isles and Newfoundland are famous islands, formed on the continental shelf in the North Atlantic Ocean. Sandwich island, Georgia Island, Falkland and Shetland islands are islands in the South Atlantic Ocean.

Bottom Relief of the Indian Ocean

The Indian Ocean has continental shelf of varying width. Continental shelf along the coast of Arabian Sea, the Bay of Bengal and Andaman varies in width from 192km to 280km. A variety of coral reefs thrive in the warm tropical water of the Indian Ocean.

Figure 5.10 Bottom relief of Atlantic Ocean

Indian Ocean has a continuous central ridge called the Arabic Indian ridge. Other important ridges include the East Indian ridge, West Australian ridge, South Madagascar ridge**.** Basins of Indian Ocean include Comoro basin, North Australian basin, South Indian basin and the Arab basin (Figure 5.11).

7ZCA4X

The average depth of the Indian Ocean is 3890m. Sunda deep near Java is the deepest part of this ocean (7450m). Madagascar and Sri Lanka are the most prominent islands present in Indian Ocean. Andaman and Nicobar islands in the Bay of Bengal are the raised part of mountains that are the extension of Arakan Yoma which forms a part of Himalayas. Reunion Island is located on a Hot spot.

5.9 Ocean Temperature

The measurement of degree of hotness or coldness of ocean water is referred to as ocean temperature. Temperature is normally measured in the unit of degree Celsius by thermometers. The major source of heat energy for ocean water is the radiation from sun. The heating and cooling capacity of water differs significantly from that of land.

Factors affecting horizontal distribution of ocean temperature

The factors affecting distribution of ocean temperature are latitude, prevailing winds, ocean currents and local weather.

1. Latitude: The temperature of surface water decreases from equator towards the poles because of the slanting rays of the Sun pole ward.

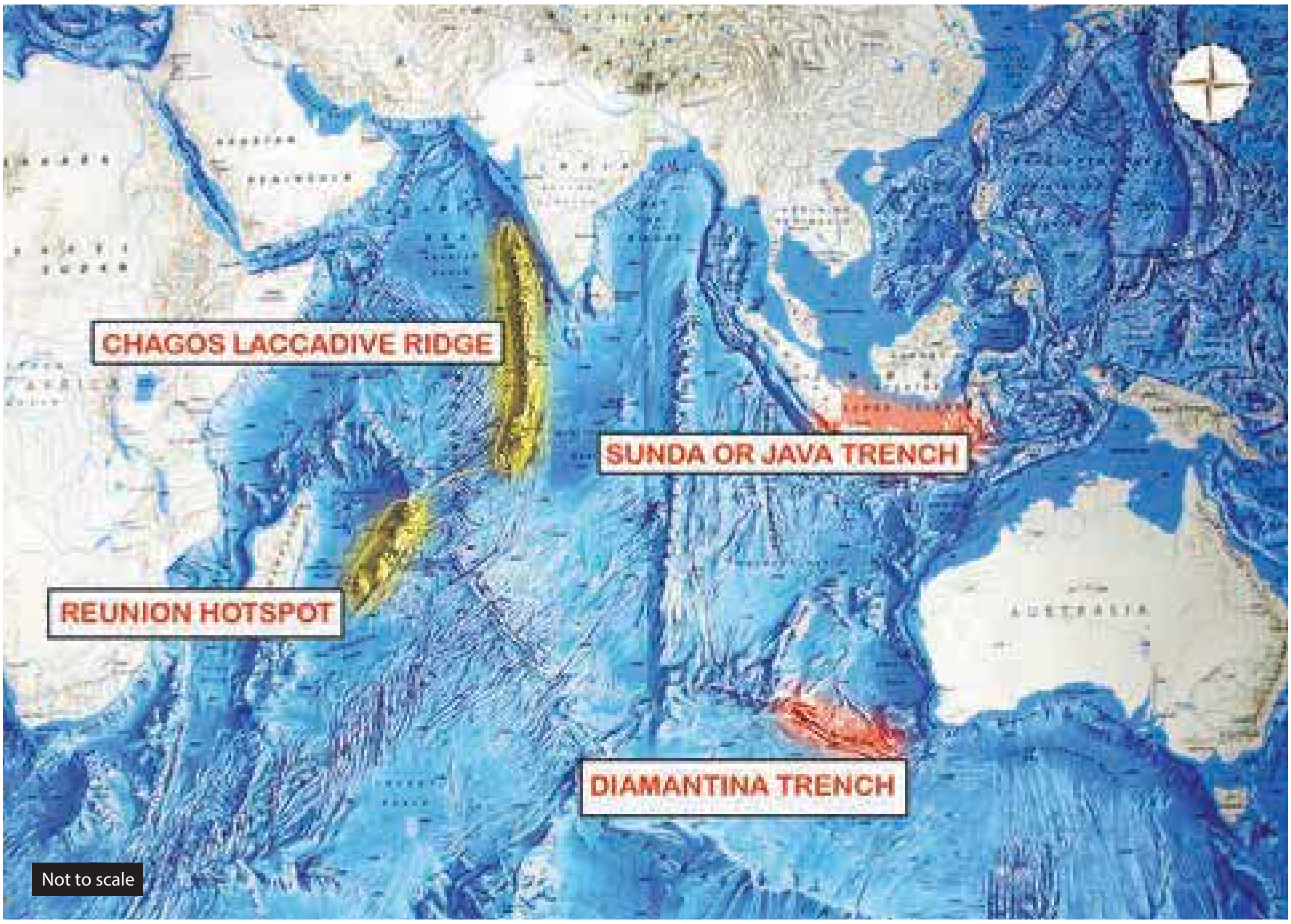


Figure 5.11 Bottom relief of Indian Ocean

2. Prevailing wind: Direction of the wind affects the distribution of temperature of ocean water. The off shore winds blowing from the land towards ocean or sea raise the temperature of ocean water. Winds blowing from snow covered regions in winter lower the surface temperature. In trade wind belt, the off shore winds initiate upwelling of cooler water from beneath and on shore winds pile up warm water to increase the temperature to certain extent.

3. Ocean currents: Warm currents raise the temperature of the oceans where they flow whereas cold currents lower down the temperature. Gulf Stream (warm current) increases the temperature of the eastern part of North America and the west coast of Europe. Labrador cold current reduces the temperature near north eastern coast of North America.

4. Apart from these, some minor factors like submarine ridges, local weather conditions like storms, cyclones, hurricanes, fog, cloudiness, evaporation and condensation also affect the surface temperature of ocean water.

These images show the sea surface temperature in Celsius. The Figure 5.12 shows the sea surface temperature in July and the Figure 5.13 in January. Cold temperatures are shown in purple, moderate temperatures in aquatic green and warm temperatures in yellow to red. Landmass is shown by black colour. The diurnal range and annual range of

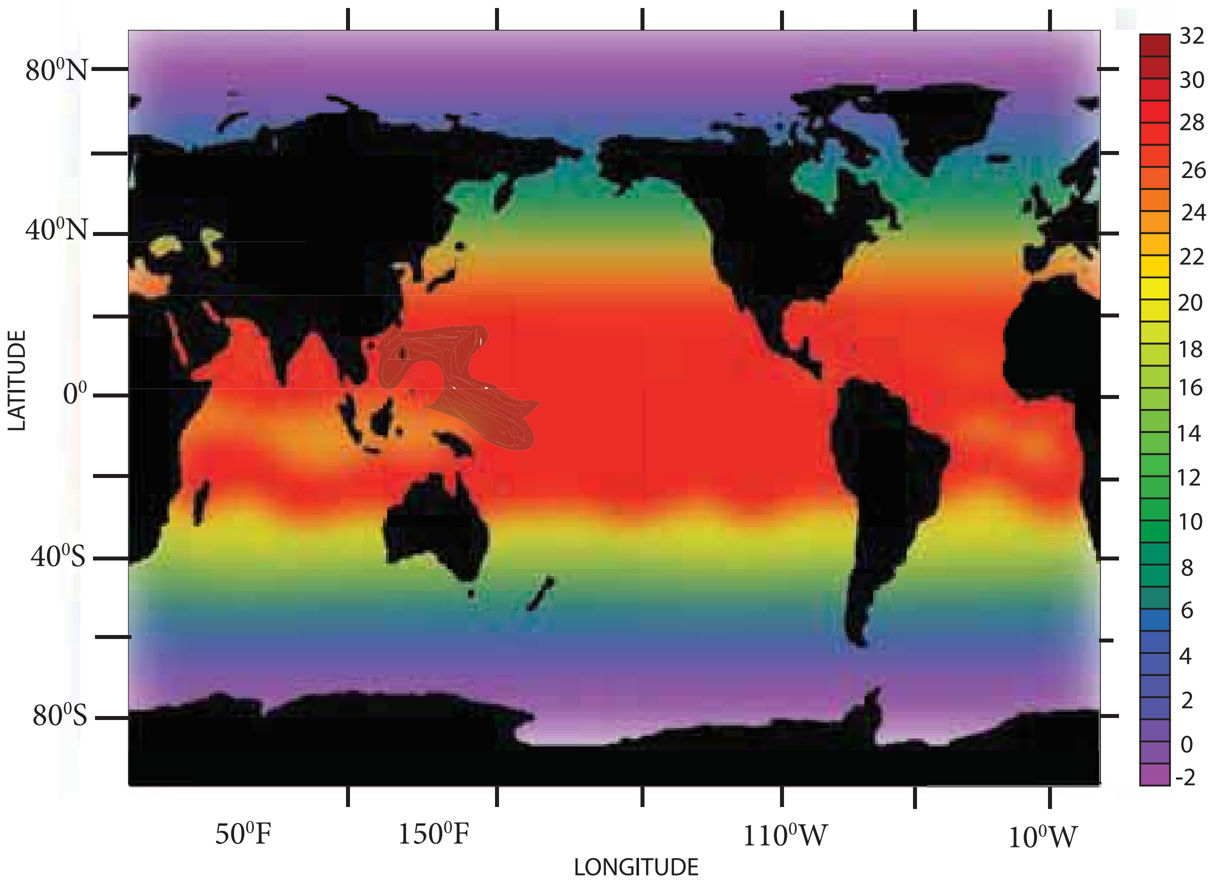
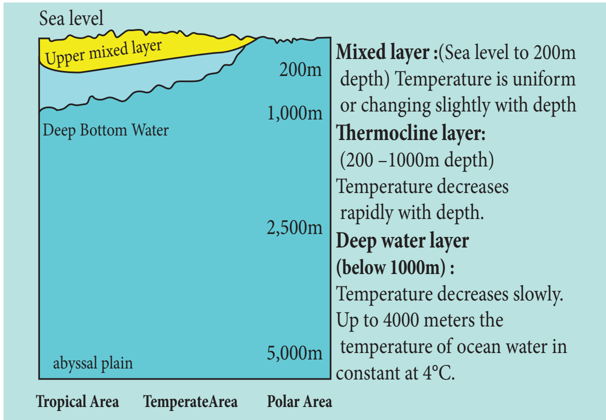


Figure 5.12 Sea surface temperature in July 1997

temperature of ocean is much less than that of the land. The temperature of the sea surface is highest (27°C to 30°C) not near Equator but few degrees north of the Equator. The lowest temperature recorded is -1.9°C near the poles. The maximum and minimum annual temperatures of ocean water are recorded in August and February in the Northern hemisphere and reverse in case of the southern hemisphere.

5.9.2 Vertical distribution of temperature in oceans

The uppermost layer of ocean water is warm and well mixed surface layer with average temperature between 20° and 25°C. The depth of this layer varies according to seasons. On an average this layer extends up to 200 m in tropical region. Beneath this layer lies the thermocline layer. This layer varies in depth between 200 metre to 1000 metre. This layer is unique that the temperature decreases rapidly with increasing depth. Below the thermocline temperature decrease is gradual up to 4000m. Beneath this depth the temperature of ocean water is constant at 4°C (Figure 5.14).



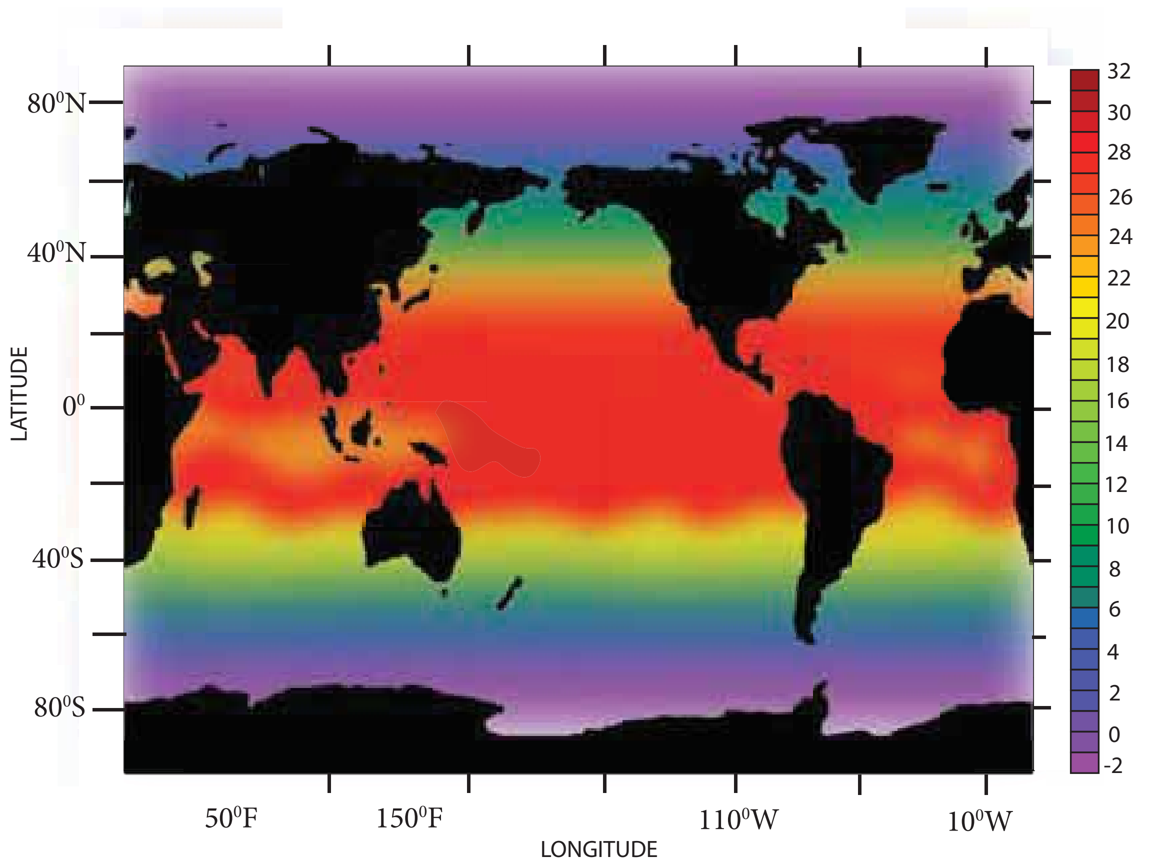


Figure 5.13 Sea surface temperature in January 1997

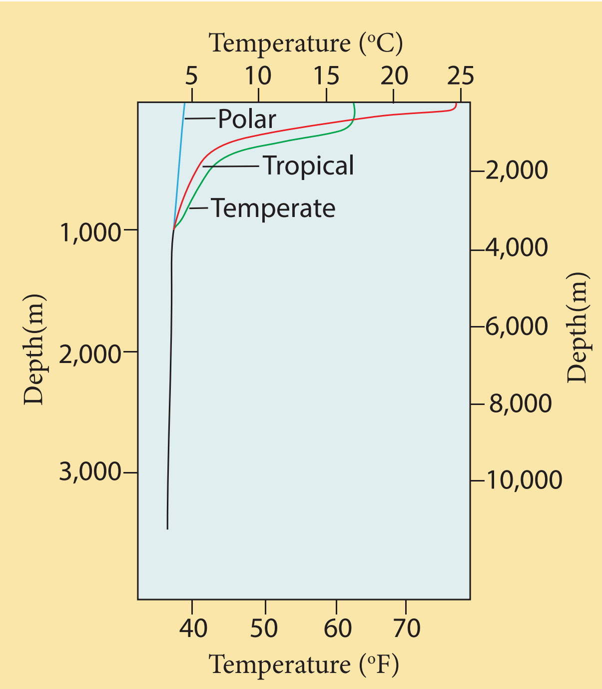


Figure 5.14 Vertical distribution of temprature in Oceans

Brain Storming

Which Ocean we can walk across and why?

5.10. Salinity of the ocean

Salinity is defined as the ratio between the weights of dissolved salts (in grams) per 1000 grams of water. It is expressed as part per thousand (‰) and has no units. Example: 30‰ means 30 grams in 1,000 grams of sea water. The average ocean salinity is 35‰.

Sources of salt in the ocean: Sea water is a weak but complex solution made up of many things including mineral salts and decayed biological marine organisms. Most of the ocean salts are derived from weathering and erosion of the earth's crust by the rivers. Some of the ocean salts have been dissolved from rocks and sediments below the sea floor, while others have escaped from the earth's crust through volcanic vents as solid and gaseous materials.

DO YOU KNOW?

In partially enclosed seas, their bottom relief and the submarine ridges with shallow water do not allow free mixing of open sea water. The temperature at the depth of 1800m in the Red Sea is higher than the temperature recorded at the same depth in the Indian Ocean.

Fact File

Depth of water is measured in the unit 'Fathom'. One fathom is equal to 1.8 metre (six feet)

Factors affecting the salinity of ocean water

The salinity of ocean water depends upon

a) The rate of evaporation

b) Amount of precipitation,

c) Addition of fresh water flow from rivers

d) Ice in Polar Regions

e) Upwelling of deep water initiated by prevailing winds and

f) Mixing of water by ocean currents.

Distribution of salinity

On an average the salinity decreases from equator towards the poles. The highest salinity is observed between 20° and 40° north latitudes because this zone is characterized by high temperature, high evaporation but less rain than the equatorial region.

The marginal areas of the oceans bordering the continents have lower salinity than their interior due to addition of fresh water to the marginal areas through the rivers (Figure 5.15).

Very high salinity is recorded in Lake Von, Turkey (330‰) Dead Sea (238‰) and Great Salt Lake, Utah, USA (220‰).

Raking refers to the use of a rake, a traditional wooden tool with the long handle and long pointed wooden toothed spade at the bottom for collecting salt.

Activity

Identify regions of high salinity and low salinity.

Compare the salinity of Arabian Sea and Bay of Bengal and find the reason for the same.

Find out the reason for low salinity on east coast of Asia and West coast of North America.(Figure 5.15)

Why does the salinity vary along the west coast of South America?

Fact File

Isohaline is an imaginary line drawn to join places having equal salinity.

Salinity of **Dead Sea** is 8.6 times saltier than other oceans. The shore of Dead Sea is 423m below sea level. It has the lowest elevation on land. The sea is 377m deep. The high salt content will make people float on the sea. The high salt content has made the Dead Sea devoid of life in it.

5.11 Ocean movements

Water in the ocean is never in a state of rest. Ocean water is always in motion. It moves horizontally as well as vertically. The movement of ocean water takes place in three different ways as waves, tides and ocean currents.

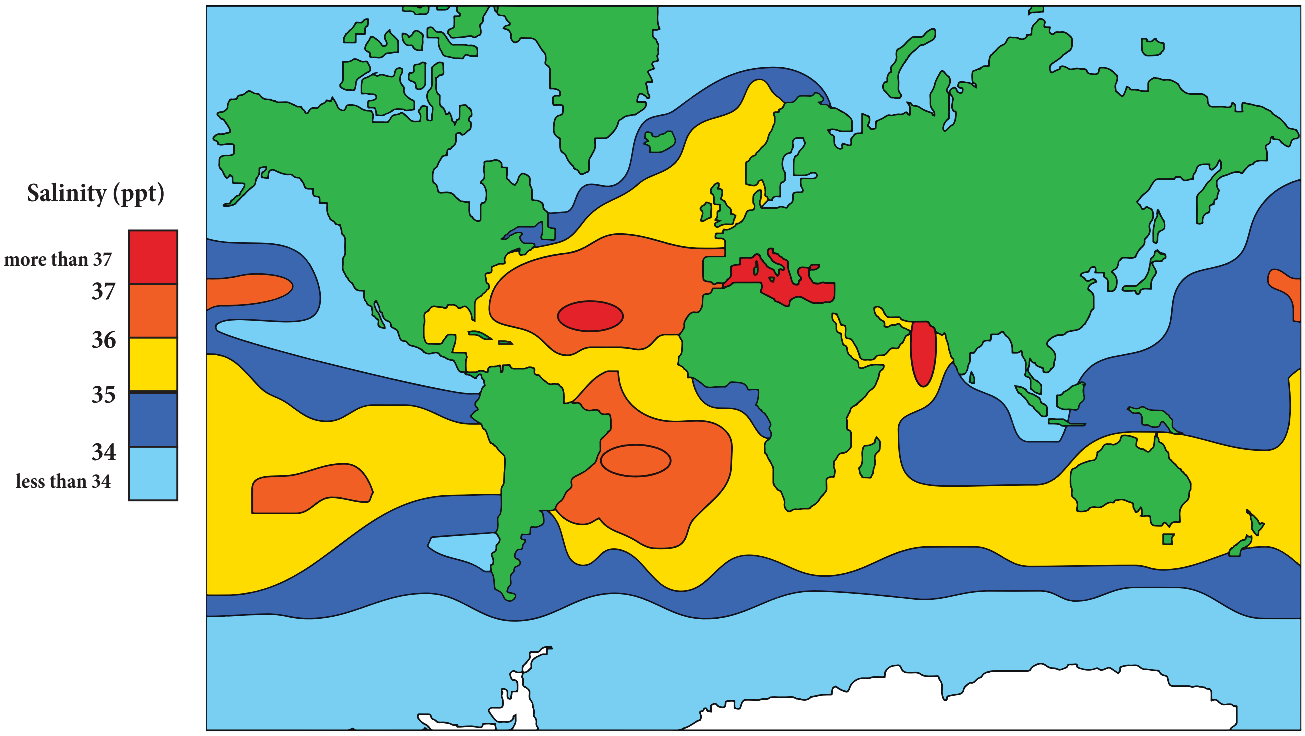


Figure 5.15 Salinity of the Oceans

Waves

The waves are oscillating movements in the ocean water which transfer energy from place to place. They are caused by friction of wind on the surface of water or any other disturbances' on the sea bottom.

Parts of Waves

1. **Crest**: The upper or highest part of a wave is called the crest. (Figure 5.16)
2. **Trough**: The lowest part of a wave is called the trough.
3. **Wave height**: The vertical distance between the crest and the trough is known as wave height.
4. **Wave length**: The horizontal distance between two crests or two troughs is known as wave length.
5. **Wave amplitude**: Wave amplitude is one-half of the wave height.
6. **Fetch**: The distance of open water across which the wind can blow without interruption is called fetch.

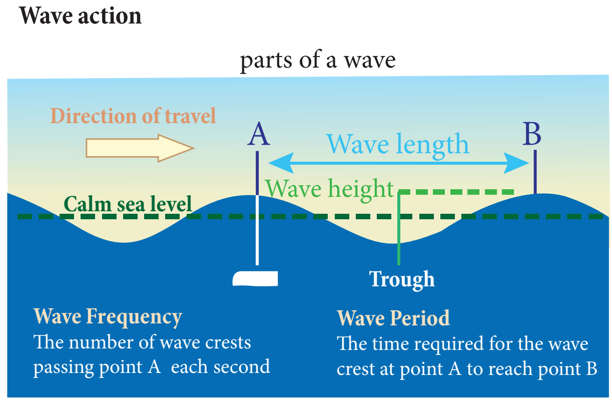


Figure 5.16 Parts of a wave

7. **Frequency**: The number of wavelengths that pass a fixed point per unit of time is frequency. Example, 100 waves per sec per cm.
8. **Period**: The time taken by one wavelength to pass a fixed point is known as period.
9. **Velocity**: Refers to speed and direction.
10. **Steepness**: Steepness of the wave is equal to the height divided by length.(H/L)

Tides

The rhythmic rise and fall of the sea water due to gravitational pull of the moon and the sun is called a Tide. Isaac Newton (1642–1727) was the first person to explain tides scientifically. The rise of seawater towards the land is known as High tide or flow tide. The fall of seawater more towards sea is known as 'Low tide water' or ebb tide. On any day there will be two high tides and two low tides. The highest high tide occurs on full moon day and new moon day. It is known as **spring tide** (Figure 5.17). Spring tide happens when the sun, earth and moon aligned in straight line. The lowest low tide is known as **neap tide**. It happens when the sun, earth and moon are positioned at right angles.

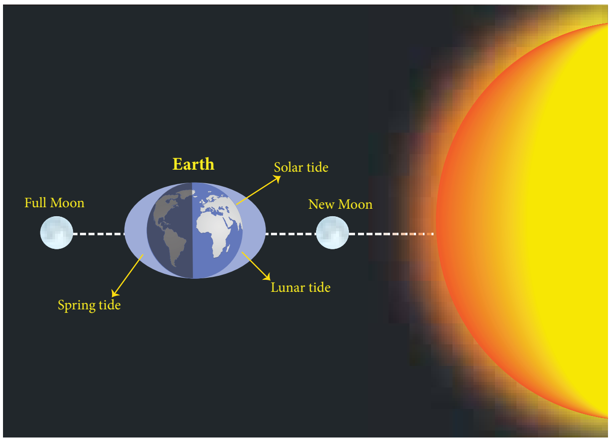


Figure 5.17 Tides

The movement of ocean water as a result of tidal action is known as a tidal current. In places of narrow coastal inlet these tidal currents flow rapidly through the mouth with greater height and velocity. For example in the Bay of Fundy, between Nova Scotia and New Brunswick of Canada, the difference between high and low tides is as high as 14m. Ports which utilize the tidal current for entry and exit of ships from the harbour are known as tidal ports. In India Kolkatta and Kandla are examples of tidal harbours.

HOTS

Why does the **highest Tide** occur when the sun, earth and moon are aligned in a straight line?

The Gulf of Cambay and the Gulf of Kutch in Gujarat on the west coast have the maximum tidal range of 11m and 8m with average tidal range of 6.77m and 5.23m respectively. Tides help to clear the sediments deposited by rivers on their bed and thus prevent siltation of harbours. The energy of the tides is used to generate electricity. Tidal power stations have been set up in UK, Canada, France and Japan. In India Gulf of Khambhat, Gulf of Kutch and Sundarbans have scope for tidal energy production.

Fact File

A harbour is a sheltered water body where ships are anchored. A port is the area at the edge of a water body where boats and ships are docked, where transfer of goods and passengers take place and where trading is facilitated.

Ocean currents

Large mass of moving water from one part of the ocean to another in a definite direction is called as ocean current. The movement is produced due to earth's rotation, temperature difference of ocean water, salinity, density and some extent

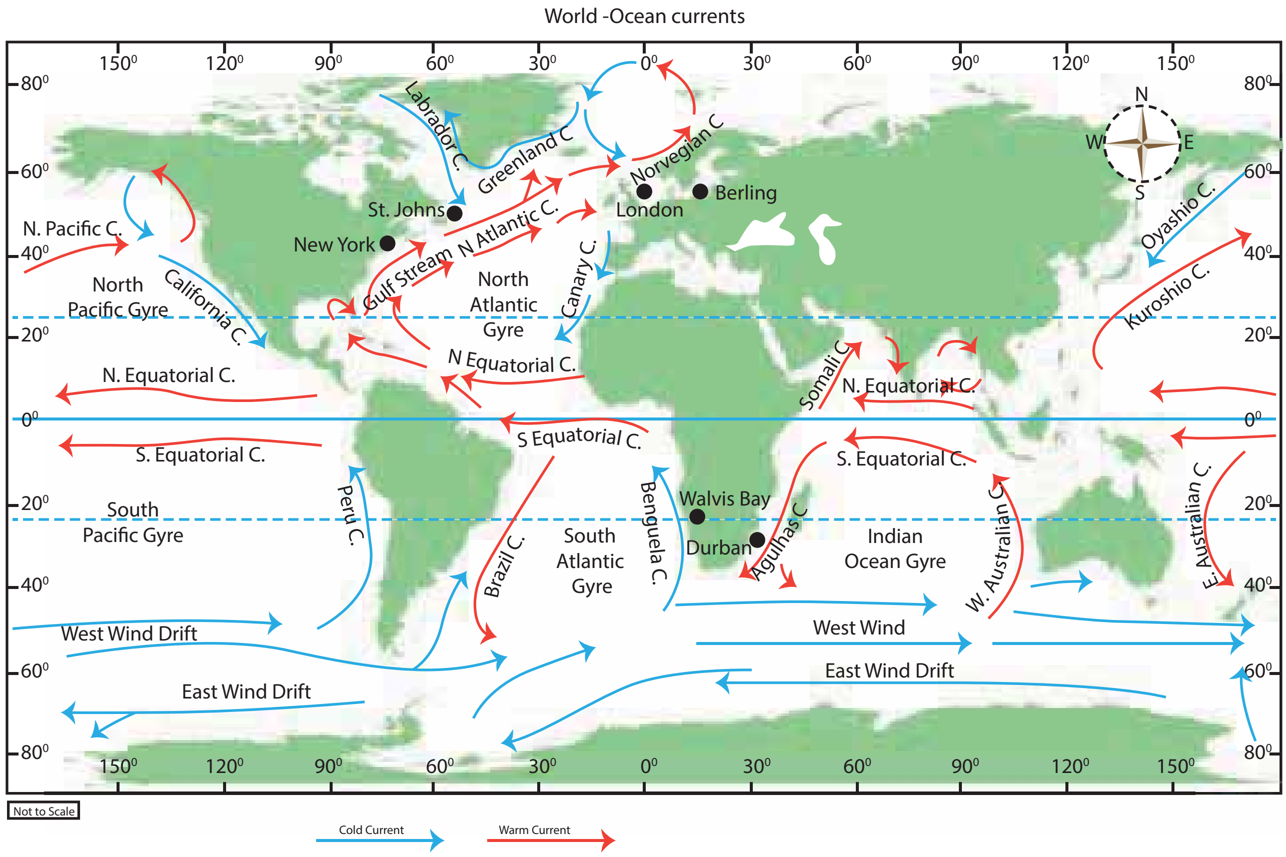


Figure 5.18 World-Ocean currents

due to air pressure and winds. Ocean currents can be classified on the basis of mode of origin, volume and velocity and boundaries.

In the order of velocity ocean currents can be classified as drifts, currents and streams. **Drifts** are movement of surface water of low velocity influenced by prevailing winds, **currents** are movement of oceanic water in definite direction and greater velocity and **streams** are larger mass of water moving in a definite direction and much greater velocity than the drifts and currents. Ocean currents are distinguished by the temperature they possess. When ocean currents originate from equator it is termed as **warm current**. Likewise when a current starts from polar region it is termed as **cold current**.

Vertical circulation of ocean water takes place due to difference in salinity and temperature between the surface and the water deep below. Upwelling is an oceanographic phenomenon that involves movement of dense, cooler, and usually nutrient-rich water towards the ocean surface, replacing the warmer, usually nutrient-depleted surface water. Down welling is the process of accumulation and sinking of cold high saline water beneath warmer or fresher water.

Major ocean currents of the world

In every ocean, there is circulation of ocean water from Equator to pole and from pole to equator. The warm currents from the equator flows over the surface of ocean towards the pole and sink to the bottom of the ocean floor in the higher latitudes due to high density and flow towards the equator to complete the circulation. This large scale circulation is known as **gyre**.

The gyre circulates is clockwise in the northern hemisphere and anti-clockwise in the southern hemisphere.

a) Ocean currents of the Pacific Ocean

1. **North Equatorial current.**

   North equatorial current originates from Revilla Gigedo island west of Mexico and flows towards the Philippines Island covering a distance of about 12,000 km from east west. It is a warm current. It derives from its water from the Californian current and the South east Monsoon drift which flows north along the Mexican coast. The volume of water increases from east to west as many small currents join it from right. It gets divided into two and the northern branch joins the Kuroshio Current and the southern branch abruptly turns and forms the Pacific counter current.

2. **South equatorial current.**

   South equatorial current is originated due the action of the trade winds from east to west. It is a warm current. It extends for about 13,600km from east to west. It is stronger than the North equatorial current. It is further divided into many branches due to the presence of many islands and uneven surface topography.

3. **Kuroshio current (Black Tide)**

   It is a warm ocean current flowing in north easterly direction up to 30° N latitude and it carries warm water off the Formosa coast. It flows towards north and meets Oyashio cold current off the Kuril Islands. It is also called as Japan current.

4. **Oyashio Current(Parental Tide)**

   It originates from the Bering Strait and flows towards south carrying cold water. It is a cold current. It meets with Kuroshio warm current and Aleutian current.

5. **Californian Current.**

   Californian current is flowing towards south along the west coast of U.S.A between 48° N and 23° N latitudes. It is cold current which exhibits great amount of up welled water. When it enters the region of Trade winds, it is deflected to the right and joins the equatorial current.

6. **Peru Current.**

   Peru Current is perhaps the best studied ocean current of the Pacific Ocean. Alexander Von Humboldt in 1802 noted the details of the Peru Current. Hence, it is also known as Humboldt Current. It is a cold current. It is flowing towards north along the west coast of South America carrying cold water from northerly deflection of the Sub-Antarctica water moving in 40° S.

7. **El Nino or Counter current.**

   It is a warm counter ocean current of the pacific equatorial waters flowing south ward at 400 m depth to a distance about 180 km.

8. **West Wind Drift.**

   It is an easterly moving drift in the Pacific Ocean extending from Tasmania to the South American coast. It is a cold current. The speed of the drift is greater under the influence of Roaring Forties. It splits into two branches and one moves south around the Cape Horn into the Atlantic Ocean and the Other one moves northward along the Peruvian coast due to deflection and joins the Peru Current.

b) Currents of the Atlantic Ocean

1. **North equatorial current.**

   North equatorial current is flowing from east to west. It is a warm current. It is situated between 5° – 20° N latitudes. After leaving the west coast of Africa, it attains its main characteristics. When it reaches the east coast of South America, it splits into two branches and one branch called Antilles current is moving along the coast of West Indies and other branch is diverted into the Caribbean sea.

2. **South Equatorial current.**

   It is flowing south of equator within 0° – 12° S latitude in between the coast of Africa and South America. It is a warm current. It is a northern continuation of Benguela current. It is stronger than the North equatorial ocean current. It is caused by the action of Trade winds.

3. **Gulf Stream.**

   Gulf Stream starts from the Gulf of Mexico and carries warm waters into the colder latitudes. It is a warm current. It bends with the coastline up to 40th parallel after which the direction is almost to the east, due to the force and the direction of the westerlies and the deflective force of the earth. It joins the labrador cold current near New Found land, Canada after passing through the strait of Florida. The Gulf Stream was discovered by Ponce de Leon in 1513.

CASE STUDY

The Sargasso Sea – Sea with landless border

The Sargasso Sea occupies about two thirds of the North Atlantic Ocean, stretching seven hundred miles wide and two thousand miles long. The only "sea" with absolutely no land around it, the Sargasso Sea got its name from common brown seaweed called Sargassum that floats in vast mats in its waters. The Sargasso Sea is surrounded only by ocean currents. It lies within the Northern Atlantic Subtropical Gyre. The Gulf Stream establishes the Sargasso Sea's western boundary, while the Sea is further defined to the north by the North Atlantic Current, to the east by the Canary Current, and to the south by the North Atlantic Equatorial Current. Since this area is defined by boundary currents, its borders are dynamic.

S. No.	World's Fishing banks	Confluence of ocean currents
1.	The Grand bank (Atlantic Ocean, Western Europe)	Gulf Stream and Labrador current
2.	The Agulhas bank (Atlantic Ocean, South west Africa)	Benguela cold current and Agulhas warm current
3.	The Dogger bank (Atlantic Ocean, North east of N.A)	North Atlantic drift and canary cold current
4.	The Reed bank (South China Sea, Pacific Ocean)	Kuroshio Warm current and Oyashio Cold Current
5.	The Pedro bank (India Ocean)	South Equatorial warm current and W. Australian cold current

4. **Canaries Current.**

   The ocean current flowing along the Western coast of North Africa between Maderia and Cape verde is known as the Canaries Current. It is a cold current. It is flowing towards south and merging with the North equatorial current.

5. **Labrador Current.**

   In the north Atlantic, a cold current flows from the Baffin Bay and Davis Strait towards south. It brings cold waters from polar zone and moves along the coast of green land.

6. **Benguela current.**

   It is a cold current flowing northward along the western coast of Africa is known as the Benguela current. It carries cold waters from sub-Antarctica surface water and mixes with south equatorial current.

C) Currents of the Indian Ocean

The south Indian gyre is formed by south equatorial current, Madagascar current west wind drift and west Australian current. To the north of equator the currents in the Arabian Sea and Bay of Bengal flow in the clockwise direction as southwest monsoon drift and in the anti-clockwise direction as northeast monsoon drift due to the influence of monsoon winds.

The Antarctic circumpolar current flows between 40 to 60° S latitude. It flows from west to east influenced by the westerly and circles around entire Antarctica. There is a counter west ward current within this circum polar current.

d) Currents of the Southern ocean

The southern ocean surrounds the continent of Antarctica. The large oceans, the pacific, the Atlantic and the Indian Ocean merge into this circum-global zone of water to their south. The movement of water in the southern ocean is in one sense a relatively simple, generally west-east circum-polar drift caused under the influence of northwesterly winds. This general flow sends offshoots to the three major oceans to its north. The Peru or Humboldt Current in the Pacific Ocean, the Falkland Current and the Benguela Current in the Atlantic Ocean and the West Australian Current in the

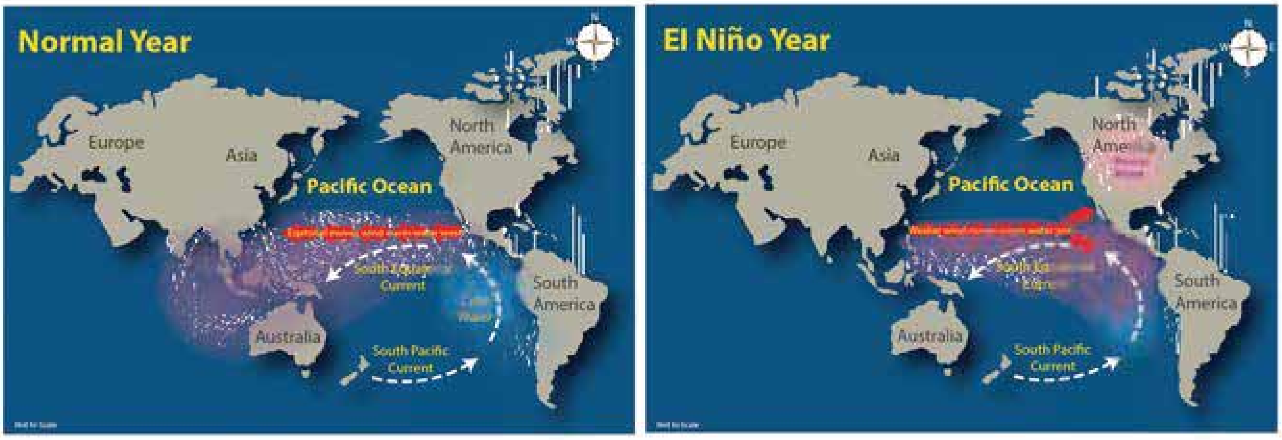


Figure 5.19 Wind circulation during Normal and El Nino Conditions

Indian Ocean receive a part of their cold waters from the Southern Ocean. Besides the surface currents, there is also a very complex system of sub-surface currents between the southern Ocean and the oceans to its north.

Generally the water moves from this ocean towards the equator on the surface and at great depths but at in remediate depth, there is a movement of water from the equatorial areas towards the Southern Ocean.

The significance of Ocean Currents

1. Ocean currents play an important role in the earth's climate. They distribute energy and nutrients within the ocean.
2. Fog is formed where warm current and cold current meet. For example, when the Gulf Stream and Labrador Current meet near New Found land one of the densest fogs is formed.
3. The warm ocean current increases the temperature of an area where it flows to and Cold Ocean current decreases the temperature of the area.
4. The warm current brings heavy rainfall when the wind blows over it becomes warm while the cold current brings drought when the wind blows over it becomes cold and dry. For example, the wind blowing over the Peru Current is cold and dry causing the formation of the Atacama Desert located on the west coast of Peru.
5. It regulates the global temperature. It gives free navigation. The Gulf Stream keeps ports & harbours of Russia and Scandinavia navigable throughout the year. The Kuroshio Current makes ports on Japan navigable during winter.
6. It distributes minerals and pollution added to it becomes highly diluted and later negligible.
7. It helps in growth of juveniles of certain fish and its distribution to other countries - from its place of origin. Some up welling and down welling are due to currents which bring minerals to photic zone used by phytoplankton. Major fishing grounds are located in the zones where cold current and warm current meet.

Normal Situation	El Nino Situation
➢ Near equator the water of the Pacific Ocean is warmer in the western side and cooler in the eastern side due to upwelling of the cold current. ➢ Air (Walker) circulation is dominant in the western Pacific Ocean. The air ascends in the western side and descends over the cooler eastern side ➢ Heavy rain is experienced in the western warmer region and dry conditions prevail in the cooler region. ➢ The Southeast Asia and Australia receive heavy rain on normal years. ➢ West coast of South America experiences dry weather.	➢ Near equator the warm water in the Pacific Ocean extends from western side to eastern side suppressing the ➢ upwelling of the cold water. ➢ Air (Walker) circulation is dominant in the eastern part of Pacific Ocean. The air ascends in the warm eastern Pacific Ocean. ➢ Heavy rain is experienced in the eastern warmer region and dry condition prevails in the western part. ➢ Southeast Asia and Australia experience dry weather conditions. ➢ West coast of South America receives heavy rainfall.

El Nino

El Nino is a phenomenon that occurs in the equatorial Pacific Ocean characterized by a positive sea surface temperature departure from normal (1971-2000 base period) in the region lying within the latitude 5°N to 5°S and longitudes 120° W to 170°W . This phenomenon occurs every two to seven years (Figure 5.19).

El Nino happens when

- Sea surface temperature increases between the central and eastern equatorial Pacific Ocean between the country Ecuador and the International Date Line
- The increase in temperature is sustained for a period of eighteen months to Two years.
- The temperature increase is up to 30 m beneath the ocean surface.
- When there is a modified vertical air circulation above the Pacific Ocean

Global influence of El Nino

El Nino effect is experienced at Global level. The change in air circulation affects the economy of different countries also. Global weather patterns are altered to such an extent that they affect eco system, agriculture, tropical cyclone, drought, forest fire, floods and flood related health hazards. El Nino influences the jet streams. Due to this phenomenon California experiences heavy rainfall, northern Europe experiences dry winter, Southern Europe experiences mild wet winters, there are less number of cyclones in Sea of Japan, and heavy rain in East Africa. South East Asia experiences severe drought and forest fire. Peru in South America receives heavy rainfall during El Nino.

Increase of temperature in the east Pacific Ocean is correlated with normal monsoon conditions in India while the increase of temperature in the central Pacific has high correlation with drought conditions in India. When temperature increases further to the west it suppresses the Indian Monsoon.

DO YOU KNOW?

International Research Institute Climate Prediction Centre predicts and forecasts El Nino occurrences. Scientists are in the opinion that El Nino can cause Global Warming and it also increases the frequency of El Nino occurrence.

La Nina

La Nina is just the opposite to the condition of El Nino. When trade winds are strong, colder water up wells on the East Pacific Ocean, walker air circulation is confined to the west Pacific, wet condition in Southeast Asia and dry weather in South America is observed.

The difference in the atmospheric pressure between the west and east tropical Southern Pacific Ocean is referred to as Southern Oscillation. Meteorologists have established a close inter link between Southern Oscillation and occurrences of El Nino and La Nina events. The acronym **'ENSO'(El Nino Southern Oscillation)** is often used to study both the phenomena.

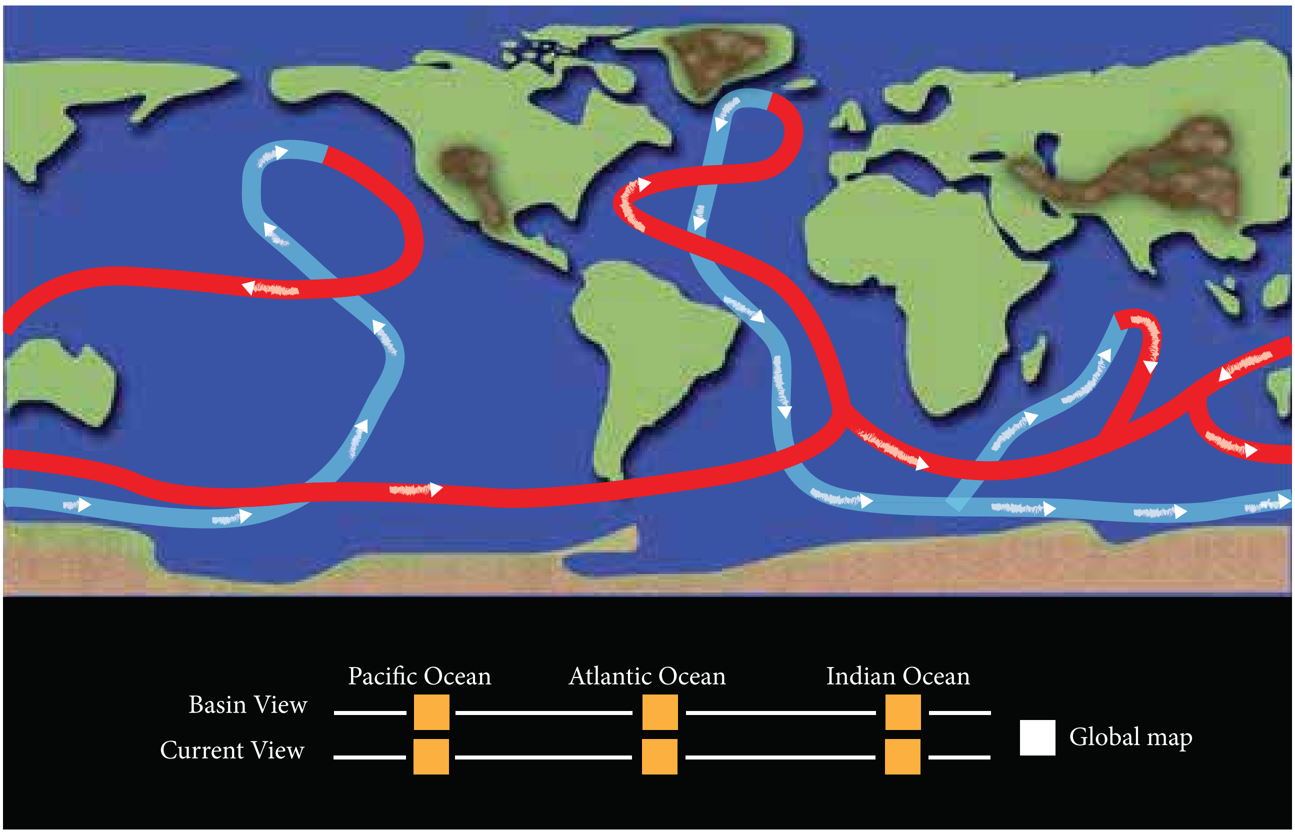


Figure 5.20 Thermohaline circulation

Fact File

Peruvian fishermen named the weather phenomenon El Nino meaning 'little boy' or 'New born Christ' and La Nina meaning 'Little girl' as the phenomenon was first noticed during Christmas time.

5.12 Thermohaline circulation

As the name indicates there is a large scale churning of ocean water due to difference in temperature and salinity. The down welling of ocean water occurs in the extreme ends of Atlantic Ocean one near the Norwegian coast and another at Weddell Sea. Upwelling of cold water occurs in the North Pacific Ocean and in the Indian Ocean. This cycle of water movement within the Global Ocean is also known as **Conveyor Belt** (Figure 5.20). The slow, steady and three dimensional flow of water in the conveyor belt distributes dissolved gases and solids, mixes nutrients and carries it to various ocean basins. This cycle provides a stabilizing effect on climate of the earth. If it is disturbed, it is capable of causing sudden climatic change within the period of a few decades. The conveyor belt is a simplified version of actual circulation in the oceans.

Glossary

Abyssal plains: An extremely large, flat, under water plain on the deep ocean floor.

Continental rise: is area between the continental slope and the sea floor.

Exclusive Economic Zone (EEZ): extends from the base line to a maximum of 200 nautical miles (370.4 km).

Isthmus: A narrow steep of land that connects two large land masses and separates two bodies of water.

Hot spot: An area is the mantle from where rocks melt and magma rises through circular to form volcano.

Permafrost: is the condition prevailing when water freezes above and below the ground, (including rock or soil) for more than two consecutive years

Trace elements: A chemical element present in minute amount in a particular sample or environment.

Isohaline: is an imaginary line drawn to join places having equal salinity

Swell: is a type of wind-generated waves that is not affected by the local wind.

Thermohaline circulation: is large circulation of ocean water due to difference in temperature and salinity.

Evaluation

7ZV288

I. Choose the correct answer

1. River Ganga has its source from ——
   a. Gangothri glacier b. a spring
   c. a laked d. a waterfall
2. The permeable rocks that can hold water and allow water to pass through them are called ——.
   a. Groundwater b. Saturated zone
   c. Rock d. Aquifers
3. An —— is ice floating in open water that has broken off from glaciers or ice shelf.
   a. Ice shelf b. Ice quake
   c. Iceberg d. Sea ice
4. The ——Ocean is the youngest ocean.
   a. Indian b. Southern
   c. Arctic d. Atlantic
5. Mid oceanic ridges are located on the —— plate boundaries
   a. Divergent b. Convergent
   c. Transform d. Subducted
6. The temperature of the sea surface is highest not near Equator but few degrees —— of the Equator
   a. South b. South east
   c. Northeast d. North
7. ——— waves transmit energy in all three states of matter
   a. Transverse b. Longitudinal
   c. Orbital d. Primary
8. Tides are caused by ———
   a. Rotation of earth
   b. Gravitational pull of moon and sun
   c. Planetary winds
   d. Revolution of earth
9. ——— is a warm current
   a. Labrador b. Gulf stream
   c. Oyashio d. Circum polar drift
10. The only sea surrounded by water all sides is ————————
    a. The Dead Sea
    b. The Sargasso Sea
    c. The South China Sea
    d. The Aral Sea

II. Very short answer

1. Define Permafrost.
2. Differentiate High Tide from Low Tide.
3. Define Contiguous Zone.
4. Why is the Dead Sea called so?
5. How is a tide different from an ocean current?

III. Short answer

1. Write a short note on Exclusive Economic Zone.
2. Distinguish between sea mounts and guyots.
3. Write briefly about the Abyssal plain.
4. List the factors affecting salinity of a place.
5. Write about the significance of ocean currents.

IV. Detailed answer

1. Describe the relief of the ocean with diagram.

2. Explain the factors affecting the horizontal distribution of ocean temperature.

3. Draw the ocean currents of North Atlantic Ocean and bring out their influence on climate in North America and Europe.

4. Describe El Nino and its influence on climate.

V. Practice

1. Prepare a diorama of the relief of ocean using available materials and present it in the class.

2. Prepare a working model of warm and cold currents of the world and present it in the class.

3. Make a model of relief of the Indian Ocean and explain to the class.

References

1. Oceanography S. Lal

2. Oceanography for Geographers, R.C. Sharma and M.Vatal

3. Oceanography Savindra Singh

4. Oceanography Tamil version Subbiah

Internet Resources

http://esminfo.prenhall.com/science/geoanimations/animations/26_NinoNina.html

https://en.wikipedia.org/wiki/Southern_Ocean

https://oceanservice.noaa.gov/education/kits/currents/06conveyor2.html

https://www.youtube.com/watch?v=q65O3qA0-n4

https://www.youtube.com/watch?v=IVnkfvqwDcM

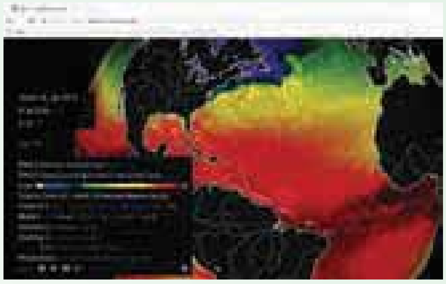
http://india-wris.nrsc.gov.in/wris.html

https://en.wikipedia.org/wiki/Southern_Ocean.

ICT CORNER

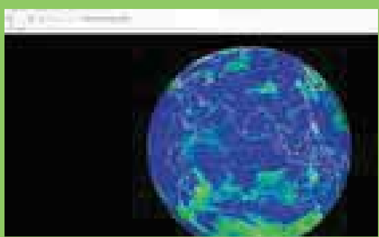
Ocean Currents Streams and Storms

Observe global Ocean currents and sea surface temperature anomaly.

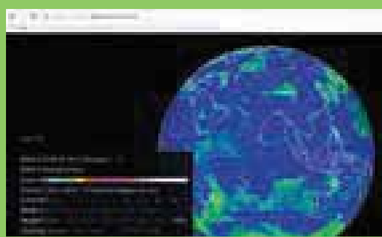


Steps

- Use the URL to reach ocean current page.
- Click 'earth' option from the left bottom side of the page. Click 'Play' button to start and stop the animation. Use 'Control' menu to change the date.
- Select 'Ocean' from 'Mode' menu and toggle between 'Currents' and 'Wave' menu from 'Animate' option to observe the global ocean currents.
- Select 'Currents' and 'SST' or 'SSTA' options from 'Overlay' menu to observe temperature anomaly. Roll the globe and zoom in and out to view the animation.



Step 1



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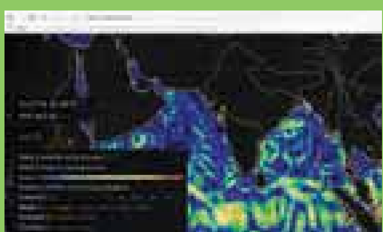
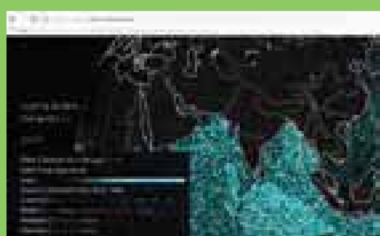


Step 3



Step 4

Website URL:

https://earth.nullschool.net/

*Pictures are indicative only.

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Unit VI

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Atmosphere

Chapter Outline

6.1 Introduction
6.2 Composition of the Atmosphere
6.3 Temperature and Heat Budget
6.4 Atmospheric Pressure and Winds
6.5 Humidity, Condensation and Clouds
6.6 Air Masses and Fronts
6.7 Precipitation
6.8 Atmospheric Disturbances (Cyclone and Anti Cyclone)

Learning Objectives:

Students must be able to

- *Understand the composition and nature of atmospheric layers.*
- *Understand the vertical and horizontal distribution of temperature in the atmosphere.*
- *Explain the mechanism of formation of various wind systems of the world.*
- *Identify various forms and types of precipitation.*

6.1 Introduction

You must have heard people, in the countryside, saying

> "*When sheep collect and huddle,*
> *Tomorrow will puddle!*"
> "*If ants march in a straight line,*
> *expect rain*"

Phrases like 'a cold morning', 'sunny day', 'cloudy day' and rainy day refer to the weather. Weather refers to the state of atmosphere at a particular place at any given time denoting the short term variations of atmosphere in terms of temperature, pressure, wind, moisture, cloudiness, precipitation and other elements. Weather is highly variable from time to time, day to day and place to place. Weather is not constant. It is always changing within hours or a day.

On the other hand, climate is the average weather conditions of an area for a long period of time. The World Meteorological Organisation (WMO) has suggested data for a period of 30 consecutive years to be referred for calculating the climatic averages of various weather elements. Climate is constant. It is a permanent condition of a place.

The ancient Greeks called the tilt of latitude as '***klima***', literally meaning 'slope' or 'inclination'. Then the earth was divided into seven latitudinal regions, called '***klimata***'. The word came into modern European languages as clime or 'climate', denoting the average weather condition.

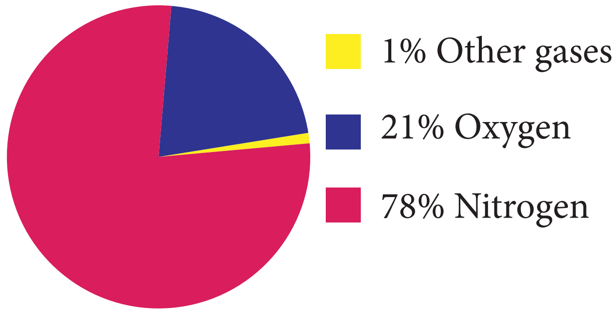


Figure 6.1 Components of Atmosphere

6.2 Composition of the Atmosphere

The atmosphere is essential for the survival of all the organisms on the earth. The atmosphere is a blanket of gases and suspended particles that entirely envelope the earth. It extends outward over thousands of kilometres from the earth's surface. Water vapour, aerosols and tiny solid particles occur in varying quantities as suspended material. These are responsible for weather phenomena as they have ability to absorb and release heat energy.

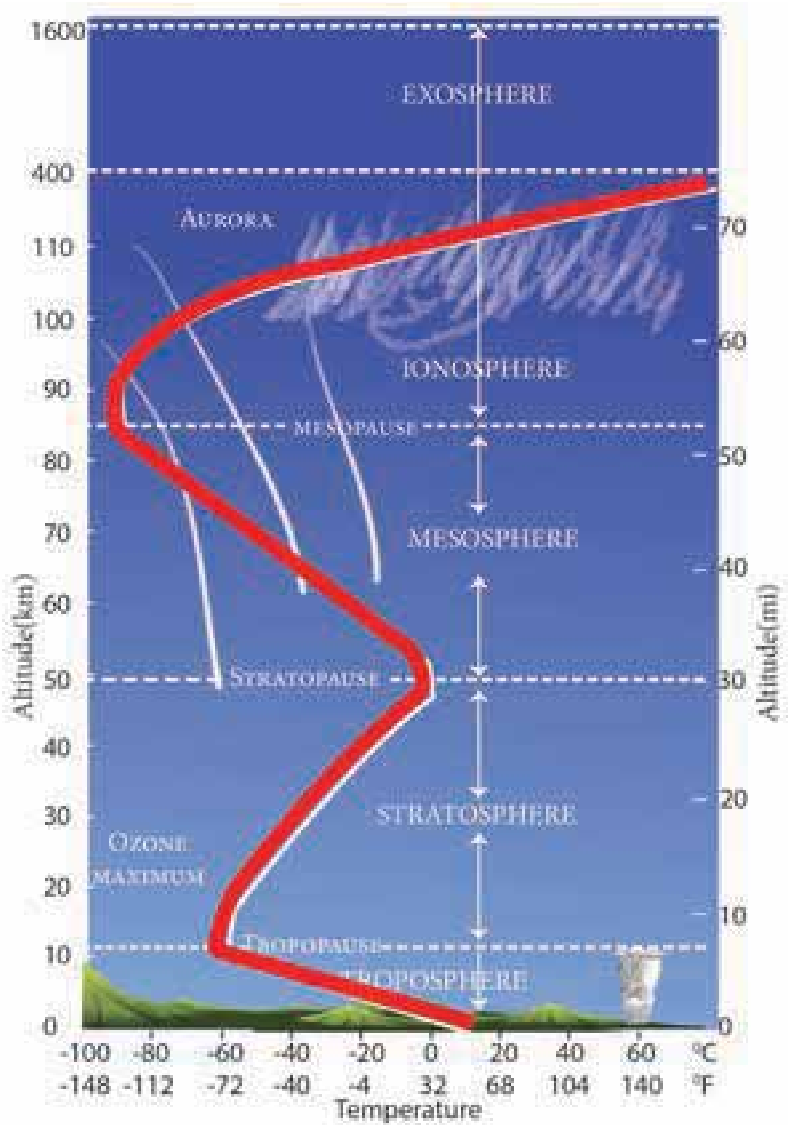


Figure 6.2 Structure of the Atmosphere

The atmosphere is composed of mixture of many gases, water vapour and other solid particles. The major components are nitrogen (78%), oxygen (21%) and other gases (1%). Argon, Carbon dioxide, Neon and the other gases found in the atmosphere (Figure 6.1).

6.2.1 Layers of the Atmosphere

The atmosphere is divided into five distinct layers (Figure.6.2) based on the temperature variations. They are,

1. Troposphere
2. Stratosphere
3. Mesosphere
4. Ionosphere(Thermosphere) and
5. Exosphere

Troposphere

The troposphere(Figure 6.2) is the lower most layer of the atmosphere. It extends approximately to a height of 8 km from the poles and 18 km from the equator. The height of the troposphere changes seasonally also. It increases during summer and decreases during winter.

All weather phenomena occur in this layer as it has dust particles and water vapour. This layer has clouds which produce precipitation on the earth. The Sun's rays directly fall on the earth and then they are reflected back into the atmosphere. The temperature decreases in the troposphere with increase in altitude at the rate of 1 °C for 165 metre or 6.5 °C for every 1000 metres of ascent. This is known as **lapse rate of temperature**. This is the densest layer as it contains 70 to 80 percent of gases. The outer boundary of the troposphere is called tropopause, which is about 1.5 kilmeter thick.

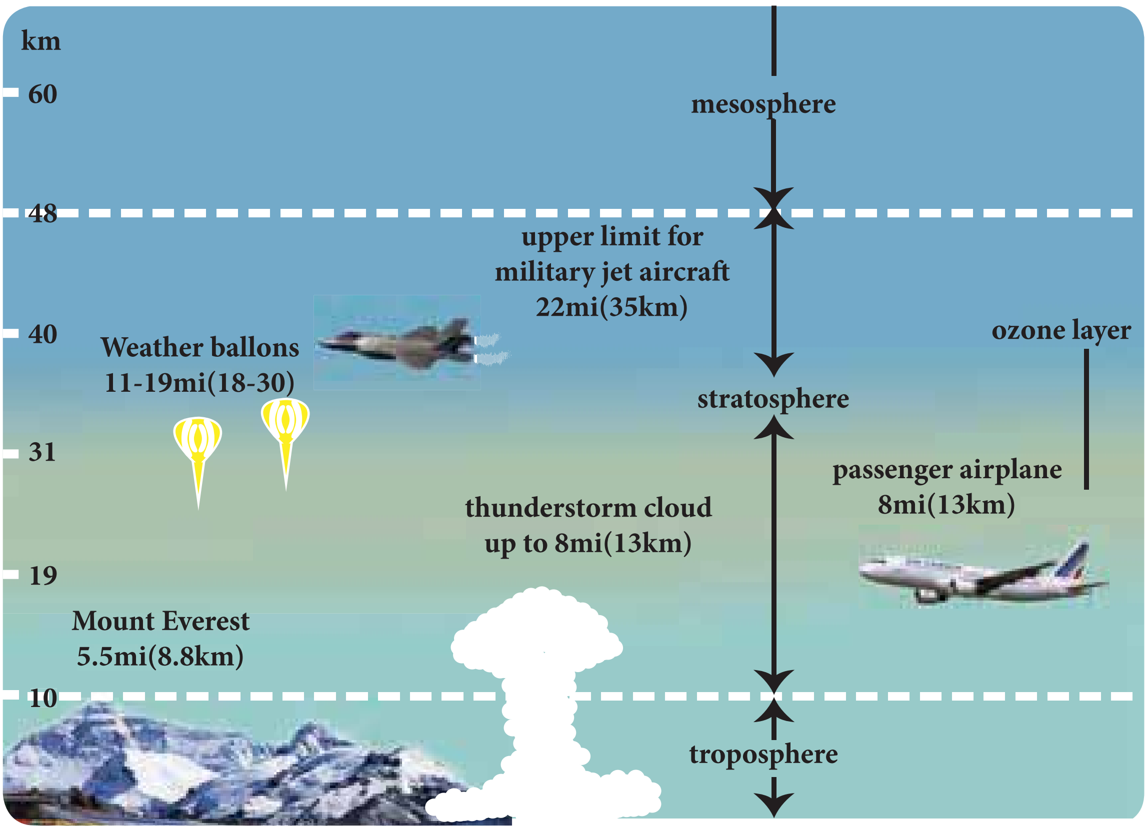


Figure 6.3 Stratosphere

Stratosphere

It is the second layer of the atmosphere found above the troposphere. It approximately extends up to a height of 50 km from the earth's surface. Temperature is constant up to a height of 20 km and increases gradually up to the stratopause where temperature is nearly -4°C. The lower part of this layer is highly concentrated with ozone gas which is called as '**ozonosphere**'. It prevents the ultra-violet rays from the Sun to enter into the lower part of the atmosphere as the rays are highly harmful it causes skin cancer and other ill effects to living organisms. But the ozone layer safeguards the life on the earth.

Mesosphere

The mesosphere is the third layer of the atmosphere found approximately up to a height of 85 km above the surface of the earth. It is the coldest layer of the atmosphere. The temperature decreases with increase of altitude due to the absence of ozone. Its upper boundary is called **mesopause** where temperature reaches −90°C. Luminous noctilucent clouds form here due to the presence of cosmic dust. Meteors falling from the space get burned in this layer. It is because when meteors hit the air, the air gets compressed and heated up causing meteors to burn out.

HOTS

Why is Mesosphere the coldest layer?

Ionosphere (Thermosphere)

The ionosphere is the fourth layer of the atmosphere extending approximately up to a height of 400 km. The temperature increases rapidly up to 1,000°C. It is due to the absorption of very short wave and high energy solar radiation by the atoms of hydrogen and oxygen gases. When light energy is transformed into heat energy, some gas molecules lose or gain electrons and become the charged particles called ions. The charged particles forming the lower part of the thermosphere as a zone, is called Ionosphere (Figure 6.4). These ionised particles create auroras at higher latitudes. Ionosphere can reflect radio waves back to the earth. This facilitates long distance wireless satellite communication. The credit of discovering ionosphere goes to Hennelly and Heaviside.

Exosphere

The upper most layer of the atmosphere which extends into the outer space from above 400 km up to 1600km. It has rarefied contents. It contains mainly oxygen and hydrogen atoms. These atoms can travel hundreds of kilometres without colliding with one another. Thus, the exosphere has no longer behaves like a gas. The temperature increases with increase of altitude and it ranges as high as 1650 °C. The gravitational pull is minimal in this layer. This layer gradually merges with the space.

Ozone and Ozone Depletion

Ozone (O^3) is form of oxygen that combines three atoms into each molecule. It absorbs and filters the harmful ultraviolet B radiation coming from the sun. This way the ozone layer protects all life on earth. However, ozone is harmful when it develops near the ground. It causes health problems like asthma and other respiratory illness.

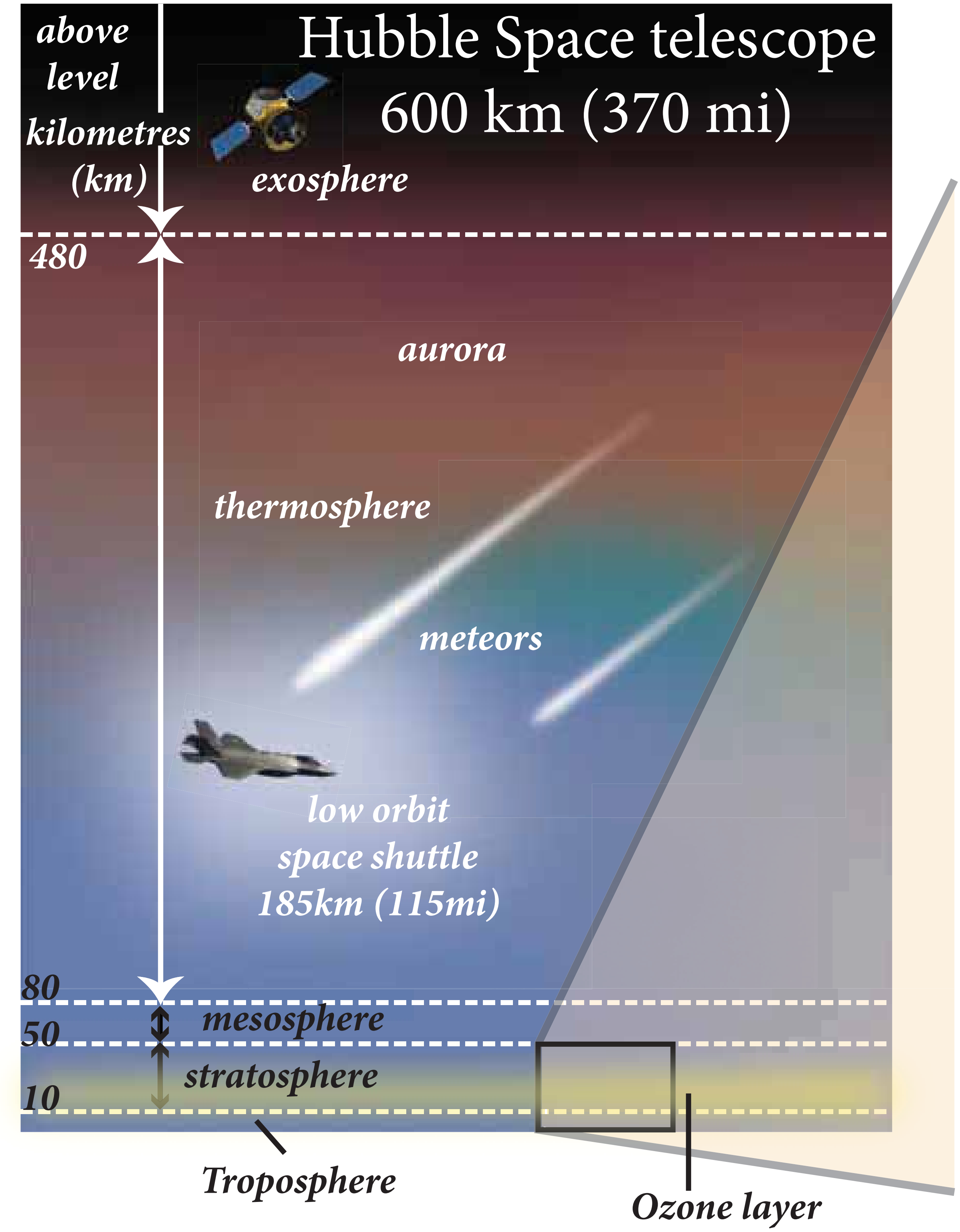


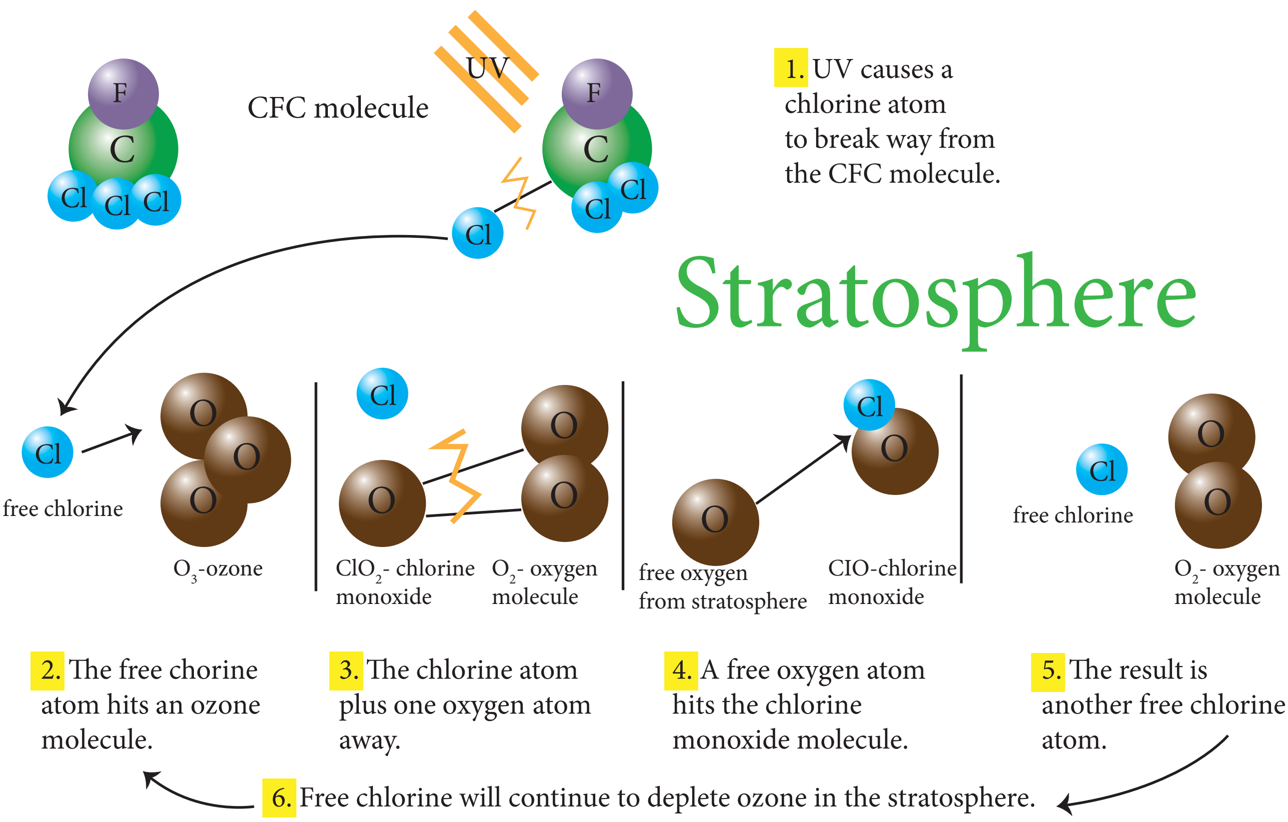
Figure 6.4 Thermosphere

Ozone Depletion: A steady decline in the concentration of **ozone** in the earth's stratosphere (the **ozone layer**) is called ozone depletion.

Ozone depletion occurs when chloro fluoro carbon (CFC) and halon gases, formerly found in aerosol spray cans and refrigerants are released into the atmosphere and they cause chemical reactions that break down **ozone** molecules and reduce the concentration of them. Nitrogen oxide released by emitted by supersonic aircrafts can also destroy the ozone molecules to break down. Ozone-depleting substances are present throughout the stratospheric ozone layer because they are transported great distances by atmospheric air motions. The severe depletion of the Antarctic ozone layer known as the "ozone hole" occurs because of the special atmospheric and chemical conditions that exist there and nowhere else on the globe. The very low winter temperatures in the Antarctic stratosphere cause polar stratospheric clouds (PSCs) to form. Special reactions that occur on PSCs, combined with the relative isolation of polar stratospheric air, allow chlorine and bromine reactions to produce the ozone hole in Antarctic springtime.

Satellite images of the earth over last decades observed that the atmospheric ozone layer is getting thinner. On October 2, 2015, the ozone hole was recorded to its maximum size of **28.2 million sq.km** over Antarctica (Figure 6.5). The size of the ozone hole is larger than the size of continent of North America. The ozone holes over Antarctica allow the ultraviolet radiation to enter and cause global warming, skin cancer, eye cataract and even blindness.

Depletion of the **ozone layer** has consequences on human, animal, plants and micro organisms. This typically results from higher UV levels reaching us on earth. Research confirms that high levels of UV rays cause non-melanoma skin cancer.



To protect the ozone layer for our future generation, avoid using products which are emitting pollutants such as aerosol sprays, blowing agents for foams and packing materials, as solvents and as refrigerants.

> **DO YOU KNOW?** The Dobson Unit (DU) is the unit of measurement for total ozone.

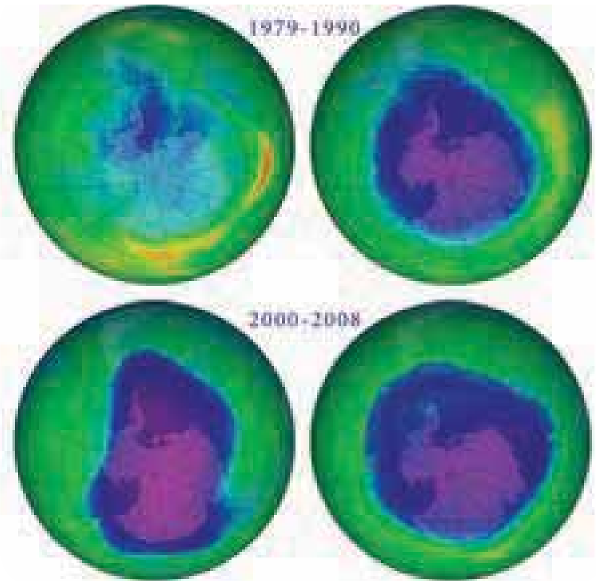


Figure 6.5 Spread of Ozone hole

6.3 Temperature and Heat Budget

Air temperature of a particular place denotes the degree of hotness or coldness of air at a given place. It is measured in Celsius. Let us understand how the earth is heated. The surface of the earth is heated by the sun's rays in the form of short wave radiation. The heat received by the earth is called 'Solar Radiation' or 'Insolation'. Heating of atmosphere is an indirect process. The processes are:

a. Terrestrial radiation

The solar radiation reflected by the earth's surface is called 'Terrestrial radiation'. Terrestrial radiation supplies more heat energy to the atmosphere due to its long wave length.

b. Conduction

The heat energy from the earth's surface is transferred to the lower atmosphere which is directly in contact with the surface by the process of conduction.

c. Convection and advection

The movement of air molecules in vertical and horizontal direction is called as 'convection and advection' respectively. This movement carries heat energy to the various parts of the earth and at different altitudes.

Heat budget

The heat energy reflected, absorbed and radiated back into the space equals the energy received by the earth. Incoming radiation and the outgoing radiation pass through the atmosphere. The earth maintains its optimum temperature.

When 100% solar radiation reaches the earth's atmosphere, 35% is reflected back to space by clouds, water bodies and ice covered areas. This heat does not heat either the earth or atmosphere.

Of the remaining 65% of heat, 14% are absorbed by the atmosphere and 51% are absorbed by the earth's surface (34% of direct solar radiation and 17% from scattered radiation). 51% received by the earth are radiated back to the space directly as terrestrial radiation (Figure 6.6).

In total, 17% are radiated to space directly and 48% are absorbed by the atmosphere (14% from insolation and 34% from terrestrial radiation) are radiated back to space gradually. Therefore, 65% heat received from the sun is balanced

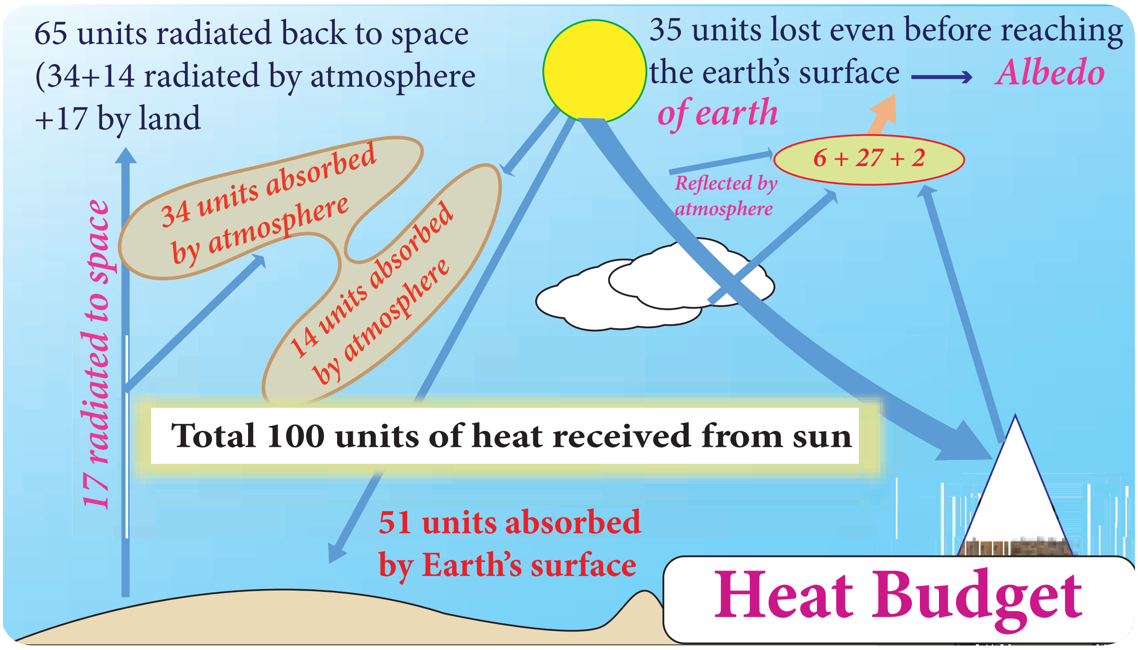


Figure 6.6 Heat Budget

by the 65% radiated by the earth. This balance between the incoming and the outgoing heat energy is called the **global heat energy balance**.

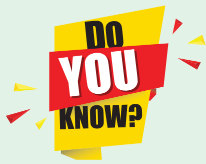
Distribution of Temperature

Distribution of temperature varies both horizontally and vertically. Let us study it under

a. Horizontal Distribution of Temperature
b. Vertical Distribution of Temperature

A) Horizontal Distribution of Temperature

Distribution of temperature across the latitudes over the surface of the earth is called horizontal distribution of temperature. On maps, the horizontal distribution of temperature is commonly shown by isotherms. **Isotherms** are line connecting points that have an equal temperature at mean sea level.



The average time taken by the solar radiation to reach the earth's surface is 8 minutes 20 seconds.

6.3.1 Factors Affecting the Horizontal Distribution of Temperature

The horizontal distribution of temperature on the earth's surface varies from place to place. Following are the factors affecting the horizontal distribution of temperature of the earth:

a. **Latitude:** The angle formed by the solar radiation to the ground is called 'angle of incidence'. The solar radiation passes vertically along the equator. The angle of incidence decreases from equator towards the poles. The area heated by the solar radiation increases towards the poles and therefore, temperature decreases from the equator to the poles.

b. **Distribution of land and water:** Land is heated and cooled at a faster rate due the conduction process whereas water is heated and cooled at slower rate due to convection process. Water takes 2.5 times of heat energy to heat a unit area compared to land. Thus, the land will have higher temperature than the water in summer and vice versa during the winter. So more land mass in northern hemisphere (15.28C) leads to higher average temperature than the southern hemisphere (13.38C).

c. **Ocean currents:** Warm ocean currents carry warm water from the tropical region towards the poles and increase the temperature while cold ocean currents carry cold water from Polar Regions and reduce the temperature along the coasts.

d. **Prevailing winds:** Warm winds like trade wind and westerly, that carry higher heat energy, increase the temperature while cold polar easterlies carry lower heat energy from polar region reduces the temperature.

e. **Cloudiness:** The cloudy sky obstructs the solar radiation from the sun to earth and reduces the temperature. But the clear sky during the day allows more solar radiation to reach the earth's surface and increases the temperature. Meanwhile clear sky at night allows more terrestrial radiation to escape. For example, the tropical hot deserts experience higher temperature at day and lower temperature at night.

f. **Nature of the surface:** The reflection from surface varies based on the nature of land cover. The more reflection from the snow surface leads to low temperature accumulation. But the dense forest, which reflects less heat energy and absorbs more heat energy, leads to higher temperature.

g. **Mountain barriers**: If a wind or air mass blows towards the mountain, it influences the distribution of temperature on either side of the mountain.

For example, polar easterlies and blizzards are obstructed by Himalayas in Asia and Alps in Europe respectively. This leads to lower temperature in the northern slopes and higher temperature in the southern slopes of the respective mountains.

6.3.2 Factors Affecting the Vertical Distribution of Temperature

We all know that the temperature decreases with increasing altitude from the surface of the earth. The vertical decrease in temperature of troposphere is called as 'Normal Lapse Rate' or 'vertical temperature (Figure 6.7) gradient' at which the temperature reduces at the rate of 6.5 8C per 1000 meter of ascent. This is influenced by the following factors:

a. Amount of terrestrial radiation reaching the altitude and

b. Density of air to absorb the heat energy at higher altitude.

As both the above said factors decrease with altitude, the temperature also decreases (Figure 6.5).

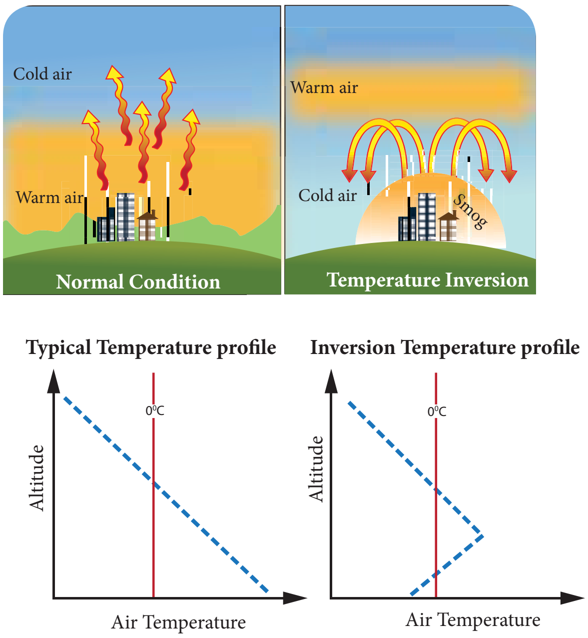


Figure 6.7 Vertical distribution of Temperature

> **Student Activity**
>
> If the temperature of Chennai (7 m) is 348C, calculate the temperature of Kodaikanal (2133m) using normal lapse rate.

6.3.3 Inversion of Temperature

The condition at which the temperature increases with altitude is called as 'inversion of temperature'. In this condition, warm air lies over cold air.

The conditions for inversion of temperature are:

a. Long winter nights: The bottom layer of the atmosphere in contact with the ground is cooled and the upper layer remains relatively warm.

b. Cloudless sky: The higher amount of terrestrial radiation reaches the higher altitude which leads to lower temperature at low level due to clear sky.

c. Dry air near the surface: the dry air absorbs less terrestrial radiation and allows them to escape into space.

d. Snow covered ground: During night, due to terrestrial radiation and higher albedo, most of the heat is lost to the atmosphere and the surface is cooled.

e. Formation of fronts: the movement of warm air over the cold air during the formation of the various fronts leads to inversion condition.

f. Mountain wind: The subsidence of cold mountain wind at the early morning leads to the displacement of warm air from the valley to higher altitude. This type of inversion is called as 'valley inversion'.

> **DO YOU KNOW?**
>
> Albedo is the amount of solar radiation reflected from the surface. The variation is based on the nature of the earth's surface. Snow has higher albedo compared to forest.

6.3.4 Measurements of Temperature

Unit of Temperature	Scientist	Year
Fahrenheit	Gabriel Fahrenheit	1714
Celsius	Andrew Celsius	1742
Kelvin	Lord Kelvin	1848

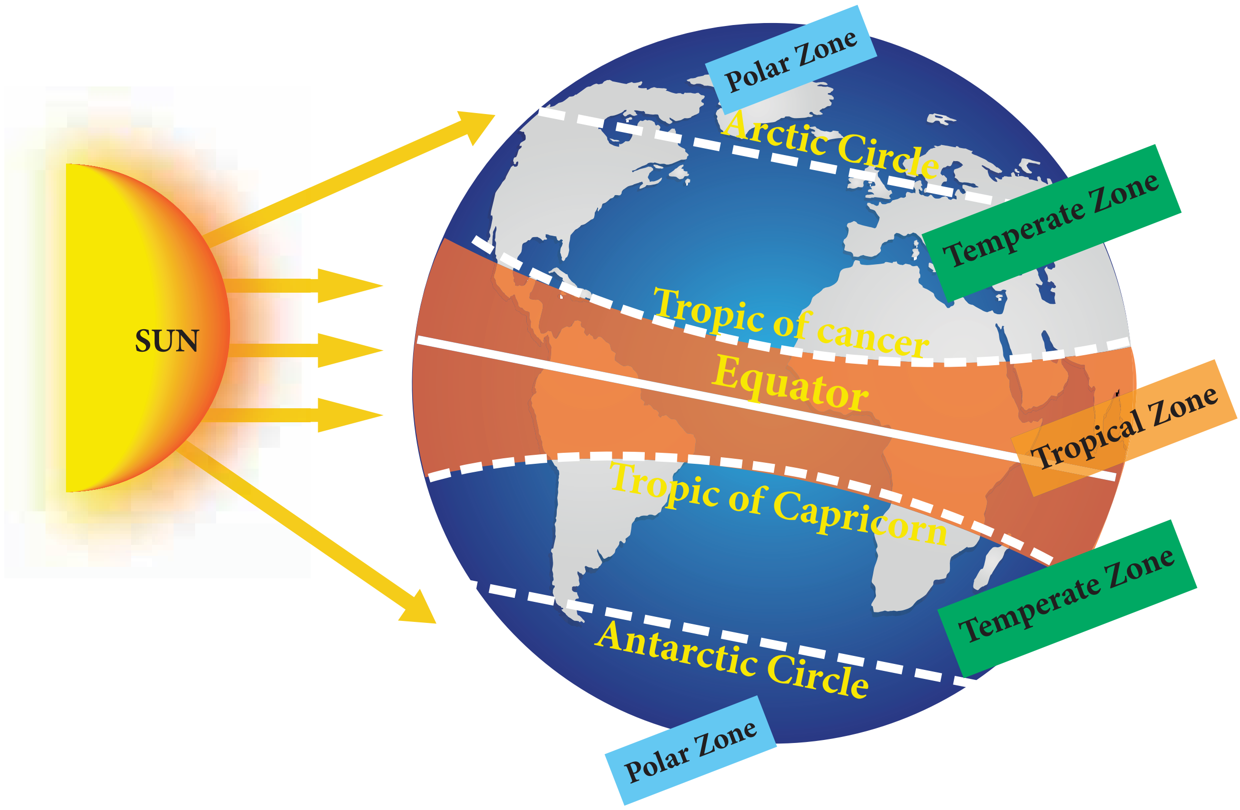


Figure 6.8 Heat Zones

Conversion of Units

Celsius to Fahrenheit	**Ex. 20°C,**
F 5 (C 3 1.8) 1 32	F 5 (20 3 1.8)
	1 32,
	F 5 36 1 32,
	F 5 68
Celsius to Kelvin	**Ex.20°C,**
K 5 C 1 273.15 k	K 5 208 1 273.15k,
	K 5 293.150k

6.3.5 Heat Zones of the World

The earth has been divided into three heat zones according the amount of insolation received. These are the Torrid Zone, the Temperate zone and the Frigid Zone.

Torrid Zone (23 ½ °N to 23 ½ °S)

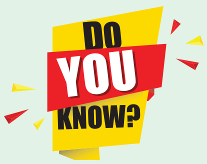
The zone lying between the Tropic of cancer and Tropic of Capricorn is called 'Torrid zone' (Figure 6.8). The sun's rays are vertical throughout the year and it receives maximum insolation. Thus, this is the hottest zone.

Temperate Zone (23 ½ °N to 66 ½ °N and 23 ½ °S to 66 ½ °S)

The temperate zone lies between the Tropic of Cancer and Arctic Circle in the northern hemisphere and the Tropic of Capricorn and Antarctic circle in the southern hemisphere. This region never experiences over head sun light but experiences longer days and shorter nights during summer and vice versa during winter. This region experiences moderate temperature and is therefore called as '**Temperate zone**'.

Polar Zone (Frigid Zone – 66 ½ 8N to 908N and 66 ½ 8S to 908S)

The region between North pole and Arctic Circle in the northern hemisphere and South pole and Antarctic Circle in the southern hemisphere is called 'Polar Zone'. This region always receives more oblique rays of the sun and so the temperature is very low. It is the coldest zone. This region experiences 24 hours of day and night during peak summer and winter respectively.



Annual Temperature : The average annual temperature of a region for a year.

Mean Annual Temperature: The average of 30 years of annual temperature of the region.

Range of Temperature: Difference between highest and lowest temperature of a place.

Annual Range of Temperature: The difference between highest and lowest temperature of a place in a year.

Diurnal range of Temperature: The difference between highest temperature and lowest temperature of a place in a day.

From the above discussion, it is clear that the energy for the earth is from the sun.

Green House Effect: As seen in the heat budget, the longer wavelengths are absorbed by greenhouse gases in the atmosphere, increases the temperature of atmosphere. These greenhouse gases act like a green house and retains some of the heat energy would otherwise be lost to space. The retaining of heat energy by the atmosphere is called the 'greenhouse effect'.

Global Warming

Global warming is observed in a centuryscale. The temperature increase over the years has been due to the greenhouse gas concentration such as carbon dioxide (CO_2), water vapour, methane and ozone. Greenhouse gases are those gases that contribute to the greenhouse effect. The largest contributing source of greenhouse gas is the burning of fossil fuels leading to the emission of carbon dioxide from industries, automobiles and domestic.

6.3.6 Urban Heat Island (UHI)

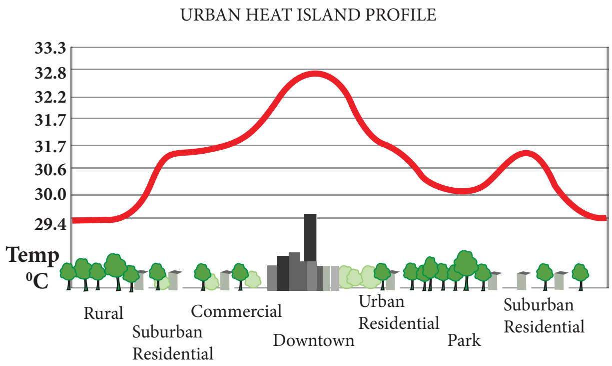


Figure 6.9 Urban Heat Island

An urban heat island is an urban area or metropolitan area that is significantly warmer than its surrounding rural area due to high concentration of high rise concrete buildings, metal roads, sparse vegetation cover and less exposure of soil. These factors cause urban regions to become warmer than their rural surroundings, forming an "island" of higher temperatures (Figure. 6.9).

Ways to reduce the impact of urban heat island:

1. Increase shade around your home: Planting trees and other vegetation, provides shade and cooling effect through evapotranspiration and it lowers the surface and air temperature.
2. Install green and cool roofs.

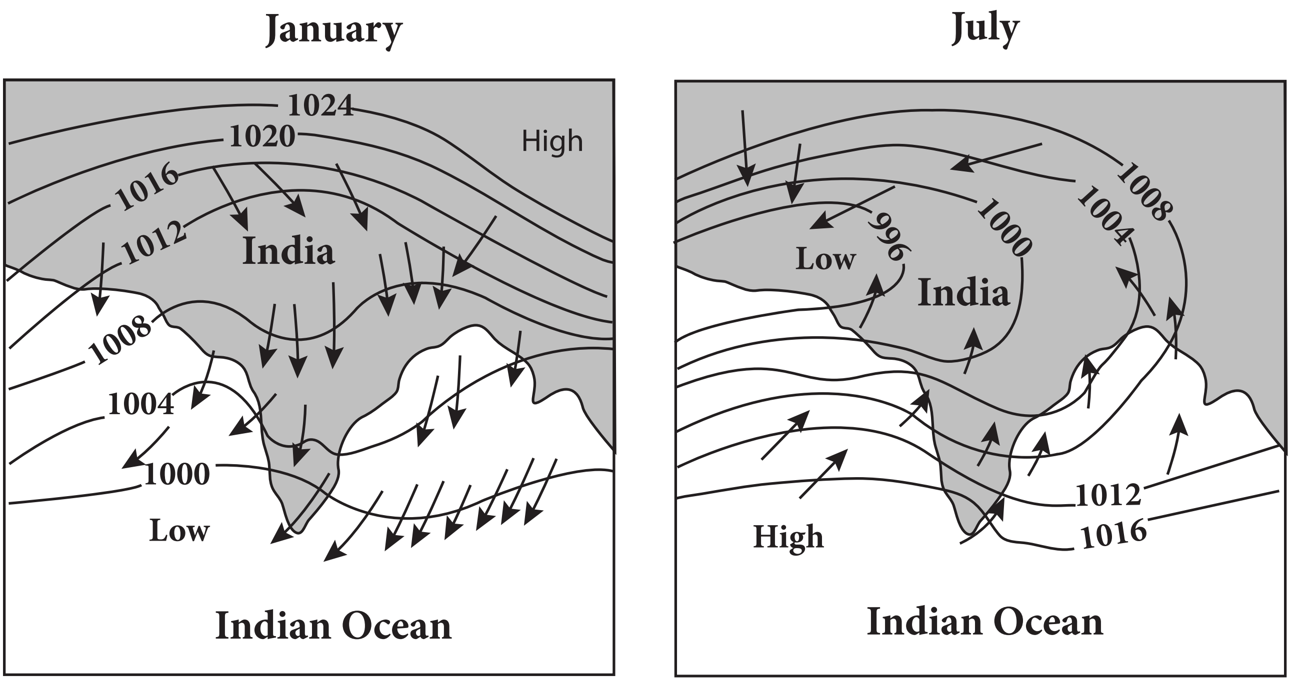


Figure 6.11 Location of High pressure and Low pressure in winter and summer

3. Use energy-efficient appliances and equipments.
4. Shift all industries away from the urban area.
5. Reduce emission from automobiles.

6.4 Atmospheric Pressure and Winds

Atmospheric pressure is defined as the force per unit area exerted against a surface by the weight of the air molecules above the earth surface. In the Figure below (Figure 6.10), the pressure at point 'X' increases as the weight of the air increases. The atmospheric pressure is not distributed uniformly over the earth. The amount of pressure increases or decreases, according to the amount of molecules, that exerts the force on the surface.

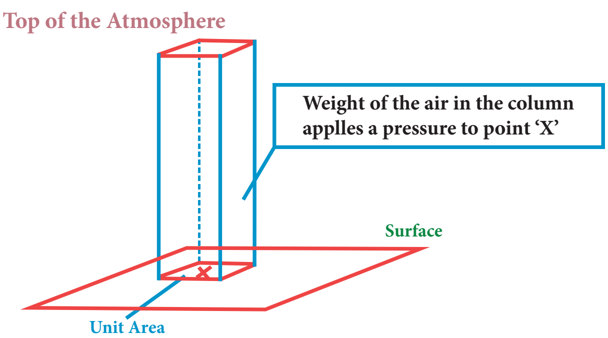


Figure 6.10 Atmospheric Pressure

When temperature of the air increases, the air expands and reduces the number of molecules over the unit area. It leads to reduction in pressure. Similarly, when the temperature falls, the air contracts and the pressure increase. Therefore, the temperature and atmospheric pressure are inversely related.

Atmospheric pressure is measured by an instrument called 'Barometer'

6.4.1 Vertical Distribution of Atmospheric Pressure

The relationship analysis between altitude and atmospheric pressure is very peculiar. The upper atmosphere is thin and less dense. The pressure at sea level is highest and keeps decreasing rapidly with increasing altitude because of the progressive reduction of the mass

> **Isobar** is an imaginary line connecting the places of uniform atmospheric pressure reduced to mean sea level

above the point where it is measured (Figure 6.12).

Relationship between Standard Pressure and Altitude

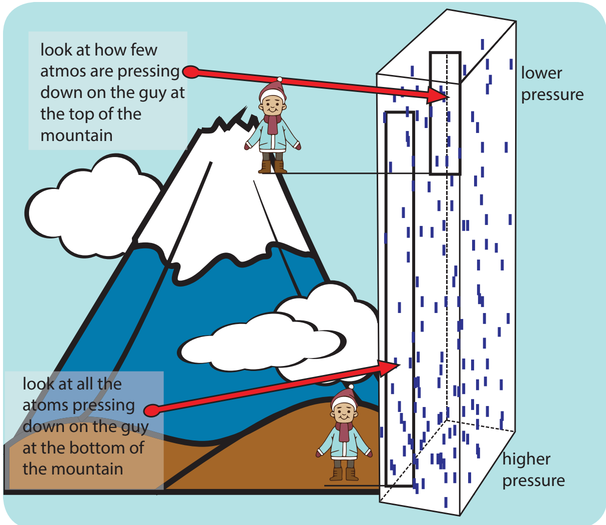


Figure 6.12 Relationship between altitude and pressure

Altitude in m	Atmospheric pressure in m b
Sea level	1013.25
1,000	898.76
2,000	795.01
3,000	701.01
4,000	616.60
5,000	540.48
10,000	264.0

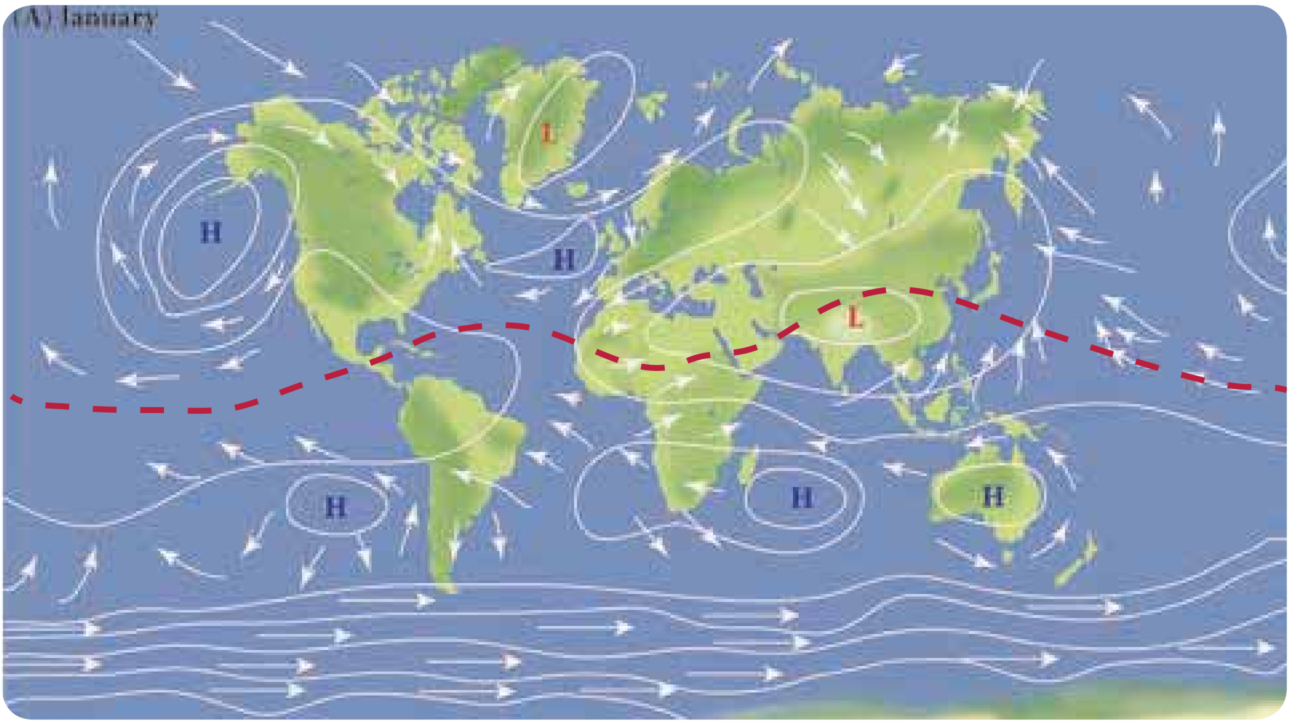
Brain Storming

People feel discomfort to breathe when they go to the places of higher altitude (mountain sickness). Why?

6.4.2 Horizontal Distribution of the Atmospheric Pressure

When the air gets heated it expands, becomes light and rises vertically. As air rises, the pressure it exerts on the earth surface is reduced, causing a low pressure area (Figure 6.13).

On the other hand, cool air is dense and heavy. As a consequence it sinks



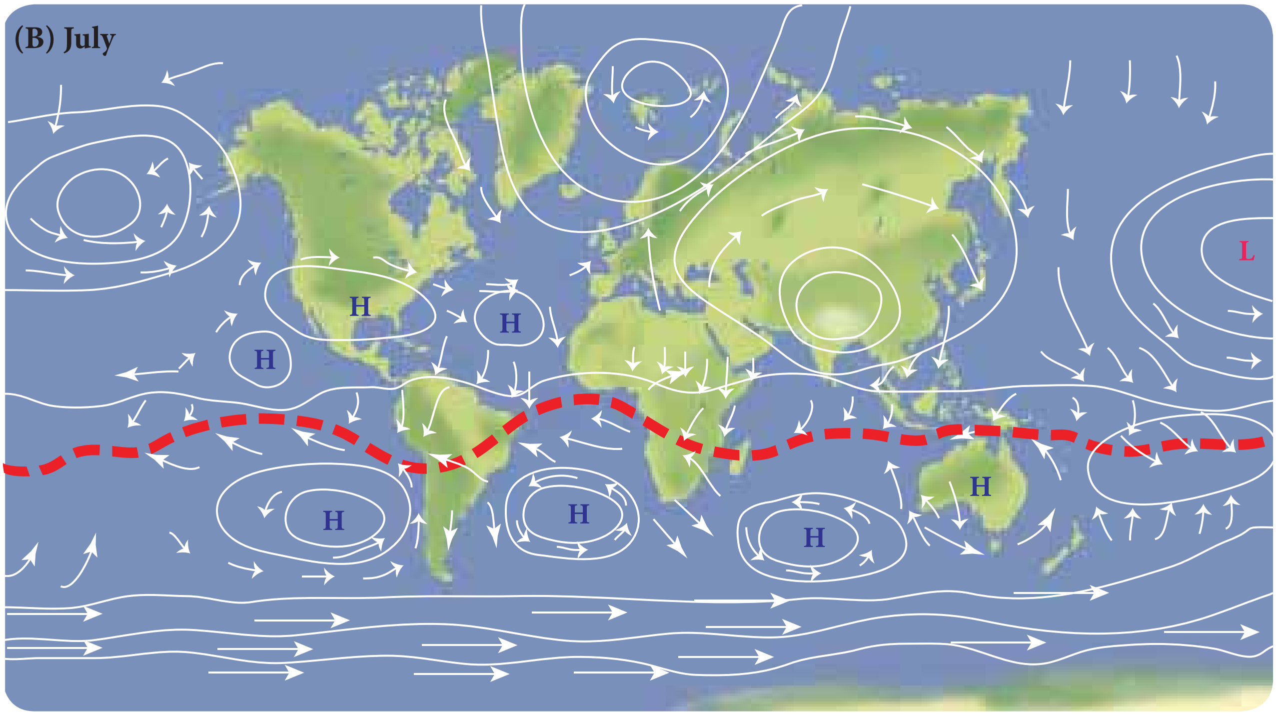


Figure 6.13 Horizontal distribution of temperature

Coriolis Effect

The rotation of the earth affects the moving objects on the earth surface. Free moving objects, affected by the rotation of the earth, do not follow a straight line. In the northern hemisphere they drift towards right and towards left in the southern hemisphere. A car travelling down a straight road at 95 km/hr in northern hemisphere would drift to the right of the path if the friction between surface and tyre is absent. The tendency is called as Coriolis Effect as it was discovered by G.G. Coriolis. This is the reason why racket launching stations are located on the east coastal areas. Example: Sriharihota, French Guyana.

vertically. It results in additional weight and pressure which cause a high pressure area to occur on the ground.

6.4.3 Pressure Belts of the Earth

The atmospheric pressure belts envelope on the surface of the earth. They are equatorial low pressure belt, sub tropical high pressure belts, sub polar low pressure belts and polar high pressure belts (Figure 6.13).

6.4.4 Wind Systems

Wind is the horizontal movement of air molecules from areas of high pressure to areas of low pressure to maintain the atmospheric equilibrium. The wind always moves perpendicular to isobars. If the earth did not rotate, the winds would blow in a straight path. Then the rotation of the earth results in corilois effect and it deflects the direction of the wind. Wind direction is identified by an instrument called Wind Vane and wind speed is measured by Anemometer.

Types of Winds

Winds are classified based on the nature and area of influence as follows;

Classification of Winds

- Surface winds
  - Primary winds (Global winds / Planetary winds / Permanent winds)
    - Trade winds, Westerlies, Polar Easterlies
  - Secondary winds / (Seasonal winds / Periodic Winds / Regional winds)
    - Monsoons, Cyclones
  - Tertiary winds / Local Winds
    1. Sea Breeze and Land Breeze
    2. Mountain and valley wind
    3. Cold and warm wind
- High Altitude winds
  - Jet streams

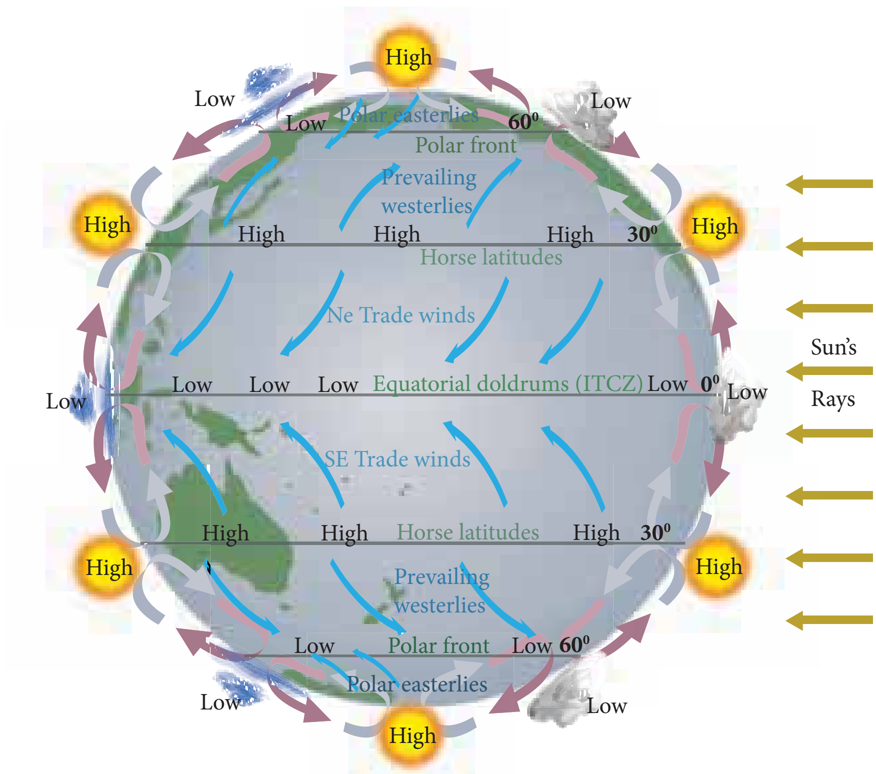


Figure 6.14 Pressure Belts and Primary Winds

6.4.5 General Atmospheric Circulation, Pressure Belts and Primary Wind System

From the equator to the poles, each hemisphere has four pressure belts and totally there are seven belts on the globe. The pressure belts lead to formation of primary wind system as follows (Figure 6.14):

a. **The equatorial low pressure belt (between 58°N and 58°S):** This is the region of calm, weak and changeable winds. Due to the high temperature over this region, the air gets heated expands and become lighter and rises upward and creates low pressure over the region. This region is a belt of calm and referred to as the 'Doldrums'. The winds blow from the sub tropical high pressure belt towards the equatorial low pressure belt. Due to Coriolis Effect these winds are deflected to the right in the northern hemisphere and to the left in the southern hemisphere. As winds are named after the direction from which they originate they are called as the North East and South east trade winds. As the winds favoured trading ships they are called as 'Trade winds'.

b. **The sub tropical high pressure belt (25° to 35° N and S):** Air begins to cool when it reaches higher altitude over equatorial region and flows towards the poles. This wind collides with the wind coming from the polar region at higher altitude and subsides down over sub tropical latitudes. This leads to formation of high pressure belt along the sub tropical region. It is said that to avoid the slowing down of ship due to high pressure the horses were thrown into the sea. So this belt is called as 'Horse latitude'. The sinking air bifurcated in to two branches towards the equator and poles, they are called as trade winds and westerly respectively. Westerlies flow towards the pole from sub tropics and turn towards right and left in northern hemisphere and southern hemisphere respectively.

c. **The sub polar low pressure belt (50° to 60° N and S):** The warm westerly wind from sub tropical region moves towards the pole and collide with the cold polar easterly wind from polar high pressure region and raises up to form sub polar low pressure belt.

d. **Polar high pressure belt (80° N and S to pole):** The constant low temperature at the poles due to inclined solar radiation and reduced insolation leads to the formation of polar high pressure belt on both poles.

DO YOU KNOW?

Ocean is dominant in the southern hemisphere between the latitudes 40° and 60°S. Hence the westerlies are so powerful and persistent that the sailors used such expressions as **"Roaring Forties", "Furious Fifties"** and **"Screeching Sixties"** for these high velocity winds in the latitudes of 40°, 50° and 60° respectively.

The high pressure on the surface always coincide with the low pressure at higher altitude while the low pressure on the surface always coincide with higher pressure on the higher altitude. High pressure always has divergence of air masses from the centre but low pressure has convergence of air.

6.4.6 Basis of Formation of Pressure Belts

There are two important bases on which the pressure belts are formed. They are;

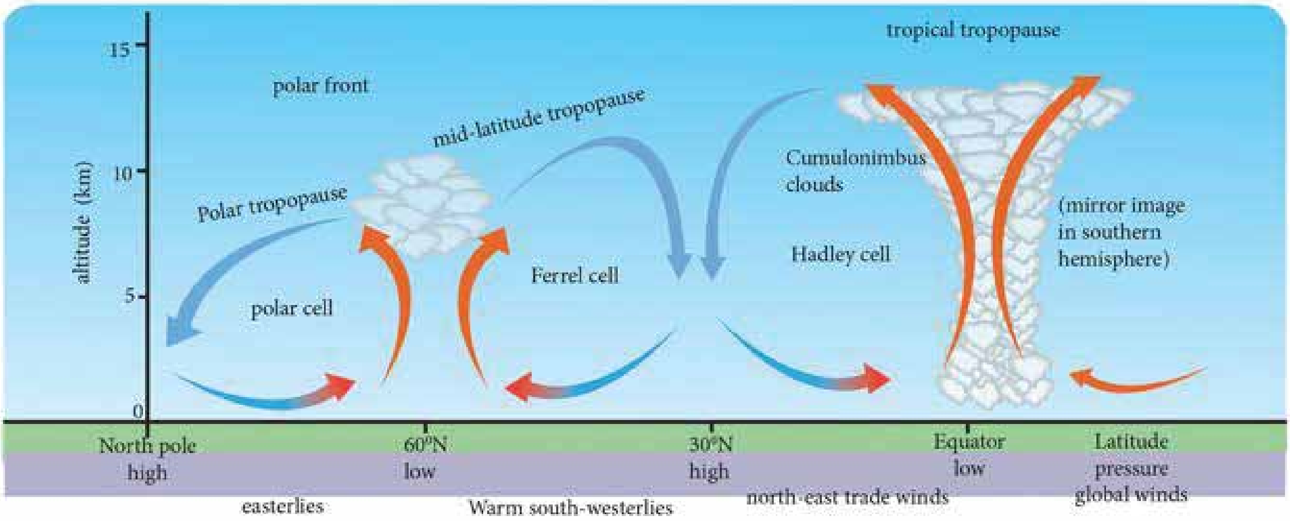


Figure 6.15 Meridional circulation

a. Temperature: The equatorial low pressure and polar high pressure belts are formed due to high and low temperature respectively. So they are called as 'Thermally formed pressure belts'.

b. Dynamism: The sub tropical high and sub polar low pressure belts are formed due to movement and collision of wind system. So they are called as 'Dynamically formed pressure belt system'.

6.4.7 Meridional Cell System

The cell along with trade winds, equatorial low and sub tropical high pressure belts is called as 'Hadley cell', meanwhile the cell formed by westerly wind along with sub tropical high and sub polar low pressure belt is called 'Ferrell's cell'. The cell at polar formed by polar easterlies with polar high and sub polar low pressure belt is called as 'Polar cell' (Figure 6.15).

ITCZ – Inter Tropical Convergent Zone

The region where both trade wind systems meet is known as 'Inter Tropical Convergent Zone'.

Shifting of Pressure Belts and Primary Wind System

These pressure belts and primary wind systems are dynamic in character as they shift 5 8 north and 5 8 south from their position along with the apparent movement of the sun.

6.4.8 Secondary Wind System

Both monsoon and cyclones are considered as secondary or regional wind systems.

Monsoons

The word 'Monsoon' is derived from the Arabic word, 'Mausim' which means 'Season'. Monsoons are seasonal winds which reverse their direction due to unequal heating and cooling of the land and the water.

Mechanism of Monsoon

The land absorbs more heat energy during summer, which leads to the formation of low pressure over continent. But the ocean will have relatively lower temperature than the continent leading to the formation of high pressure system over ocean. So, the wind blows from sea to land during summer season. Meanwhile the land reradiates more heat energy to space during winter leading to the formation of high pressure above the continent. But the ocean will have relatively higher temperature than the continent leading to formation of low pressure system over ocean. So, wind blows from land to sea during the winter season. This mechanism has an important effect on rainfall received over the region.

Nature of Monsoon System

There are three distinct characteristics related to monsoon wind system which differentiates it from other wind systems. They are;

1. Minimum 1608 reversal of wind direction between seasons.
2. They affect a large part of the continents and oceans.
3. The formation of low and high pressure systems over land and water and their interchange between the seasons.

> **DO YOU KNOW?**
>
> If any wind system has all the above mentioned characters of monsoon in one season but absence of at least one in the other season then is called as 'Pseudo monsoon'. The other names are 'Monsoon tendency' or 'false monsoon'.

Monsoon system is classified into two groups based on the location. They are;

a. Asian Monsoon
b. South Asian Monsoon

a. Asian Monsoon

The Asian monsoon system is divided into two components based on season it flows. The presence of high temperature with low pressure in the lake Baikal region and low temperature with high pressure in the Aleutian islands region leading to flow of wind from Pacific Ocean to interior part of Asia during summer is called 'Summer

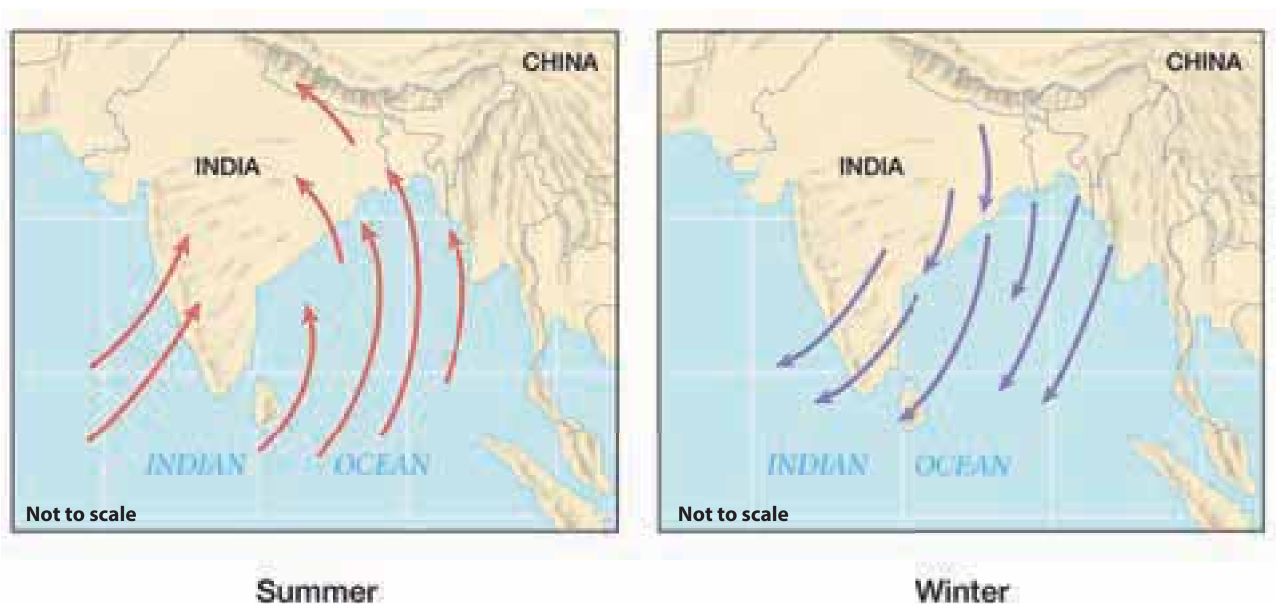


Figure 6.16 South Asia Monsoon

Monsoon of Asia'. This leads to rainfall in the east coast of Asia.

Meanwhile, in winter the low temperature and high pressure in the Lake Baikal region and high temperature and low pressure in the Aleutian Island region leading to flow of wind from Central Asia to Pacific Ocean is known as 'Winter Monsoon of Asia'. As the wind system flows off shore, the rainfall does not occur in the continent of Asia except western coast of Japan.

b. South Asian Monsoon

South Asian Monsoon includes the countries in the southern part of Himalayas, that is India, Pakistan, Bangladesh, Sri lanka, Maldives, Nepal and Bhutan. This monsoon system has been classified into two groups based on the direction of origin of wind namely south west monsoon and north east monsoon (Figure 6.16).

South West Monsoon

During summer the Indian peninsula is heated more than the sea around it. Intense low pressure is formed in the region of Peshawar of Pakistan. At the same time, the Indian Ocean has higher pressure due to relatively low temperature. So the wind blows from Indian Ocean towards South Asia as Southeast Winds. The wind turns towards right due to Coriolis Effect and blows as south west winds which bring heavy rains around four months of the year. This is known as south west monsoon in Indian Sub continent. This wind system bifurcates into two branches as Arabian Sea branch and Bay of Bengal branch.

Arabian Sea Branch

The Arabian Sea branch strikes the Western Ghats at perpendicular direction and rises over it. The orographic effect by the Western Ghats results in heavy rainfall in the windward side and low rainfall in the leeward side. So the west coast of India receives high rainfall when compared to the eastern side of the Western Ghats. Kerala is the first state to receive rainfall from the south west monsoon in India, which occurs during first week of June. Then, the wind gradually moves towards the north of the western coast and leads to gradual development of the monsoon in parts of Karnataka, Goa, Maharashtra, Gujarat and Rajasthan. The wind further advances towards foot hill of the Himalayas and creates orographic rainfall in the Himalayan states, Punjab and Haryana. The other part of the Arabian Sea branch moves towards the east and results in onset of monsoon in Uttar Pradesh and Bihar. Here, it unites with the Bay of Bengal branch and leads to heavy rainfall and flood.

Bay of Bengal Branch

Bay of Bengal branch flows from south west which results in orographic rainfall in Sri Lanka and reaches Andaman and Nicobar Islands and results in orographic rainfall. Indira point in the Great Nicobar is the first place which receives rainfall during south west monsoon in India during middle of May. The wind flows parallel to the east coast of India and Eastern Ghats. So Coromandel Coast of India doesn't get enough rainfall during south west monsoon. The wind strikes Arakanyoma Mountain in Myanmar and results in heavy rainfall in western coast of Myanmar. The wind funnels towards north eastern part of India after deflected by the Arakanyoma Mountain in Myanmar. This wind strikes Meghalaya plateau which leads to heavy rainfall in Bangladesh and

North eastern part of India. Mawsynram, the wettest place (highest annual rainfall) in the world, is located in the windward side of Meghalaya plateau.

The wind further advances towards the Himalayas where it creates heavy rainfall in the southern slopes. This leads to flood in River Brahmaputra. The wind gradually moves towards the west and results in onset of monsoon in Bhutan, Sikkim, West Bengal, Nepal and Bihar. It joins with Arabian Sea branch in Bihar and results in heavy rainfall and flood.

The south west monsoon gradually withdraws from south Asian continent due to apparent movement of the Sun towards the southern hemisphere. This is called as 'Withdrawal of South West Monsoon'.

North East Monsoon

During winter the Indian Subcontinent becomes colder than the Indian Ocean. As a result the wind blows from Northeast to South West direction. This is dry wind system and it does not produce rainfall in the coastal region of south Asia except the Coromandel Coast of India and Sri Lanka.

CASE STUDY

Mawsynram, world's wettest place!

''It was the kind of rain you wouldn't see anywhere else. We could barely see four feet ahead of us. We could touch the clouds, smell the clouds, and taste the clouds" said a local resident. Yes, it is about Mawsynram which is located in Meghalaya's East Khasi Hills, with the cluster of about 1,000 homes. It holds the Guinness Record for "the wettest place on earth". The average annual rainfall is 11,861mm, according to the Guinness website.

However, the soil in the limestone plateau doesn't absorb water. "There is barely any forest cover, so a lot of erosion of top soil happens. All of it flows down into Bangladesh. The irony is that "the wettest place on earth" grapples with an acute water shortage after monsoon ends around October. Hence, people call world's rainiest place Mawsynram, which is also world's wettest desert.

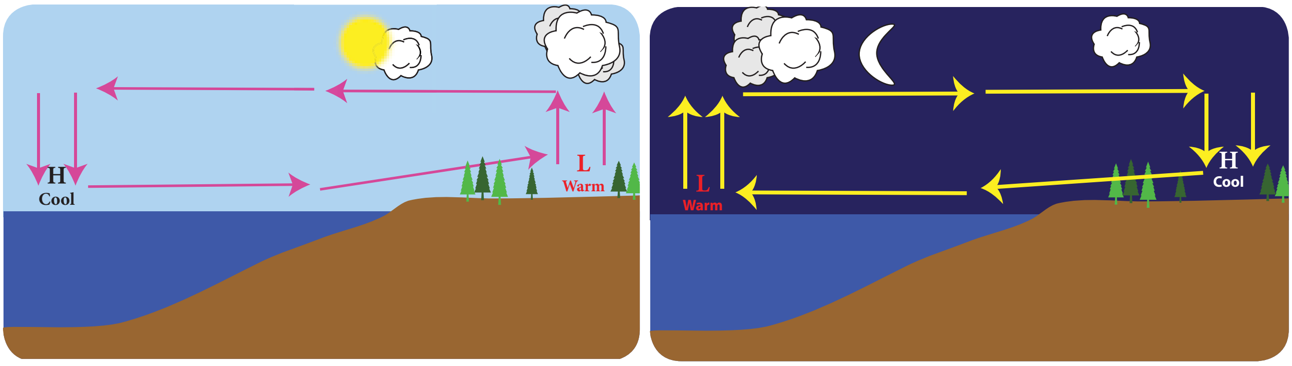


Figure 6.17 Sea breeze and Land breeze

This is known as North East Monsoon or Retreating Monsoon in South Asia.

Agriculture in India mostly depends on the rainfall brought by the monsoons.

During the El Nino year the temperature of the ocean water increases. This weakens the high pressure over Indian Ocean thereby reduces the strength of south west monsoon over south Asia. However during winter, it induces the low pressure over the ocean resulting in severe depressions and cyclones.

6.4.9 Tertiary Winds

The tertiary winds are formed due to pressure gradients which may develop on a local scale because of differences in the heating and cooling of the earth's surface.

Sea and Land Breezes

During daytime, land heats up much faster than water. The air over the land warms and expands leading to form low pressure. At the same time, the air over the ocean becomes cool because of water's slower rate of heating and results in formation of high pressure. Air begins to blow from high pressure over ocean to the low pressure over the land. This is called as 'Sea breeze'. During night time, the wind blows from land to sea and it is called as 'Land breeze' (Figure 6.17).

DO YOU KNOW?

Sea breeze and land breeze influence the movement of boats near the coastal region and fisher men use these winds for their daily fish catching. Fishermen go for fishing at early morning along the land breeze and return to the shore in the evening with the sea breeze.

Mountain and Valley Breezes

A valley breeze develops during the day as the sun heats the land surface and air at the valley bottom and sides. As the air gets

DO YOU KNOW?

Mountain and valley wind systems influence the weather pattern of the mountain top and valley bottom. Mountain top can be seen clearly at early morning and valley bottom at evening. But mountain top will be covered with clouds at evening due to rising of valley wind system and valley bottom would be covered by clouds at early morning due to arrival of mountain wind system. These clouds are sometimes called as 'fog' which is used for cultivation in the dry regions like Yemen.

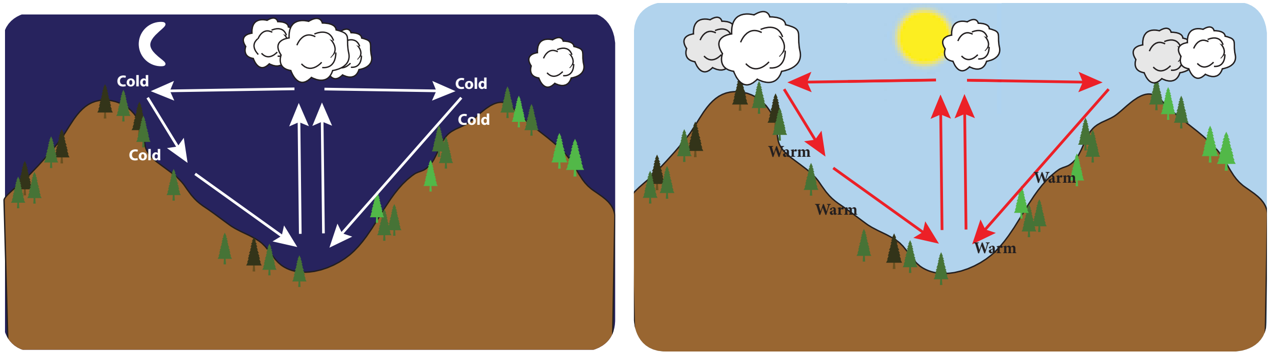


Figure 6.18 Mountain and Valley breeze

Figure 6.19 Local winds of the world

heated it becomes less dense and begins to blow gently up the valley sides. This is called as 'valley wind'. This process reverses at night leading to blow of wind from mountain top to valley bottom referred to as 'mountain wind' (Figure 6.18).

Local Winds

Local wind systems influence the weather pattern where ever they blow (Figure 6.19). Some important local winds are;

Bora: North easterly from eastern Europe to north eastern Italy

Chinook: Warm dry westerly off the Rocky Mountains

Fohn: Warm dry southerly off the northern side of the Alps and Switzerland.

Harmattan: Dry northerly wind across central Africa

Karaburan: 'Black storm' a spring and summer katabatic wind of central Asia

Khamsin: South easterly from North Africa to the eastern Mediterranean

Loo: Hot and dry wind which blows over plains of India and Pakistan.

Mistral: Cold northerly from central France and the Alps to Mediterranean.

Nor'easter: Strong winds from the northeast in the eastern United States, especially New England

Nor'wester: Wind that brings rain to the West Coast, and warm dry winds to the East Coast of New Zealand's South Island, caused by the moist prevailing winds being uplifted over the Southern Alps, often accompanied by a distinctive arched cloud pattern.

Pampero: Argentina, very strong wind which blows in the Pampa.

Simoom: Strong, dry, desert wind that blows in the Sahara, Israel, Jordan, Syria, and the desert of Arabia.

Sirocco: Southerly from North Africa to southern Europe.

Zonda wind: On the eastern slope of the Andes in Argentina.

Figure 6.20 Jet Stream

6.4.10 Jet Streams

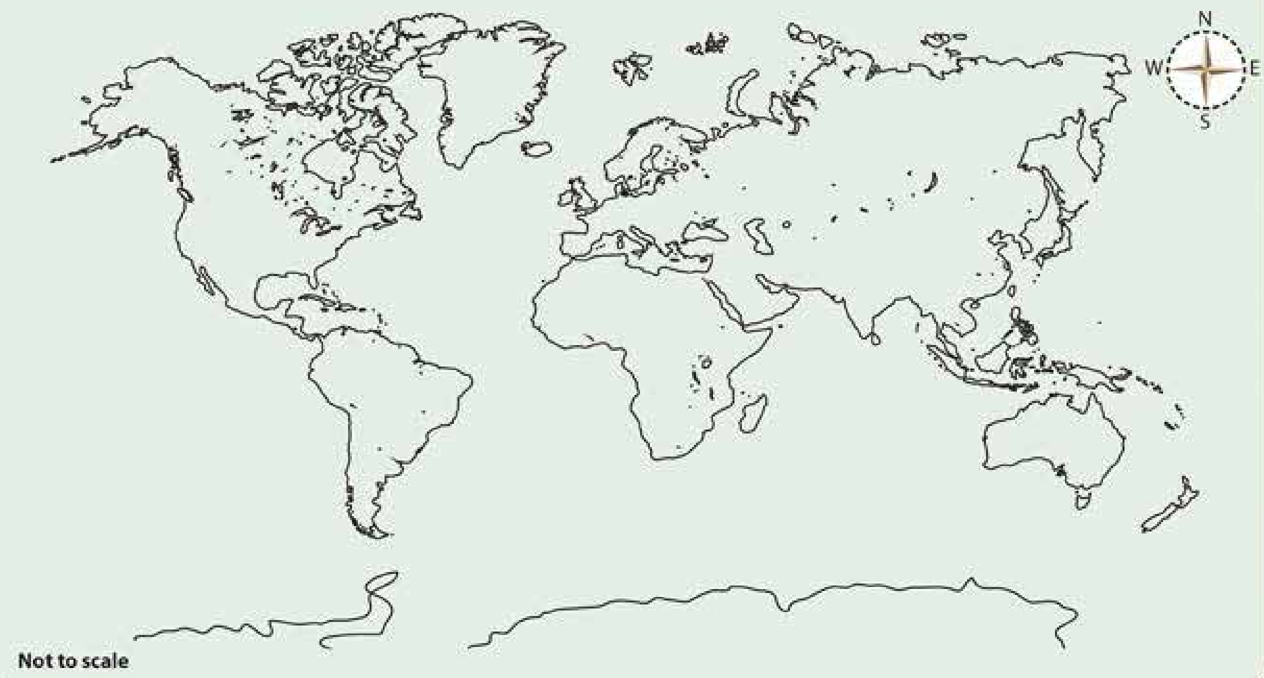
Jet streams are high altitude westerly wind system blows at a height of 6 to 14 km, with very high speed up to 450 km/h in wavy form at both hemispheres. As they encircle the poles

DO YOU KNOW?

The wavy structure of the Jet stream is represented as 'Rossby waves'.

Student Activity

Mark the direction of the primary winds in the given world map.



they are called as 'Circum polar wind system' (Figure 6.20).

Although the jet streams flow at higher altitude they also influences the surface weather pattern of the Earth.

> Jet streams were discovered during the Second World War as the jet pilots felt the strong obstruction in the higher altitudes.

The Major impacts of Jet streams

1. **Creation of Polar vortex:** Polar westerly jet stream will carry cold polar air masses towards temperate region which creates severe cold waves in North America and Eurasia during winter.
2. **Sudden burst of South west monsoon:** Sudden withdrawal of polar westerly jet stream from Indian sub continent to northern part of Pamir, leads to sudden burst of South west monsoon into Indian Sub continent.
3. **Late and early monsoon in South Asia:** Rate of with drawl of polar westerly jet stream decides the onset of south west monsoon. Slower and faster rate of with drawl leads to late and early onset of south west monsoon.
4. **Intensity of monsoon rainfall:** The arrival of tropical easterly jet stream influences the intensity of south west monsoon. This leads to increasing intensity of rainfall during south west monsoon.
5. **Bringing rainfall to India by western disturbances:** Polar westerly jet stream carries rainy clouds from cyclones formed over Mediterranean Sea during winter towards India. These clouds piles up on the Himalayas and results in rainfall over the states of Punjab and Haryana. This assists in the cultivation of wheat in India.
6. **Development of super cyclone:** The condition at which the speed of the jet stream is transferred to tropical cyclone may leads to development of super cyclone.

6.5 Humidity, Condensation and Clouds

Humidity is the amount of water vapour in the atmosphere. Temperature of the air controls the capacity of the air to hold moisture. The maximum amount of moisture that can be hold by the air in the particular temperature is called as Humidity Capacity. As the volume increases with the temperature of the air, it can hold more moisture. So, humidity capacity increases with temperature. It is measured as weight of humidity or volume of the air.

Humidity of the air can be expressed in the following ways.

a. **Absolute Humidity:** This measures the total amount of water vapour present in the air at particular time. It is highly variable based on the surface on which the air moves. It is measured as weight of humidity/ volume of the air.

> Hygrometer is used to measure the relative humidity of a region.

b. **Relative Humidity (RH %):** This is the ratio of Absolute humidity and humidity capacity in term of percentage. It reveals the condition of air to get saturated. This is controlled by both temperature and moisture content of the air. The condition is that when the temperature increases RH% decreases. But when absolute humidity increases RH% increases.

6.5.1 Process of Condensation

Condensation is the change of the physical state of water vapour (gas state) into water (liquid state). The following process explains mechanism of condensation in the atmosphere.

If an air reaches 100% relative humidity, it means that the air is completely filled with moisture content. It indicates that both the absolute humidity and the humidity capacity of the air are in same level. This condition is called 'saturation of air' which can be attained by reducing the temperature of the air or increasing the moisture content. The temperature at which the air gets saturated is called as 'dew point'. The RH crosses the 100% when the temperature of the air drops below its dew point. This condition is called as 'super saturation' of the air. In this condition the air releases the excess moisture out of it in the form of tiny water droplets which floats and form clouds in the atmosphere.

If the same process occurs on the surface of the earth, it is called as 'fog' or cloud on the ground.

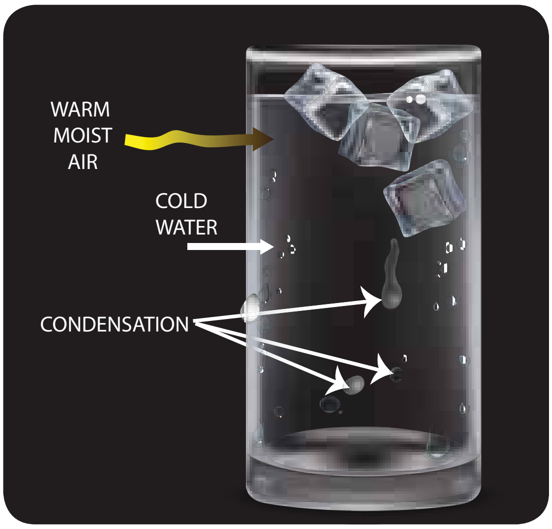


Figure 6.21 Process of Condensation

Student Activity

The cup filled with ice cubes has tiny water droplets on its outer surface (Figure 6.21). Identify why.

The moisture in the atmosphere is based on the following processes:

a. Evaporation – Water changes from liquid state to gaseous (vapour) state.

b. Transpiration – Water state changes from liquid in to (gas) vapour state due to the activity of plants.

c. Evapotranspiration – This denotes that the total amount of (liquid) water state changed in to (gas) vapour state due to evaporation and the activity of plants transpiration.

6.5.2 Clouds and its Types

Clouds are tiny water droplets suspended in the air formed due to the condensation.

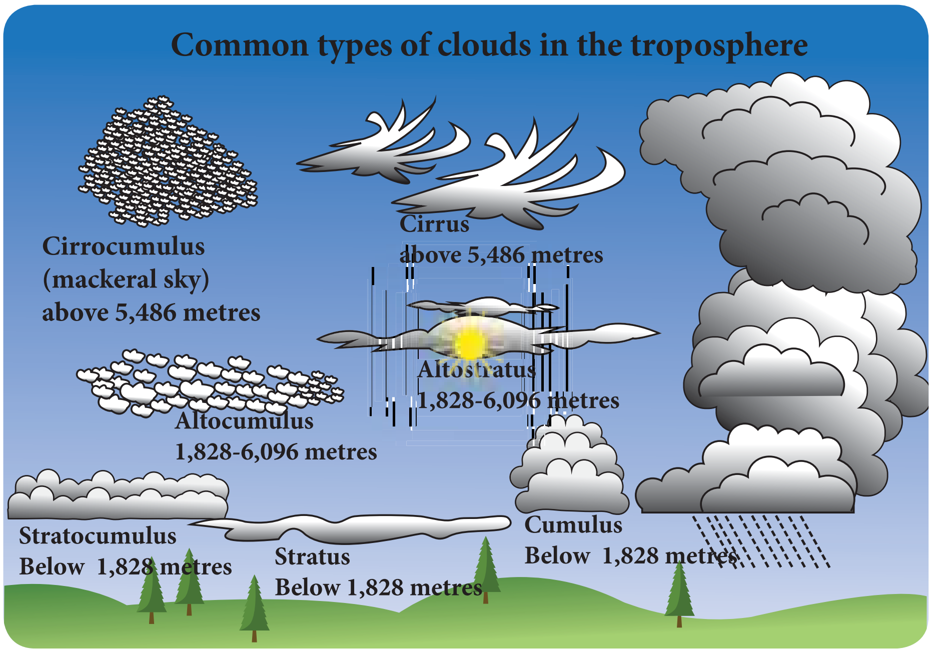


Figure 6.22 Types of Clouds

Isonephs – The imaginary line connecting the places having equal amount of cloudiness.

The clouds can be classified based on their form, height and appearance as follows: (Figure 6.22)

a. **High clouds:** Mainly cirrus (Ci) which are feathery form at 6 km above the ground.

i. Cirrus (Ci) – This looks fibrous and appears as wisps cotton in the blue sky. It indicates fair weather and gives brilliant sun set.

ii. Cirro Cumulus (Cc) – This appears as white globular masses, forming a mackerel sky.

iii. Cirro Stratus (Cs) – This resembles a thin white sheet. The sky looks milky and the sun and moon shines through this clouds and form a 'halo'.

b. **Middle Clouds:** Mainly Alto (Alt) clouds at 2 km to 6 km above the ground.

iv. Altocumulus (Alt-Cu): These are woolly, bumpy clouds arranged in layers appearing like waves in the blue sky. They indicate fine weather.

v. Altostratus (Alt-St): These are denser and have watery look.

c. **Low Clouds:** Mainly Stratus or sheet clouds below 2 km height.

vi. Stratocumulus (St-Cu): This is rough and bumpy clouds with wavy structure.

vii. Stratus (St): This is very low cloud, uniformly grey and thick, appears like highland fog. It brings dull weather and light drizzle. It reduces the visibility and is a hindrance to air transportation.

viii. Nimbostratus (Ni-St): This is dark dull cloud, clearly layered, as it brings rain, snow and sleet and it is called as rainy cloud.

d. **Clouds with vertical extent:** These are mainly cumulus clouds whose

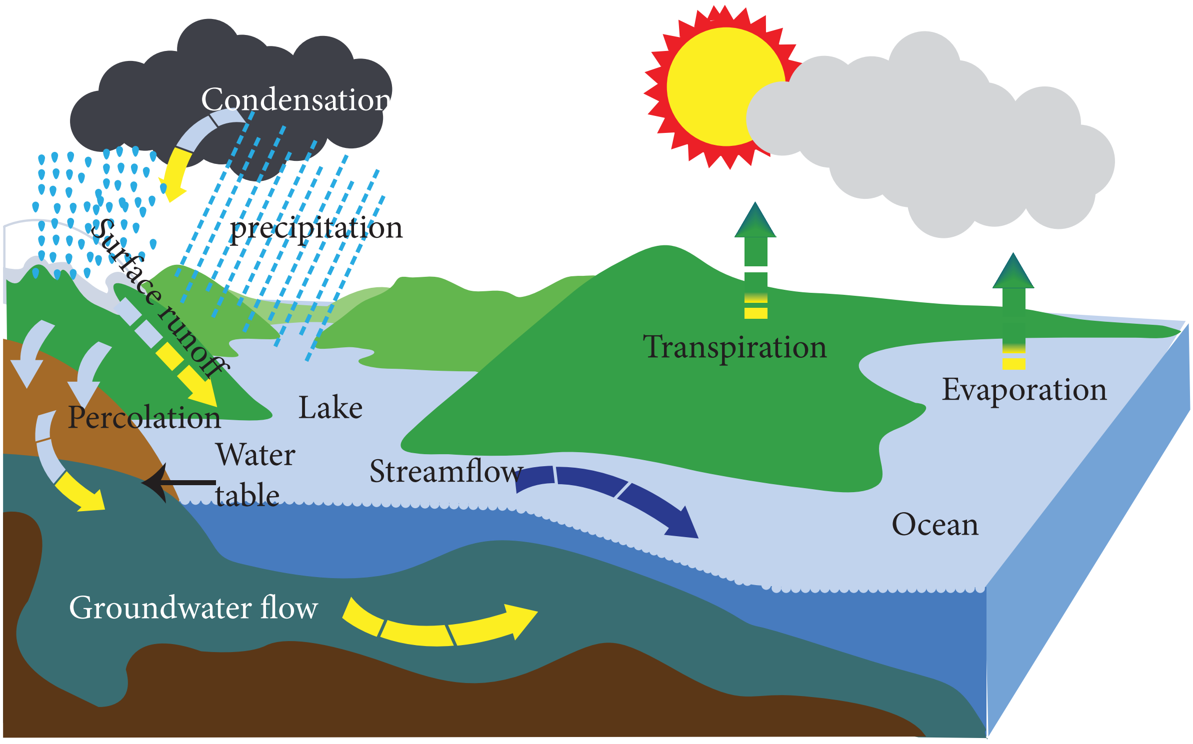


Figure 6.24 Hydrological cycle

heights extend from 2 km to 10 km approximately.

ix. Cumulus (Cu): This is vertical cloud with rounded top and horizontal base, associated with convectional process in the tropical region. It also called as 'fair weather cloud'.

x. Cumulonimbus (Cu-Ni): This is over grown cumulus cloud with great vertical extent, with black and white globular mass. The cauliflower top spreads like an anvil. This is formed due to heavy convection in the tropical regions. It is accompanied by lightning, thunder and heavy rainfall.

Figure 6.23 Smog at New Delhi

Student Activity

Collect the information regarding the smog in the cities of London (Great London Smog), Bhopal, Beijing and New Delhi.

Identify the precautionary steps to be followed in the regions of smog.

6.5.3 Fog, Mist and Smog

- **'Fog'** is defined as almost microscopic droplets of water condensed from super saturated air and suspended over or near the surface of the earth. Fogs reduce the visibility to less than 1 km. Fog occurs during calm or light wind conditions. It is more common in the areas near to the ocean due to the supply of more moisture by sea breeze. In the interior of the continents fog is formed due to reduction of temperature to extreme low during the winter nights.
- If the fog has higher visibility due to lesser water drops near the surface it is termed as **'mist'.**
- In large industrial areas the air is more polluted. If the fog forms in that area it mixes with the pollutants and turns into smog (smoke 1 fog 5 smog) which is more hazardous to the health of the people.

6.5.4 Hydrological Cycle

Continuous movement of water among the three spheres is known as **Hydrological Cycle**. Hydrological cycle involves evaporation, condensation, precipitation, advection, interception, evapo-transpiration, infiltration, percolation and runoff to the ocean (Figure 6.24).

Evaporation is the process by which water in liquid state changes into vapour state using heat energy from Sun. Evaporation is maximum when the temperature is high, on the large expanse of water and when dry winds blow over water surface.

Condensation is the process by which water vapour cools to form water droplet by loosing temperature. The condensation occurs when dew point is reached in the atmosphere.

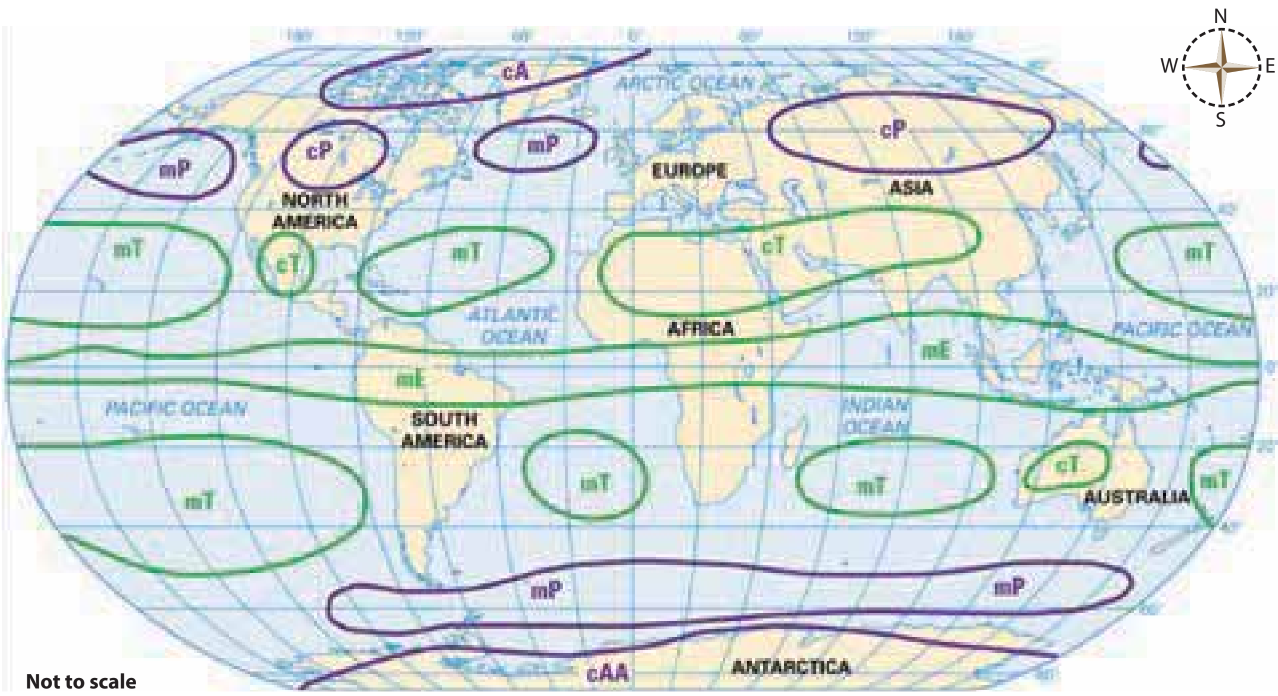


Figure 6.25 Types of air masses

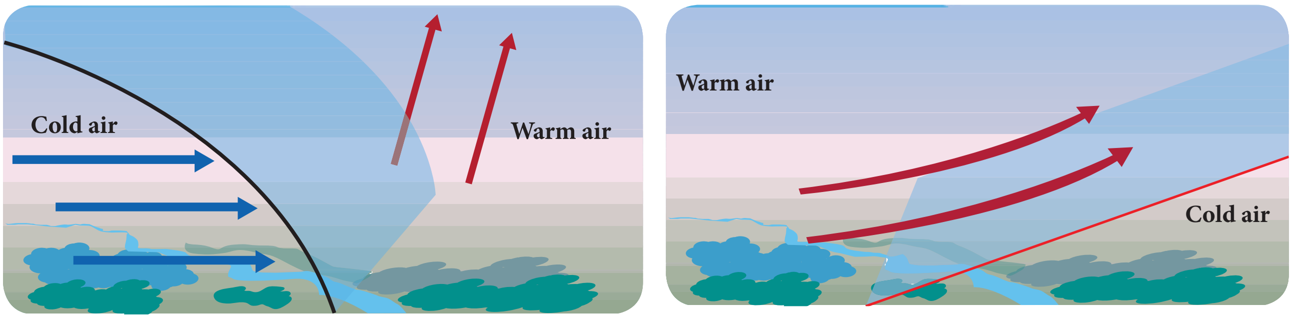


Figure 6.26 Types of fronts

Precipitation is the process by which all forms of water particles fall from the atmosphere and reach the ground.

> **DO YOU KNOW?** The rain drop that falls may get evaporated before it reaches the ground in an extremely arid region.

6.6 Air Masses and Fronts

The study of air mass is very important part of Meteorology. Air always takes some of the properties of the area over which it lies. This parcel of air may remain stationary for several days and develops its own characteristics. Under this situation, the air becomes recognisable as an air mass.

An air mass is defined as 'an immense body of air several kilometres in length and breadth and thickness which is characterised by homogeneous physical properties (like temperature, moisture) in horizontal direction at any level'.

Such an extensive portion of the surface area over which air mass has acquired its qualities is called as 'Air mass source region'. The source region may be land or water body. For example, Sahara desert, Siberia, the Great Plain of North America, Northern Plain of Europe, Western Australia, Antarctica, Green Land, Arctic Ocean, Northern and Southern Pacific, Atlantic Oceans are favourable locations as source region for air masses.

6.6.1 The air masses can be classified based on the following factors;

a. Latitude - Tropical(T) and Polar (P) air masses
b. Nature of the surface – Continent (c) and marine (m) air masses
c. Temperature – warm (w) and Cold (k) air masses
d. Stability – stable (s) and unstable (u) air masses

Air masses normally migrate from their source region to other regions, which have different surface properties, mostly along with primary winds. As the air masses move out from their source regions, they not only modify the weather of the areas they occupy, but also modify themselves according to the surface over which it moves.

6.6.2 Fronts

When two air masses with different physical characters meet, there is usually little mixing of the air. The zone of transition between two contrasting air masses is called as **'Fronts'.** As heavier air mass always tends to push up the lighter air mass, the front always slopes over the cold air mass.

If cold air mass moves forward rapidly and causes the warm air to rise vertically, it leads to the formation of steep slope called as **'Cold front'.** Cold fronts result in the formation of cumulo nimbus clouds with heavy rainfall associated with lightning and thunder.

If warm air is moving over cold air mass, it produces a gentle slope called as **'Warm front'.** Warm fronts result in the formation of stratus and nimbo stratus clouds and cover over large areas, leading to moderate rainfall (Figure 6.26).

Condition for Formation of Fronts:

1. There must be two air masses with contrasting physical characters.
2. There must be collision of air masses.

At the equatorial low pressure belt although two trade wind systems meet, they do not form any front, because the air masses are of similar physical characteristics (both warm) and they do not collide with each other. Whereas the sub polar low pressure belt contrasting air masses collide with each other forming fronts.

6.7 Precipitation

Precipitation is the product of condensation of atmospheric water vapour that falls under gravity and reaches the surface of

Fact File

Acid Rain

Acid rain is a rain that is unusually acidic, it has elevated levels of hydrogen ions. It is caused by a chemical reaction of compounds like sulphur dioxide and nitrogen oxides that are released into the air from anthropogenic activities and from volcanic eruptions. These substances can rise very high into the atmosphere, where they mix as hygroscopic nuclei and react with water vapour, oxygen, and other gases to form more acidic water which falls to the ground as acid rain. It is harmful for plants, animals, human and environment.

Normally the rainfall is slightly acidic because of the presence of dissolved carbonic acid. The pH of normal rain has been given a value of 5.6. Acid rain has the pH value of less than 5.6. A great way to reduce acid rain is by using renewable energy resources, such as solar and wind power and reducing the use of fossil fuels.

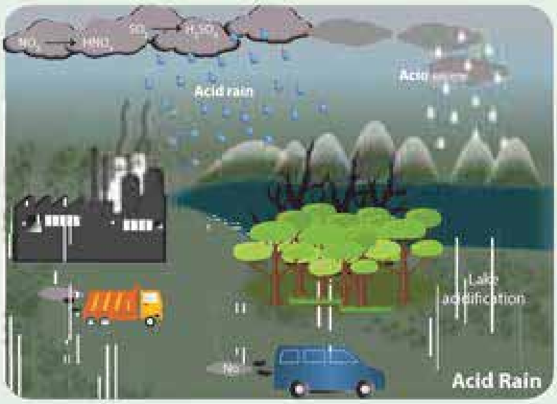


Figure 6.28 Acid rain

the earth. In order to fall as rain drop or snow, the tiny drop lets in a cloud must grow larger. The droplets accumulate over the nuclei and combine to grow large enough to fall and reach the surface of the earth due to gravity.

If the drop is smaller it falls slowly so that it evaporates before it reaches the ground. Ice crystals in cloud also cause precipitation. Each ice crystal grows by cooling so that they become large in size and fall to the ground. They melt on the way due to friction with the atmosphere and fall as rain.

6.7.1 Forms of Precipitation

The precipitation has various forms based on the condition of occurrence (Figure 6.27). The various forms are;

Rainfall: When water droplets of more than 0.5 mm diameter falls from the atmosphere to the ground it is called as 'Rainfall'. If the diameter is less than 0.5mm, it is called as 'Drizzle'.

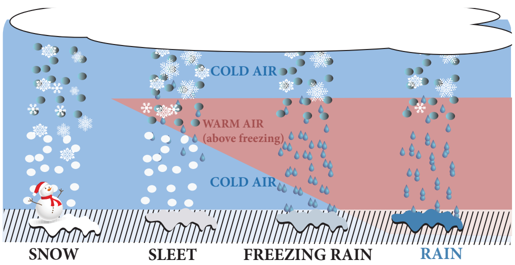


Figure 6.27 Form of precipitation

Hail: When precipitation occurs at sub zero temperature, the water droplets crystallise and fall as ice pellets with the size of 5 to 50 mm or some times more. This is called as 'Hail'.

Sleet : Precipitation occurs as falling of raindrop along with ice pellets less than 5 mm diameter or snow, called as 'Sleet'.

Fact File

Cloud Seeding or Artificial Rainfall

People have always wanted to create rain, so that they would not suffer from drought. Modern science has been successful in causing rain in a limited way through cloud seeding. This method is based on the knowledge of growing ice crystals in clouds.

One method to cause rainfall from clouds is to introduce particles of dry ice (solid CO2) into the cloud from an air plane. The dry ice causes ice crystals to form in the cloud. These ice crystals coalesce, grow, melt and fall as rain. Cloud seeding will not be successful unless the cloud is already saturated with water vapour.

Snow: Precipitation occurs at below freezing point and falls as thin ice flakes or powdery ice, called as 'Snow'.

Dew: Condensation of water droplets on the objects at the surface of the earth such as leaves and grasses are called as 'Dew'.

6.7.2 Types of Precipitation (Rainfall):

Precipitation can be classified based on the causes for the rising up of air,

1. Convectional rainfall
2. Orographic or Relief rainfall
3. Cyclonic or Frontal rainfall

Convectional Rainfall: As a result of heating of the surface air, the warm moist air expands and is forced to rise to a great height. As the air rises, it cools, reaches dew point and condenses to form clouds. This process influences the upper tropospheric circulation. By further cooling, precipitation takes place as rainfall. This rainfall occurs throughout the year near the equator in the afternoon. It is called as 4 'O' clock rainfall region. In middle latitudes, convectional rainfall occurs in early summer in the continental interiors (Figure 6.29).

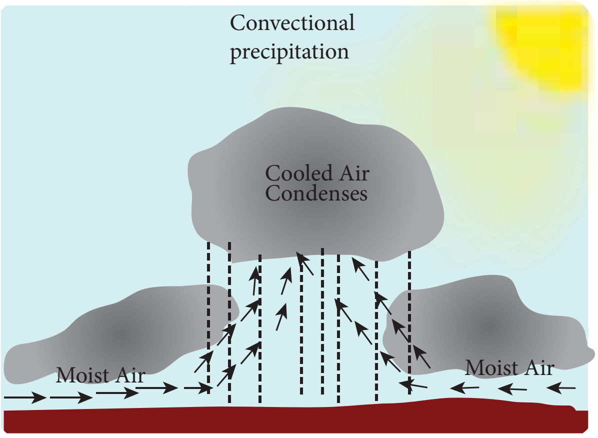


Figure 6.29 Convectional rainfall

Orographic or Relief Rainfall

It occurs when large mass of air is forced to rise across land barriers, such as high mountain ranges, plateaus, escarpments, or over high hills. On the windward side of the region the warm moist air raises, temperature of the air falls below its dew point, forming clouds which give subsequent rainfall. As the wind moves to the leeward side it has emptied itself of moisture and thus descends the slope as warm dry winds. The leeward side of the mountain therefore is called as the **rain shadow region (Figure 6.30)**.

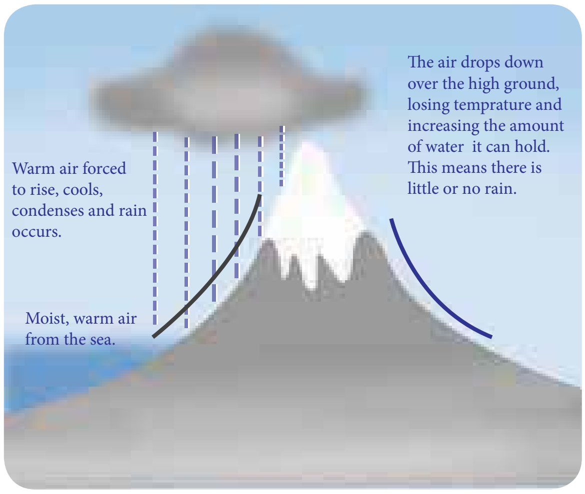
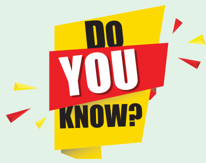


Figure 6.30 Orographic Rainfall



When altitude increases, the rainfall also increases in orographic pattern. But the rainfall decreases with altitude, once the amount of moisture reduces in the air after a point where it reaches maximum rainfall which is called as 'Maximum Rainfall Line'. This condition where the rainfall decreases with altitude is called 'Inversion of Rainfall'.

Cyclonic or Frontal Rainfall

This type of precipitation is associated with a cyclonic activity (Tropical and Temperate) and also occurs along the frontal zone. Cyclonic rainfall is associated with Cumulo Nimbus (CuNi) clouds. The rainfall is very heavy and accompanied with lightning and thunder and high speed winds which has the potential to cause damage.

'Frontal rainfall' is associated with fronts which form due to collision of different air masses. Warm front is formed due to advent of warm air masses which leads to moderate rainfall. In the same way cold

DO YOU KNOW?

An isohyets or isohyetal **line** is a **line** joining points of **equal rainfall** on a map in a given period. A map with isohyets is called an isohyetal map.

front is formed due to advent of cold air mass which leads to heavy rainfall with lightning and thunder.

6.7.3 Cloud Burst

A 'cloud burst' is a sudden aggressive rainstorm falling in a short period of time limited to a small geographical area. Meteorologists say that the rain from a cloud burst is usually of the heavier rain with a fall rate equal to or greater than 100 mm (3.94 inches) per hour. Generally cloudbursts are associated with thunderstorms. The air currents rushing up words in a rain storm hold up a large amount of water. For example cloud bursts in the region of Uttarkhand (2013) and Chennai (2015).

DO YOU KNOW?

Lightning and Thunder are caused by differences in the electrical charge of different parts of the cloud. The top of the cloud becomes positively charged and the bottom is mostly negatively charged. When the difference is great lightning occurs. Differences in the charge between cloud and the earth surface also cause lightning.

Thunder is caused by rapid expansion of the air that is heated as the lightning passes through it.

6.8 Atmospheric Disturbances (Cyclone and Anti Cyclone)

The atmospheric disturbances which involve a closed circulation of air around a low pressure at centre and high pressure at periphery, rotating anticlockwise in northern hemisphere and clockwise in southern hemisphere is called 'Cyclones' (Figure 6.31). Cyclones may be classified into two types based on latitude of its origin.

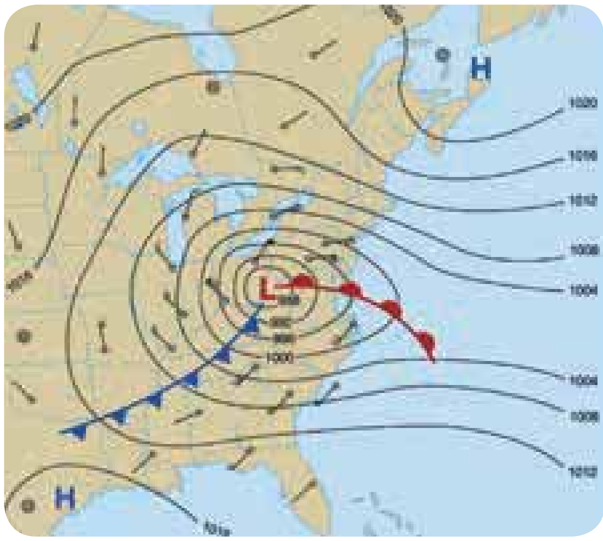


Figure 6.31 Cyclone

They are:

A. Tropical cyclone B. Temperate cyclone.

A. Tropical Cyclone

Cyclone formed in the low latitudes is called as Tropical cyclone. They form over warm ocean waters in the tropical regions. The warm air rises, and causes an area of low air pressure.

6.8.1 Stages of Development of Tropical Cyclone

As per the criteria adopted by the World Meteorological Organisation (W.M.O.), India Meteorological Department

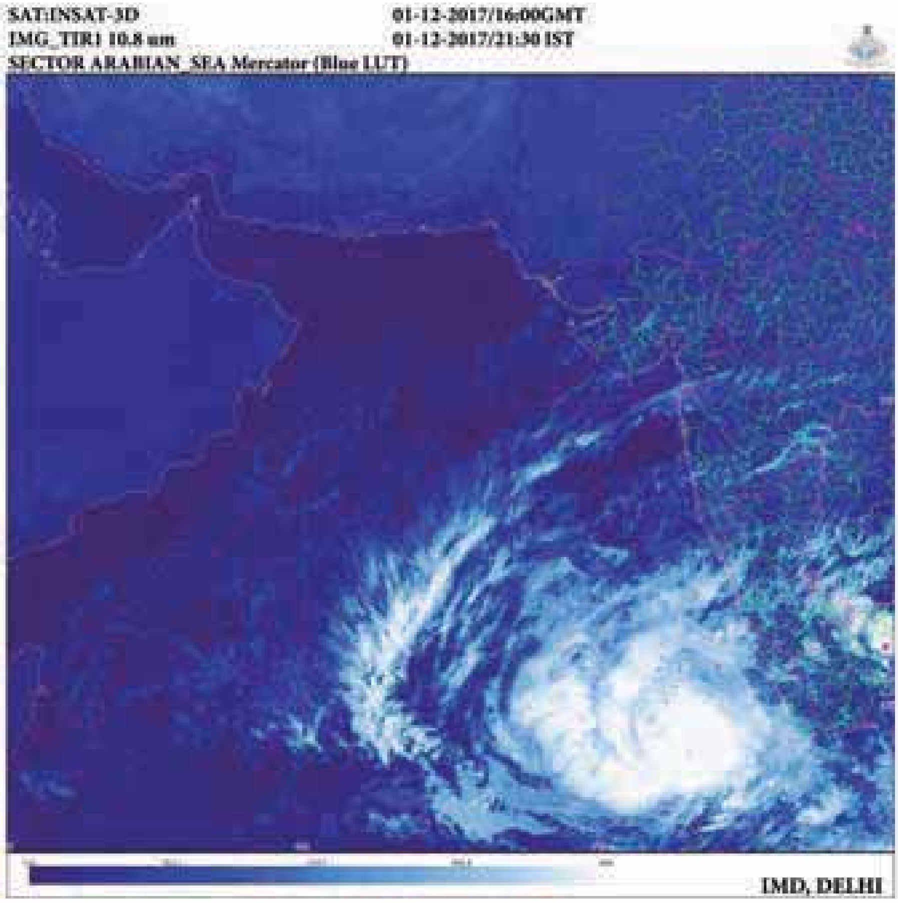


Figure 6.33 Track of Tropical cyclone

classifies the low pressure systems in to vary classes based on wind speed.

1. Tropical Disturbances
2. Tropical depressions Low winds with a speed between 31 and 61 km ph.
3. Tropical cyclone wind speed from 62 to 88 km ph and it is assigned a name.
4. Severe Cyclonic Storm (SCS) wind speed is between 89 to 118 km ph
5. Very SCS wind speed between 119 to 221 km ph and
6. Super Cyclonic Storm when wind exceeds 221 km ph.

6.8.2 Origin of Tropical Cyclone

Tropical cyclones have certain mechanism for their formation. These are

A source of warm, moist air derived from tropical oceans with sea surface temperature normally near to or in excess of 27 °C (Figure 6.32)

Wind near the ocean surface is blowing from different directions converging and causing air to rise and storm clouds to form.

Winds which do not vary greatly with height are known as low wind shear. This allows the storm clouds to rise vertically to high level;

Figure 6.32 Structure of Tropical Cyclone

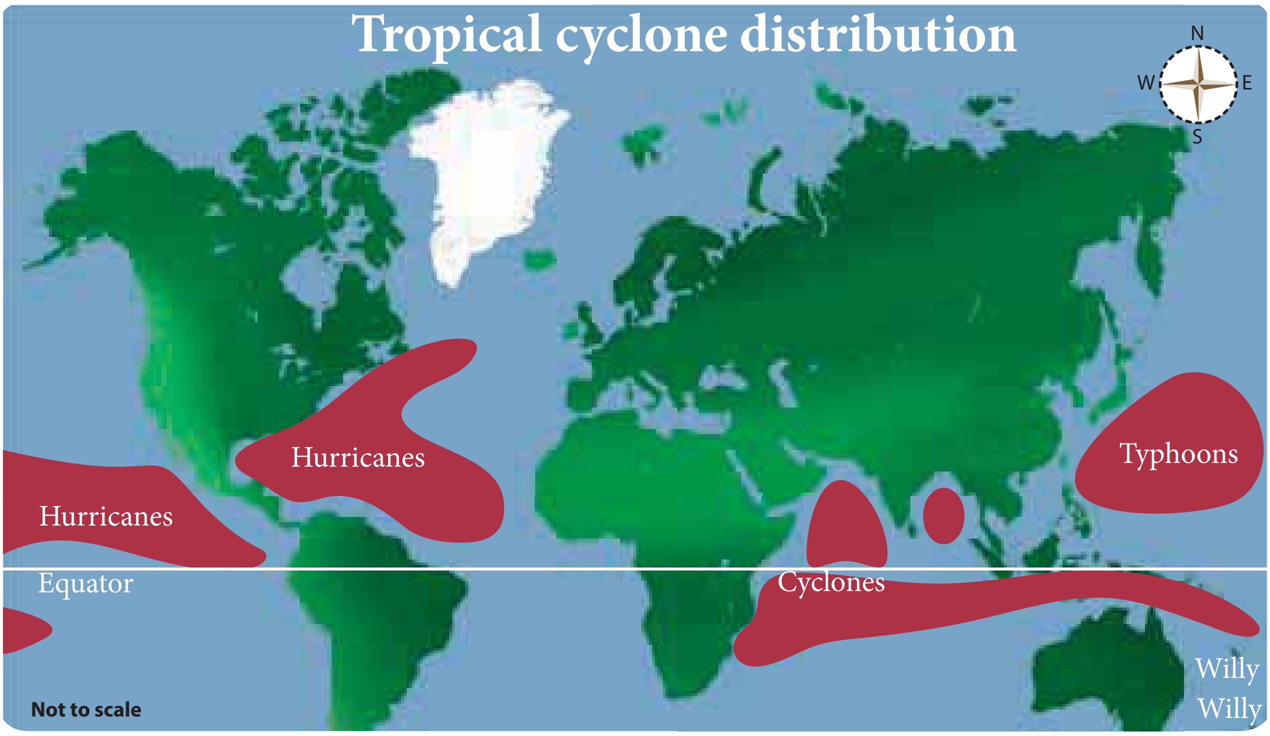


Figure 6.35 Distribution of Tropical Cyclone

Coriolis force is induced by the rotation of the Earth. The mechanisms of formation vary across the world, but once a cluster of storm clouds starts to rotate, it becomes a tropical depression. If it continues to develop it becomes a tropical storm, and later a cyclone/ super cyclone.

Characteristics of the Tropical Cyclone

The centre of the cyclone where the wind system converges and vertically rises is called as Eye. The eye is a Calm region with no rainfall and experiences highest temperature and lowest pressure within the cyclonic system (Figure 6.32).

Cyclone wall is made up of Cumulo Nimbus clouds with no visibility, higher wind velocity and heavy rain fall with lightning and thunder.

Tropical cyclones mostly move along with the direction of trade wind system. So they travel from east to west and make land fall on the eastern coast of the continents (Figure 6.33).

Landfall: The condition at which the eye of the tropical cyclone crosses the land is called 'Land fall' of the cyclone (Figure 6.34).

Figure 6.34 Landfall of tropical cyclone

Names	Location of Landfall	Date of Land fall
Hurricanes		
Typhoons		
Cyclones		

Naming of Tropical Cyclones

The practice of naming storms (tropical cyclones) began years ago, in order to help in the quick identification of storms in warning messages because names are presumed to be far easier to remember than numbers and technical terms (Figure 6.35).

In the pursuit of a more organized and efficient naming system, meteorologists later decided to identify storms using names from a list arranged alphabetically. Since 1953, Atlantic tropical storms have been named from lists originated by the National Hurricane Centre. They are now maintained and updated by an international committee of the World Meteorological Organization (WMO).

Large scale destruction caused by Odisha cyclone in 1999, triggered the issue of naming tropical cyclones developed in the North Indian ocean. As a result, naming conventions for storms that develop in the Indian Ocean began in 2004. WMO (World Meteorological Organisation)had informed each of the eight South Asian member countries to submit a list of their own eight names for the cyclones.

Condition of Super Cyclone Formation

1. Longer travel or stay of low pressure system over warm ocean water.
2. The speed of jet stream may influence the formation of super cyclone.

Student Activity

Students have to collect the recent names of the hurricanes, typhoons and cyclones and date and location of landfall in last 5 years.

6.8.3 Tornado and Water Spouts

It is a very small intense, funnel shaped very speed whirl wind system. Its speed and direction of the movement are erratic (Figure 6.36). The winds are always as fast as 500 km ph. The fast moving air converges in the middle and rises up. The uplift is capable of rising dust, trees and

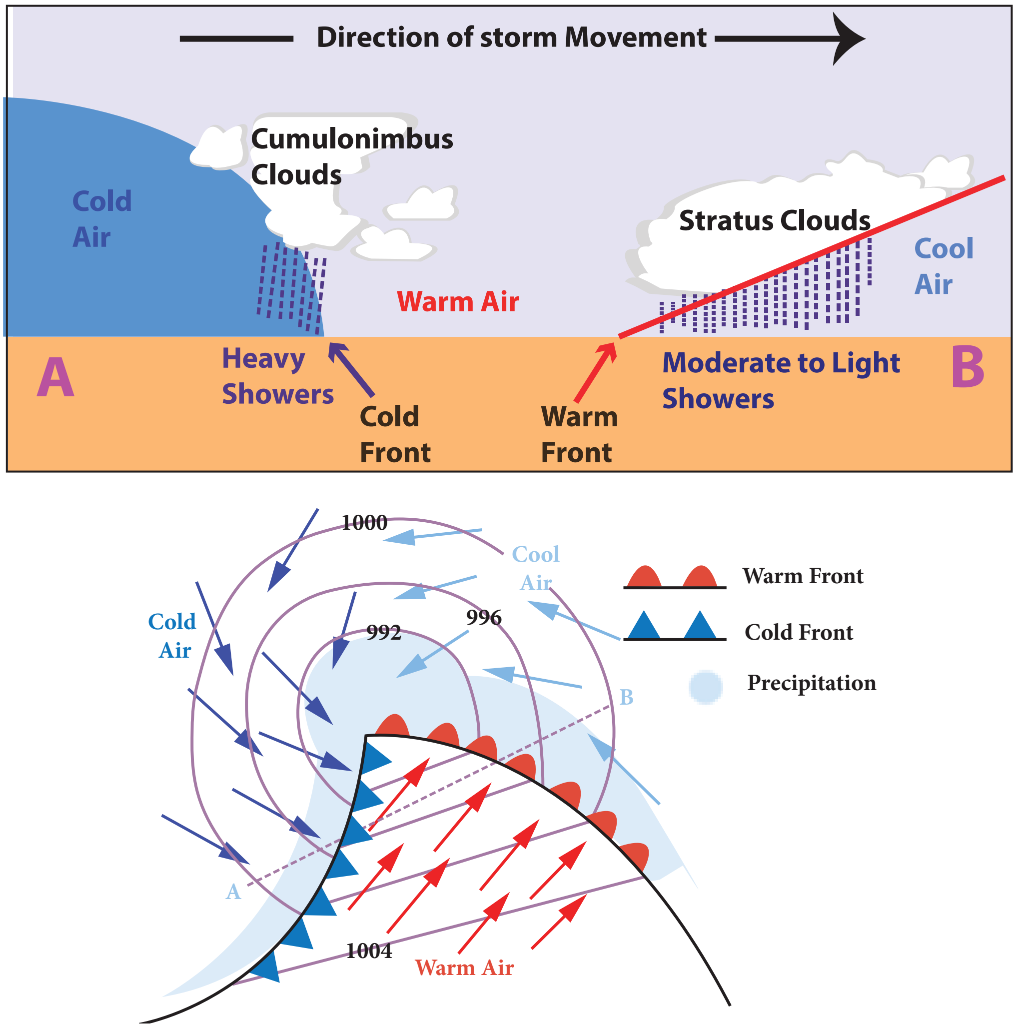


Figure 6.37 Sector structure of Temperate cyclone

other weaker objects in its path. South and western part of Gulf States of USA experiences frequent tornados.

Water spouts are formed over water body similar to tornados in the formation and structure. This sometimes leads to fish rain, if the mass of fish comes under the water spout.

Figure 6.36 Tornado

Web link for Water spout at Chennai, Tamil Nadu https://www.youtube.com/watch?v=v0RubwHxlgM

B. Temperate Cyclone

The cyclone formed in the mid latitudes is called as temperate cyclone. As they are formed due to movement of air masses and front, they are called as 'Dynamic cyclone' and 'Wave cyclone'. This cyclone is characterised by the four different sectors, which are varied with their weather patterns (Figure 6.37).

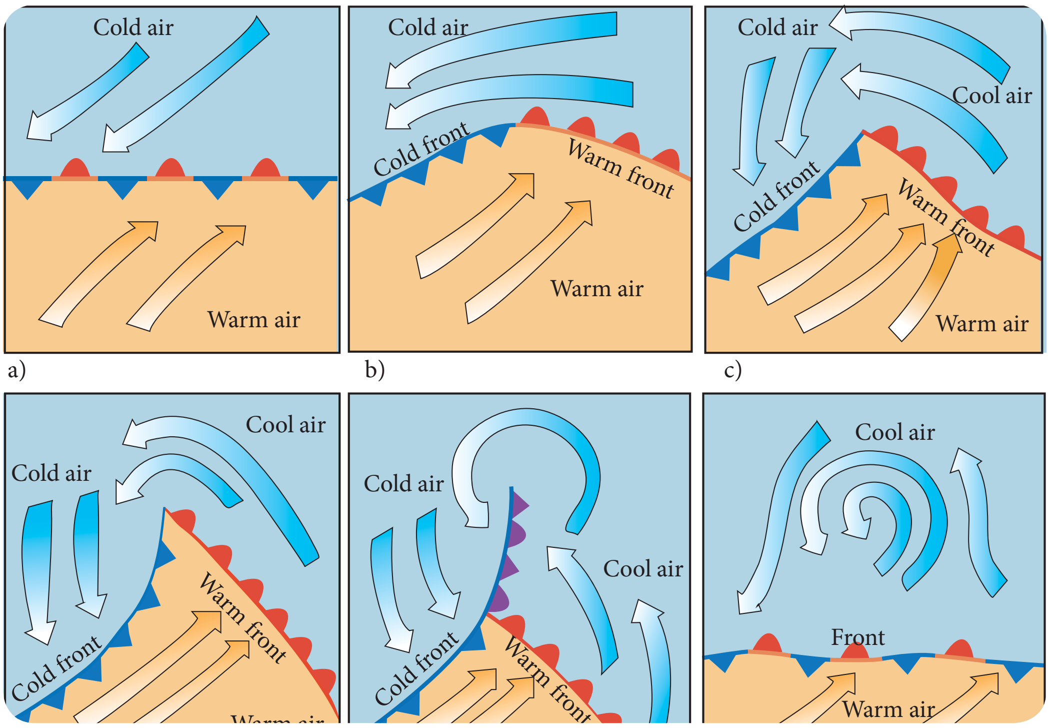


Figure 6.40 Development of Temperate cyclone

6.8.4 Stages in the Formation of Temperate Cyclone

a. Frontogenesis –Formation of front due to collision of two contrasting air masses (Figure 6.38).

b. Cyclone genesis – Formation of cyclone due to conversion of fronts into various sectors.

c. Advancing Stage – The stage where cold front advances towards warm front.

d. Occlusion stage - The stage where the cold front over takes warm front

e. Frontalysis – The last stage where fronts disappear and cyclone ends its life.

Characters

Unlike tropical cyclone, temperate cyclone forms over both land and water in all seasons. It covers larger area than tropical cyclone and stays for a longer period.

Track

Temperate cyclone moves along with the westerly wind system from west to east.

Anti Cyclones

Anti cyclone is a whirlwind system in which high pressure area at the centre and surrounded by low pressure at periphery rotating clockwise in northern hemisphere and anti clock wise in southern hemisphere(Figure 6.39).

This is the largest among the whirl wind systems. Normally, they are associated with high pressure belts of sub tropical and polar region.

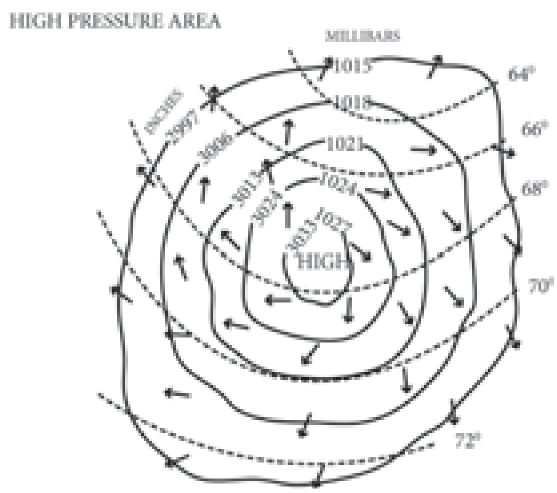


Figure 6.39 Anticyclone

Anti cyclones are classified as warm core and cold core, based on their temperature, which are resulted in aridity and cold waves respectively.

A-Z GLOSSARY

Buoyant: Able to keep afloat on the top of air or liquid.

Collision: Hit by accident when moving.

Equilibrium: A balanced state of molecules where the acting forces are equal.

Escarpment: A long, steep slope especially one of the edge of a plateau or surface.

Expansion: The action of becoming larger or more extensive.

Funnelling: Guided through the area that has widening at front and narrow at the end.

Hygroscopic: Tending to observe moisture from air.

Insolation: Amount of solar radiation reaching a given area.

Meteorology: is a branch of the atmospheric sciences which includes atmospheric physics and chemistry, with a major focus on weather forecasting.

Molecules: A group of atoms bonded together.

Permeable: Allowing liquids or gases to pass through it.

Subsistence: The gradual movement of air molecules from higher altitude to lower altitude.

Torrid: Region of Very hot and dry condition.

Vortex: A whirling or rotating mass of fluid or air.

Evaluation

81DTBI

I Choose the best answer

1. Which of the following atmospheric layer known as the weather layer?
   a. Troposphere b. Stratosphere
   c. Thermosphere d. Mesosphere
2. Which is the most suitable layer for flying Jet air craft?
   a. Troposphere b. Stratosphere
   c. Mesosphere d. Exosphere
3. Which of the following atmospheric structure absorbs the ultra violet rays of the sun and protect the earth from intense heating?
   a. Troposphere b. Ozonosphere
   c. Thermosphere d. Exosphere
4. An imaginary line connecting the places having equal atmospheric temperature is called
   a. Isotherm b. Isohytes
   c. Isobar d. Contour
5. Speed of the wind is measured by
   a. Barometer b. Hygrometer
   c. Thermometer d. Anemometer
6. What happens to atmospheric pressure with increase in altitude?
   a. It remains constant
   b. It increases
   c. It decreases
   d. It constantly fluctuates
7. Which one of the following winds is the example of secondary winds?
   a. Trade winds b. Westerlies

c. Polar easterlies   d. Monsoon

8. Albedo means
   a. Amount solar radiation reflected by the surface
   b. Amount moisture absorbed by the surface
   c. Amount moisture present in air
   d. Amount of molecules present in air
9. Which instrument is used to measure the relative humidity in air?
   a. Hygrometer   b. Barometer
   c. Thermometer   d. Altimeter
10. Convectional rainfall mostly occurs in ________?
    a. Temperate region
    b. Equatorial region
    c. Tundra region
    d. Desert region

II Very short Answer.

1. Define lapse rate.
2. What is mountain wind?
3. Draw and label the pressure belts on the globe.
4. Differentiate rainfall and snow.
5. What are the stages of formation of temperate cyclone?

III Short Answer.

1. Why is ozone layer depleting?
2. Draw the diagram for heat budget and mark the radiation emit.
3. How is an urban heat island formed?
4. Differentiate between sea breeze and land breeze.
5. List the forms of precipitation.

IV Detailed Answer.

1. Elucidate the types of clouds.
2. Discuss the mechanism of Asian monsoon.
3. How is the cyclone different from anticyclone?

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Web References

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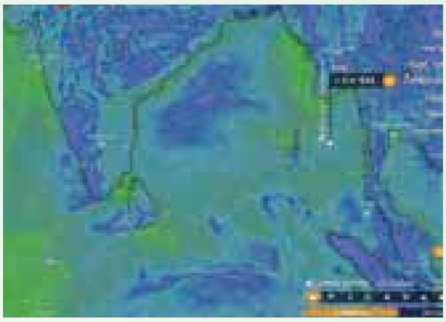
ICT CORNER

Atmosphere Vital Blanket

Through this activity you will explore atmosphere system.

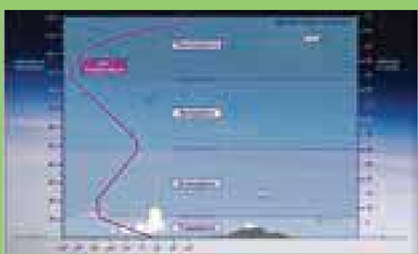


Steps

- Use the URL to reach 'Vertical Structure of the Atmosphere' page. Click launch to start the interactive atmosphere page.
- Click begin and select 'Objects' check box to observe the vertical content of the atmosphere.
- Select 'Temperature' and 'Pressure' check boxes to study physical properties of the atmosphere.
- Use https://www.windy.com to observe live wind flow of any place on the earth.

Step 1

Step 2



Step 3

Step 4

Interactive Atmosphere's URL:

https://www.pbslearningmedia.org/resource/ess05.sci.ess.watcyc.vertical/vertical structure-of-the-atmosphere/#.Wq-xD8OuzIU

*Pictures are indicative only.

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Unit VII

81MPD6

The Biosphere

"Man's attitude towards nature is today critically important simply because we have now acquired a fateful power to alter and destroy nature. But man is a part of nature and his war against nature is inevitably a war against himself."
– Rachel Carson

Chapter Outline

Learning Objectives:

- *Throw light on the importance, vastness and variety that exists in the life sphere.*
- *Describe the distribution of life forms and their adaptations over geographical space.*
- *Sensitise the student on their role in conserving the biosphere.*

7.1 Introduction

The earth was formed 4.6 billion years ago. Geographers are concerned about the earth and its various spheres. These spheres did not exist on the primitive earth as they are today. They evolved over a long period of time after the earth was formed. There was no life on earth for a very long time. Scientists believe that the first life forms on earth came into existence about 3.5 billion years ago. Which marked, 'The birth of the biosphere'.

Since then life has multiplied in numbers and varieties and evolved to the present biosphere that we are part of and which we are gifted with.

In the last 100 years, man has had used, overused and misused the natural resources of the earth. This has disturbed the ecological balance of the earth. The realization about the damage caused to earth by our action came when we began to experience global warming, desertification, increase in disease and distress and recurrence of severe natural disasters.

It was in 1962 that **Rachel Carson** published the book 'Silent Spring' which inspired an environmental movement that led International agencies to focus their attention on protecting and sustaining the biosphere.

In 1971, UNESCO launched the Man and the Biosphere Programme to study our impact on nature and how it could be minimized. Even after several decades the programme still continues to shape the future of sustainability of the earth.

7.2 Biosphere

The word Biosphere originates from the Greek words bios = life and sphaira = sphere. Earth is the only planet in the solar system that supports life. There are many reasons that contribute to this and the most important being the earth's distance from the sun, the presence of oxygen in the atmosphere and the presence of water. The above factors, along with the existence and interaction of the three spheres of the earth (the lithosphere, hydrosphere and atmosphere) gives rise to the fourth sphere which is the life sphere or biosphere (Figure 7.1). The term *Biosphere* was coined by **Eduard Suess** in 1875. Later contributions to the study of biosphere were from, **Charles Darwin** and many other scientists.

Thus, in the biosphere, life exists on land, water and air and life forms range from microorganisms to plants, animals, birds, amphibians, reptiles and mammals including human beings.

The biosphere is formed of biotic components. It consists of *organisms, population, community* and *ecosystem*.

7.3 Ecosystem

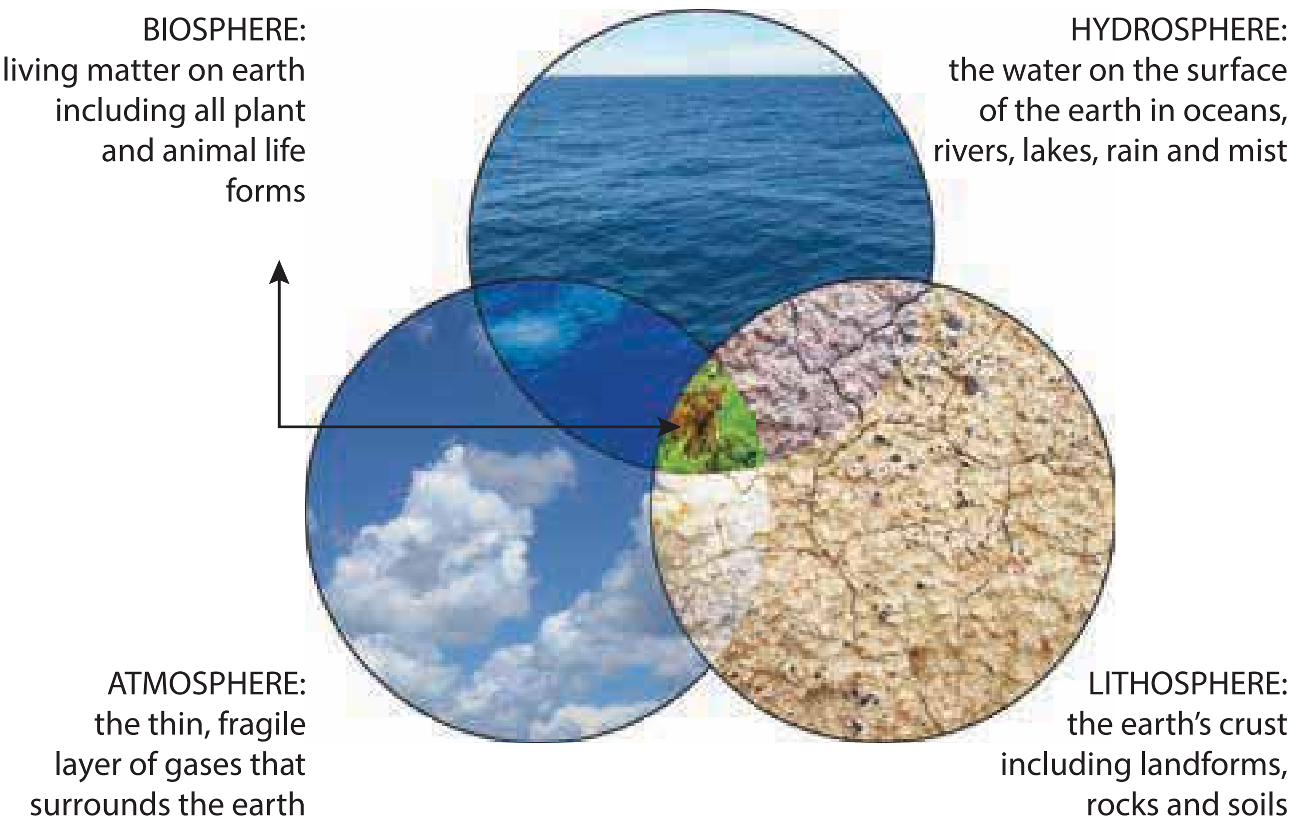


Figure 7.1 Biosphere

Organism – includes animals, plants and micro organisms.

Population – is a group of similar plants or animals living in an area.

Community – refers to all the plants and animals living in an area.

Ecosystem – all living and non living things and their interaction within an area.

Life cannot exist in isolation. It flourishes in an environment which supplies and fulfills its material and energy requirements. A biotic community and its physical environment in which matter and energy flow and cycle is called as ecosystem.

The term *ecosystem* was first proposed by Arthur George Tansley in 1935. Tansley defined ecosystem as, 'the system resulting from the integration of all living and non-living factors of the environment'. The ecosystems can vary in size. It can be very small, extending to about a few square centimeters or it can extend over many square kilometers. Example; tropical forests.

7.3.1. Major components of an ecosystem

The ecosystem is made up of two main components:

A. Abiotic Component and

B. Biotic Component

A. Abiotic Component: This component of the ecosystem includes the non-living substance of the environment. Example; light, air, soil, water, climate, minerals, etc. Sun is the main source of energy for the earth.

B. Biotic Component: This includes a variety of living organisms such as microorganisms, plants and animals. The biotic component of an ecosystem can be further divided into producers, consumers and decomposers based on their capacity to sustain themselves (Figure 7.2).

Ecosystem

https://youtube/aYmdrJWLQ4Y

a. **Producers:** Organisms that can produce or manufacture their own food are known as producers. Plants that have green pigments or chlorophyll, produce their own food in the presence of CO_2 in the atmosphere, water from the soil and sunlight through a process called '*photosynthesis*'. These green plants are called as '*autotrophs*' (auto – self; trophs – nourishing) as they manufacture their own food.

b. **Consumers**: Consumers are organisms that cannot manufacture their own food and get their food and nutrients from producers directly or from other organisms. They are called as '*heterotrophs*' (hetero – others; trophs – nourshing).

Consumers can be divided into primary, secondary and tertiary consumers.

1. **Primary Consumers**
   Organisms that feed on producers (green plants) are called primary consumers. They are also called as '*herbivores*' or plant eating organisms. Examples of terrestrial herbivore

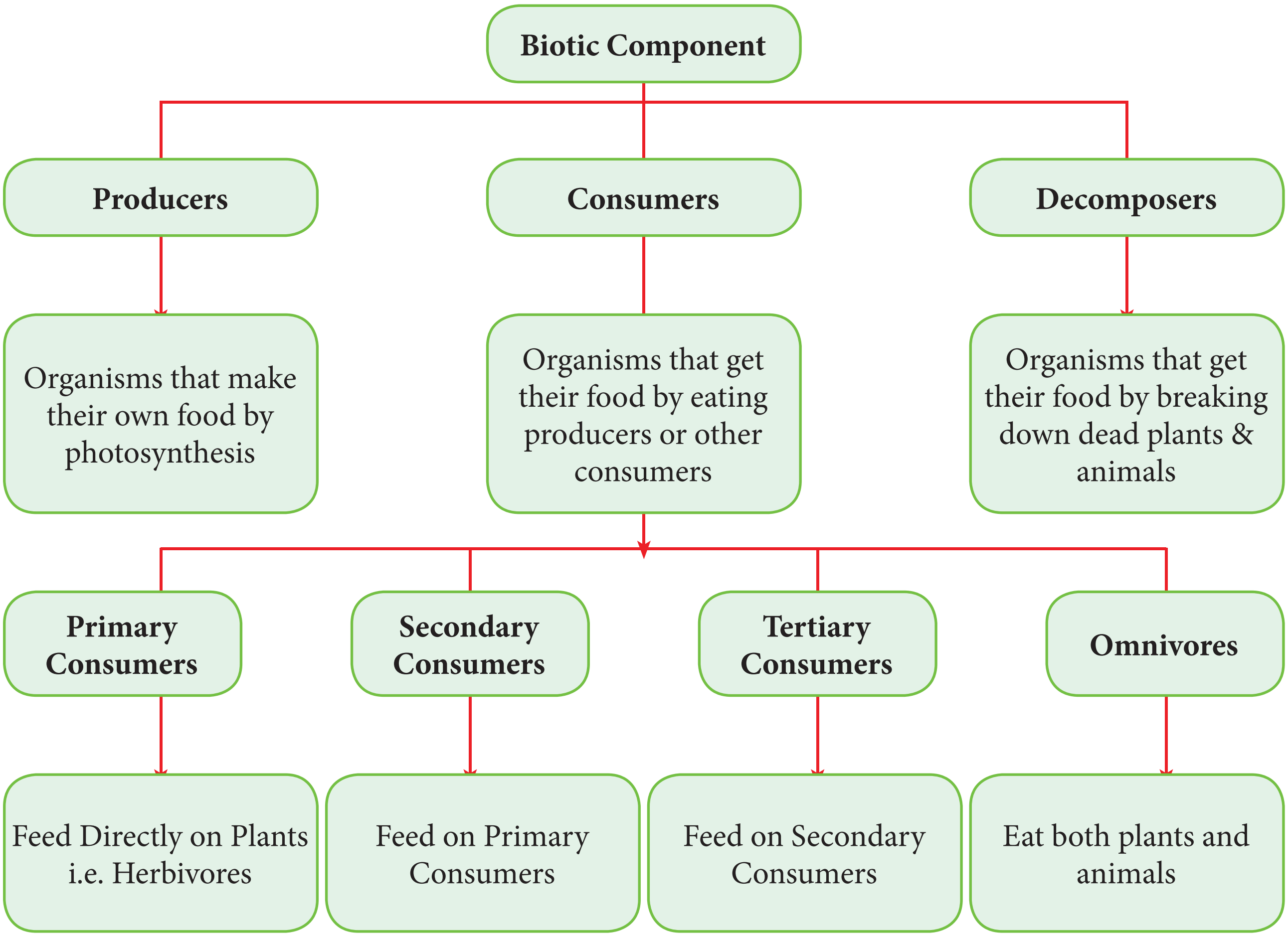


Figure 7.2 Biotic Components

are grasshopper,sheep, goats, cow, rabbit, deer, elephant etc. Examples of aquatic herbivores are zoo plankton, krill, squid, small fish, sea urchin, etc.

2. **Secondary Consumers**
   Animals that kill and eat the herbivores or plant eating animals are called secondary consumers. They are also called as '*carnivores*', Example; lion, tiger, foxes, frogs, snakes, spider, crocodiles, etc.

3. **Tertiary Consumers**
   They are top predators in a food chain. They are carnivores at the topmost level in a food chain that feed on other carnivores or secondary consumers. Example: an owl eats a snake but an owl is eaten by a hawk, therefore a hawk is a tertiary consumer. Tertiary consumers that occupy the top trophic level, and are not predated by any other animals are called '*apex predators*'. However, when they die their bodies will be consumed by scavengers besides the decomposers Example; alligator andhawk.

Some organisms eat both plants and animals. These animals are called as'*omnivores*. Example; cockroach, foxes, seagull and human.

Some omnivores are '*scavengers*', which eat food that other animals have left behind Example; hyena and vultures.

Plants and animals that live on or inside other plants or animals are called as *Parasites*. Example; mistletoe lives on other plants. Other examples are tapeworms, round worms, lice, ticks, flea etc.

'*Detritivores*' are consumers that feed on detritus. Detritus includes fallen leaves, parts of dead trees and faecal wastes of animals. Ants, termites, earthworms, millipedes, dung beetle, fiddler crabs and sea cucumbers are detritivores.

> **DO YOU KNOW?**
> The earthworm is called as the friend of the farmer. Find out the reason why?

4. **Decomposers:** Decomposers are organisms that help decompose dead or decaying organisms. Decomposers are also heterotrophs. Decomposers are nature's built-in recycling system. By breaking down materials – decomposers return nutrients to the soil. They, in turn, create another food source for producers within the ecosystem. Mushrooms, yeast, mould, fungi and bacteria are common decomposers.

7.3.2. Food Chain and Food Web

Every living creature in an ecosystem has a role to play. Without producers, the consumers and decomposers would not survive because they would have no food to eat.

Without consumers, the populations of producers and decomposers would grow out of control. And without decomposers, dead producers and consumers would accumulate as wastes and pollute the environment.

All organisms of an ecosystem depend on one another for their survival. Each organism living in an ecosystem plays an important role in the flow of energy within the system. Organisms need energy for respiration, growth, locomotion, and reproduction. This movement of energy is usually understood through food chains or food webs. While a food chain shows one path along which energy can move through an ecosystem, food webs show all the overlapping ways that organisms live with and depend upon one another.

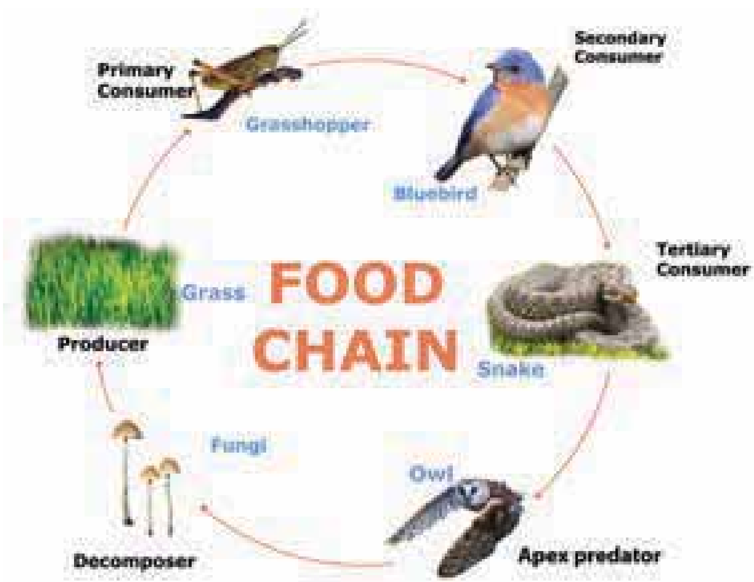


Figure 7.3 Food Chain

A. Food Chain

A food chain describes the flow of food in an ecosystem. This flow or feeding structure in an ecosystem is called '*trophic structure*'. Each level in this structure is called a trophic level. A food chain starts the movement of energy from one trophic level to the next (Figure 7.3). Example; Plant (primary producer) is eaten by a rabbit (herbivores, primary consumer), rabbit is eaten by a snake (carnivores, consumer or primary carnivore)and the snake is eaten by a hawk (tertiary consumer).

Food Web

A Food Web is a complex network of interconnected food chains. Food chains show a direct transfer of energy between organisms.

A chain might involve a mouse eating some seeds on the forest floor, a snake eating the mouse and later an eagle eating the snake.

With each step, some of the energy from the sun, which is trapped within the seeds, is getting passed on.

In a food web, the mouse might eat seeds, but it also might eat some grains, or maybe even some grass. The mouse might be eaten by a snake, or the eagle, or even a fox. The snake could be eaten by the eagle, but also might be eaten by a fox in the forest.

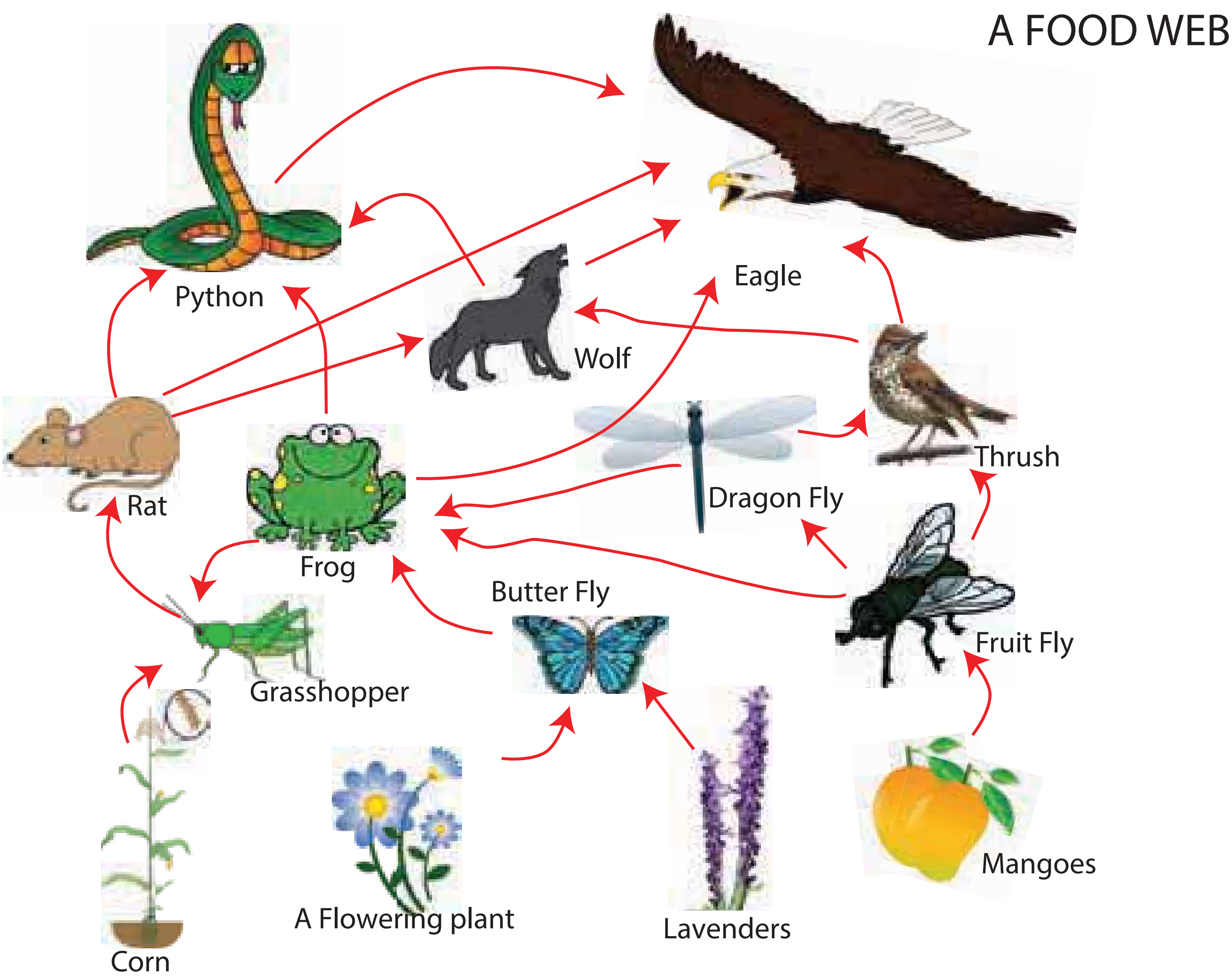


Figure 7.4 Food web

Since each organism can eat multiple organisms and be eaten by multiple organisms, a food web is a much more realistic scheme of the transfer of energy within an ecosystem (Figure 7.4).

Food chains and food webs are found in both terrestrial and aquatic ecosystems.

Organisms in a food chain or food web are linked and dependent on one another for survival. If organisms in one trophic level become threatened, it impacts the organisms in other trophic levels. Primary consumers get less food due to loss or destruction of habitat.

This in turn means less primary consumers for secondary and tertiary consumers to feed on. The plant and animal species in such an environment could become endangered or even extinct. For this reason, it is vital that an ecosystem remains balanced containing an appropriate proportion of producers and consumers.

7.3.3 Energy Flow in an Ecosystem

Energy in an ecosystem flows from producers to consumers. The available energy in a food chain decreases with each step or trophic levels up in the food chain. As such, there is less energy available to support organisms at the top of the food chain. That is why the tertiary

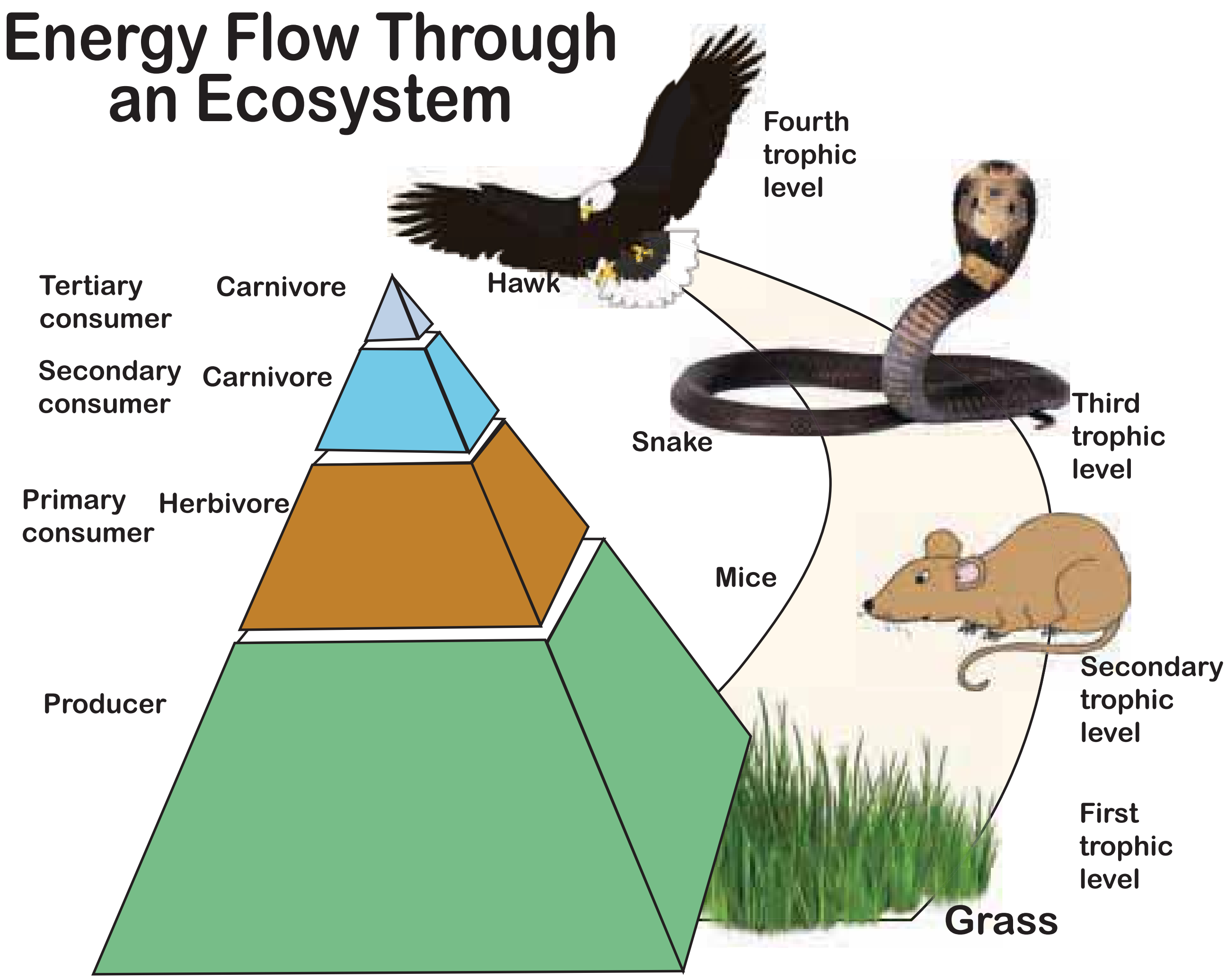
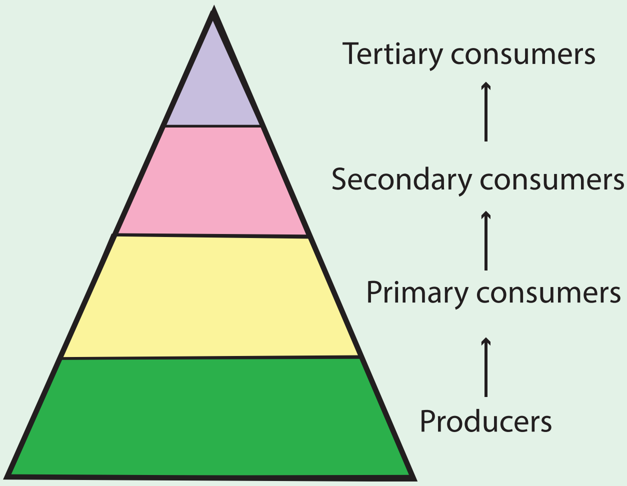


Figure 7.5 Energy Pyramid

Student Activity

Give at least two examples for each level.



Trophic level	Example

and quaternary consumers are far less in number in an ecosystem than organisms at lower trophic levels.

7.3.4 Energy Pyramids

Energy pyramids are another tool that ecologists use to understand the role of organisms within an ecosystem. As you can see, most of the energy in an ecosystem is available at the producer level. As you move up on the pyramid, the amount of available energy decreases significantly. It is estimated that only about 10% of the energy available at one trophic level gets transferred to the next level of the energy pyramid. The remaining 90 percent of energy is either utilized by the organisms within that level for respiration and other metabolic activities or lost to the environment as heat.

The energy pyramid shows how ecosystems naturally limit the number of each type of organism it can sustain (Figure 7.5).

7.3.5 Cycles in an Ecosystem

Nutrients move through the ecosystem in cycles is called '*biogeochemical cycles*'. A biogeochemical cycle is a circuit or pathway by which a chemical element moves through the biotic and the abiotic components of an ecosystem. All life processes are associated with the atmosphere by important cycles such as the Carbon, Oxygen, Nitrogen cycles etc. Through these cycles energy and materials are transferred, stored and released into various ecosystems. Let us discuss one of biogeochemical cycles in detail - the Carbon cycle.

The Carbon Cycle

Carbon is exchanged, or cycled among all the spheres of the earth. All living organisms are built of carbon compounds. It is the fundamental building block of life and an important component of many chemical processes. Living things need carbon to live, grow and reproduce. Carbon is a finite resource that cycles through the earth in many forms.

Carbon is an essential element in all organic compounds and since there is only a limited amount available it must be recycled continuously. This takes place in the biosphere. Atmospheric carbon is fixed in green plants through photosynthesis.

This carbon is passed on to other living organisms through the food chain. The carbon food compound is utilized and later released to the atmosphere through the process of respiration.

By-products of respiration are carbon-dioxide and water which are returned to the air.

A carbon cycle is completed by decomposers like bacteria and fungi which break down dead plants and animal tissues there by releasing some carbon to the air, water and soil.

All producers and consumers are not decomposed. The organic matter of some of them is preserved in fossil fuels such as coal and petroleum for millions of years.

In a carbon cycle (Figure 7.6), carbon moves between reservoirs. Carbon reservoirs include the atmosphere, the oceans, vegetation, rocks, and soil.

Today, the carbon cycle is changing. Human activities have added more carbon into the atmosphere. More carbon is moving to the atmosphere when fossil fuels, like coal and oil, are burned. More carbon is moving to the atmosphere as humans destroy the forest. This increase in carbon in the atmosphere causes the earth to warm up more than the normal level, leading to climate change and many problems connected with it.

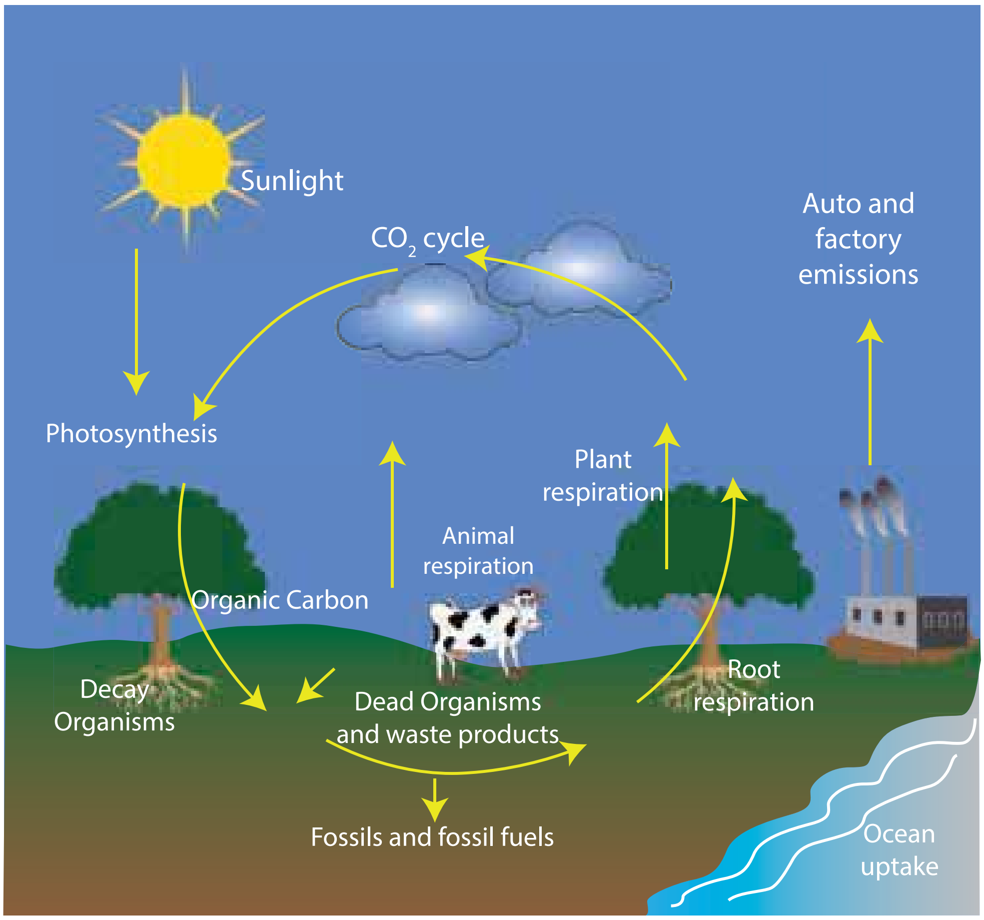


Figure 7.6 Carbon Cycle

DO YOU KNOW?

A **carbon sink** is a natural or artificial reservoir that accumulates and stores carbon for an indefinite period. The process by which carbon sinks remove carbon dioxide (CO_2) from the atmosphere is known as **carbon sequestration**. The main **natural carbon sinks** are **plants**, the **ocean** and **soil.**

7.4 Biomes

An ecosystem as already explained consists of a biological community and an abiotic environment. Ecosystem may be broadly divided into land or *terrestrial ecosystem* and water or *aquatic ecosystem*. The aquatic ecosystem can be further divided into freshwater and marine ecosystem.

An ecosystem becomes a biome when it extends over a large area. According to **I.G. Simmons** (1982) the most extensive ecosystem unit which is convenient to designate is called a '*Biome*'. It may be concluded that a biome is in fact a large ecosystem where we study the total assemblage of plant and animal communities. Since vegetation is the most dominant component of a biome and as vegetation and climate are very intimately related, the world is divided into a number of biomes based on major world climatic types (Figure 7.7).

7.4.1. Types of Biomes

World Biomes are mega ecosystems existing and operating over large areas. These divisions are based on climate pattern, soil types, and the animals and plants that inhabit an area. Basically, biomes are classified into two major groups such as *Aquatic biomes* and *Terrestrial biomes*.

Wetlands are transition zones between aquatic and terrestrial biomes

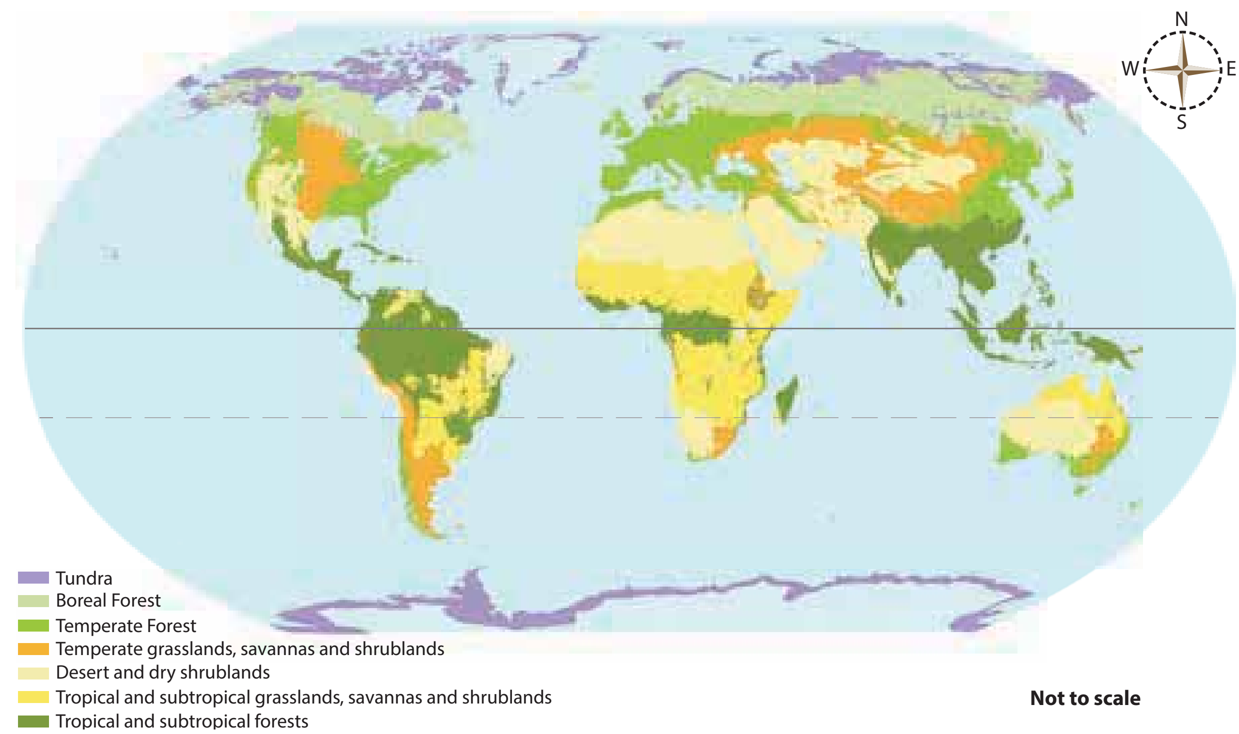


Figure 7.7 Biomes of the World

To understand the earth biomes, it is necessary to understand the following:

1. The characteristics of regional climates.
2. Aspects of the physical environment.
3. The type of soil and the processes contributing to soil development.
4. The distribution of flora in the area.
5. The distribution of fauna in the area and their adaptation to the environment.

A. **Aquatic Biomes**

The aquatic biomes are the most important of all the biomes as, the water forms the vital resource and is essential for any life form. Since many types of species live in the water, it is one of the most important natural resources that need to be protected.

Aquatic Biome is further divided into:

a. Fresh Water Biome and
b. Marine Biome

a. Fresh Water Biome

These biomes are spread over all parts of the earth and have different set of species depending on their location and climate. Fresh water biomes include areas of ponds, lakes, streams, rivers and wetlands. Lakes and ponds are stagnant water bodies and are smaller in their area. The diversity of life forms in river changes with increasing water volume. For example, Dolphins are found in the river Ganges, Brahmaputra and the Indus which carry huge volumes of water.

b. Marine Biome

Marine biome is an aquatic biome which is salt water biome occupying seas and oceans of the world. Marine biome plants have various roles, plants such as sea grasses and macro algae give shelter and nutrient for many animals.

Marine plants are sources of nutrients for the corals and help corals to build up reefs. The reefs are kept intact by plants like coralline algae.

Coral Reefs

Corals are marine invertebrates which live in compact colonies. They inhabit tropical oceans and seas. Corals cannot survive in waters below 20°C but grow optimally in temperatures between 23°–29° Celsius. Coral reefs are marine ecosystems which are held together by structures made of calcium carbonate secreted by the corals. Coral reefs are mainly classified into three types – Fringing reef, Barrier reef and Atoll .

Fact File

Sea grasses are plants that live in saltwater. There are over 50 species of sea grasses. Sea grasses have flowers, roots, and specialized cells to transport nutrients within a plant. This makes them similar to land plants and different from algae or seaweeds.

Fringing reefs grow seaward from the shore along the coast forming a fringe. They are the common type of reefs.

Fringing Reef

Barrier reefs also border the shoreline but are separated from the coast by an expanse of water or lagoon.

Barrier Reef

Atolls are coral reefs that are circular in shape enclosing a lagoon with absence of an island in the center.

Atoll Reef

Marine biome includes fishes, whales, crustaceans, molluscs, sea anemones, fungi and bacteria. Marine species are continuously impacted by change in climatic condition and the oceans are frequently disturbed by ocean waves and currents.

c. Wetlands:

A wetland is an area of land which is permanently or periodically saturated with water and exists as a distinct ecosystem. Wetlands play many roles in the environment, such as water purification, flood control, carbon sink and shoreline stability. Wetlands are home to a wide range of aquatic plants and animal life. Wetlands can be freshwater, brackish, or saltwater. Examples of aquatic vegetation that thrive in wetlands are milkweed, bald cypress trees, mangroves and cattails.

Mangrove

Fact File

Crustaceans are chiefly aquatic arthropods having a body covered with a hard shell or crust and several pairs of legs. Example: crab, lobsters, crayfish, barnacles shrimps, krill etc.

Molluscs are organisms with soft bodies. Often their bodies are covered by hard shells. Example: snail, slug, squid, cuttlefish, mussel, clams, oysters, octopuses etc.

Swamp

Marshland

Fen

B. Terrestrial Biome

Terrestrial biomes are very large ecosystems over land and they vary according to latitude and climate. They can be divided into numerous sub-types. In this lesson they are broadly divided into eight types.

Fact File

A Bog is a type of wetland ecosystem characterized by wet, spongy, poorly drained peaty soil formed from dead plants specially moss. Bogs have moss, sedges, grasses, such as cotton grass; insectivorous plants like pitcher plants; and many orchids. The gradual accumulation of decayed plant material in a bog functions as a carbon sink.

A Fen is a low land that is covered wholly or partly with water. They receive nutrients from ground water and have peaty alkaline soil. Their characteristic flora are sedges and reeds.

Mangrove swamps are coastal wetlands found in tropical and subtropical regions. These wetlands are often found in estuaries, where fresh water meets salt water. Mangrove trees dominate this wetland ecosystem due to their ability to survive in both salt and fresh water. The Sundarbans is the largest Mangrove region in the world and a UNESCO World Heritage Site.

Mangrove forests of Tamil Nadu: Mangrove forests are found along the coast of Tamil Nadu in Pichavaram, Muthupet, Ramnad, Gulf of Mannar and Punnakayal.

i. Tropical Evergreen Rain Forest Biome

Tropical Evergreen Rain Forest Biome extends between 10° North and South of the equator (Figure 7.8). This biome is seen in the Amazon Basin of South America, Congo Basin of Africa and the Indo Malaysian Region of Southeast Asia (Java, Sumatra, Borneo, Malaysia and Guinea)

This biome receives direct sunlight throughout the year and so temperatures are high year round. The average annual temperature is 20°C to 30°C. The average annual rainfall of the tropical evergreen rain forest is 200cm.

The Tropical Evergreen Rain Forest Biome has the largest number of plant and animal species. Broad leaved, tall evergreen hard wood trees are found in this biome. Trees grow up to 20 to 35 meters high. The forest is characterized by thick undergrowth and creepers. The main trees in this biome are mahogany, rose wood, ebony, cinchona, rubber, coconut palm, cane, bamboo etc.

This forest biome has innumerable insects, birds, reptiles and furless animals. At the edge of the forest animals like gorilla, and monkey are found.

Important tribes inhabit this biome, for example the Pygmies in the jungles of Africa and the Yanomani and Tikuna tribes of the Amazon region. Traditionally they live by hunting and gathering food. In the recent years in South East Asia, the tropical evergreen rainforest has been slowly replaced by rubber and sugarcane plantations. The human settlements in this biome are small and scattered.

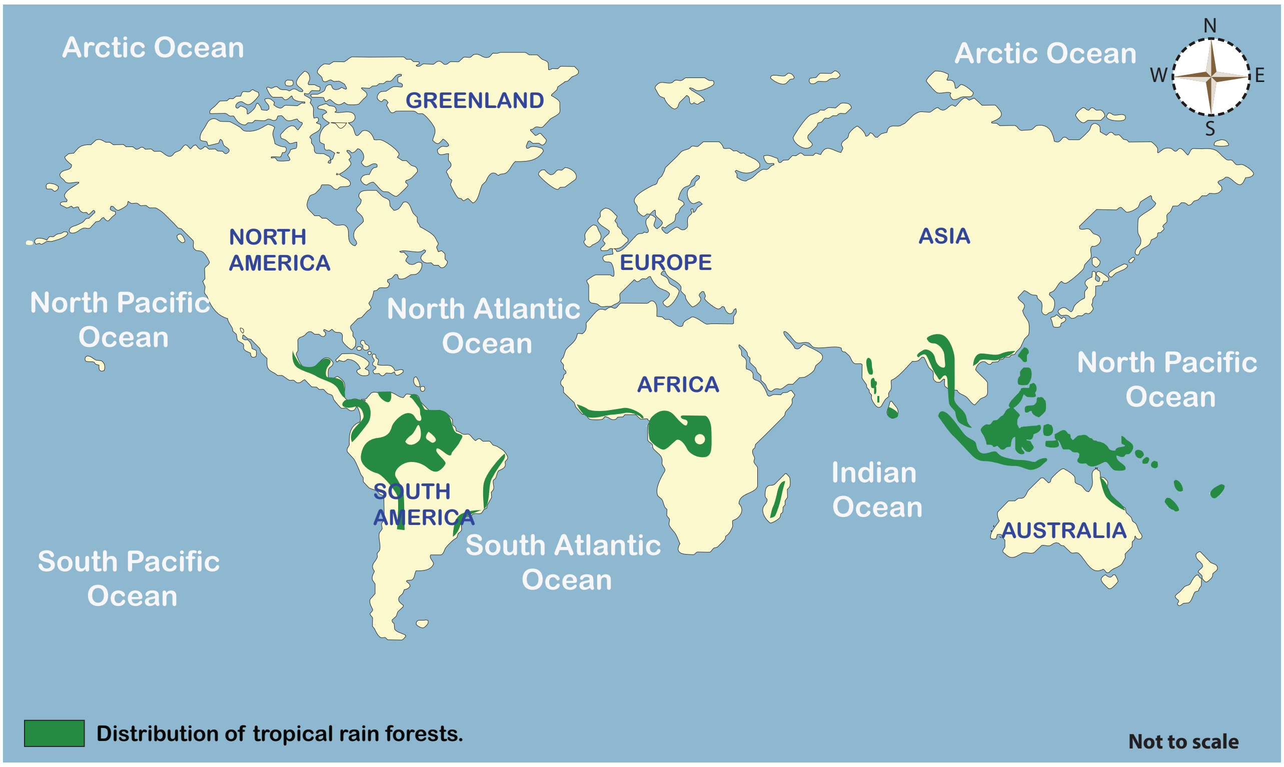


Figure 7.8 Tropical Evergreen Forest Biome

DO YOU KNOW? The forests of the Silent Valley National Park in Kerala on the Western Ghats are the last remaining tropical evergreen forests in India. It is part of the Nilgiris Biosphere Reserve

Tropical Rain Forest

Student Activity

1. On the outline map of the world draw the equator and colour and label the following.
2. Show the areas of tropical rain forest, tropical grass land, and Tropical desert in Africa and South America in both the hemispheres.
3. Colour and label the Taiga forest and it is the longest belt of distribution. Reason out why so.

   ____

   ____

4. Find out why Tropical deserts are on the western margins of the continents.

   ____

   ____

5. Give two reasons for their pole ward distribution.

   ____

   ____

ii Tropical deciduous Forest/Monsoon Forest

Tropical Monsoon forest

Tropical deciduous forest is found in the regions experiencing monsoon climate. This biome is also called as the dry forest or monsoon forest biome.

This is found in South and South East Asia in parts of India, Myanmar, Vietnam, Thailand, Cambodia and southern coastal China. It is also found in eastern Brazil and in smaller areas in South and Central America, the West Indies, southeastern Africa, and northern Australia.

In this biome, the temperature varies from one season to another season. In summer the maximum temperature ranges from 38°C to 48°C. Summer season is warm and humid. In the dry winter season temperature ranges between 10°C to 27°C. The total amount of precipitation is 75 to 150 cm/year and this affects the natural vegetation of the tropical deciduous forest biome.

The plants shed their leaves during the dry season. Trees here have huge trunks with thick rough barks. The plants grow at three different levels. The common trees are teak, sal, sandalwood, mahua (illupai), Mango, Wattle, Bamboo, semal (Illavamaram), sheesham (Karuvellamaram) and banyan.

The animals of this biome are elephant, lion, tiger, leopards, bison, tapier, hippopotamus, wild boar, flying squirrel along with a wide variety of bird species. This biome faces rapid rate of deforestation and is, therefore, one of the most disturbed ecosystem in the world. Large tracts of forests have been destroyed for agriculture and urban development. Several species of precious animals have now become endangered Example: lions, tigers, leopards, etc.

iii. Temperate Deciduous Forest Biome

The temperate deciduous forest is a biome that is always changing. This biome lies in the mid- latitude areas of the earth, between the tropics and Arctic Circle i.e., between 30° and 50° north and south of the equator. The temperate deciduous forest biome can be seen in the eastern United States, most parts of Europe, China, Japan, North and South Korea (Figure 7.9). The average annual temperature is 10°C.

These biomes have four seasons such as winter, spring, summer and fall. Winters are cold and summers are warm. As winter approaches, the duration of day light decreases. In this biome, deciduous trees shed their leaves in the fall. The production of chlorophyll in the leaves slows and eventually stops revealing leaves having bright red, yellow and orange colors. These forests are also known as broad leaved forest, because the trees have wide flat leaves. Some important trees found here are oak, maple, beech, hickory, cedar and chestnut. On the forest floors

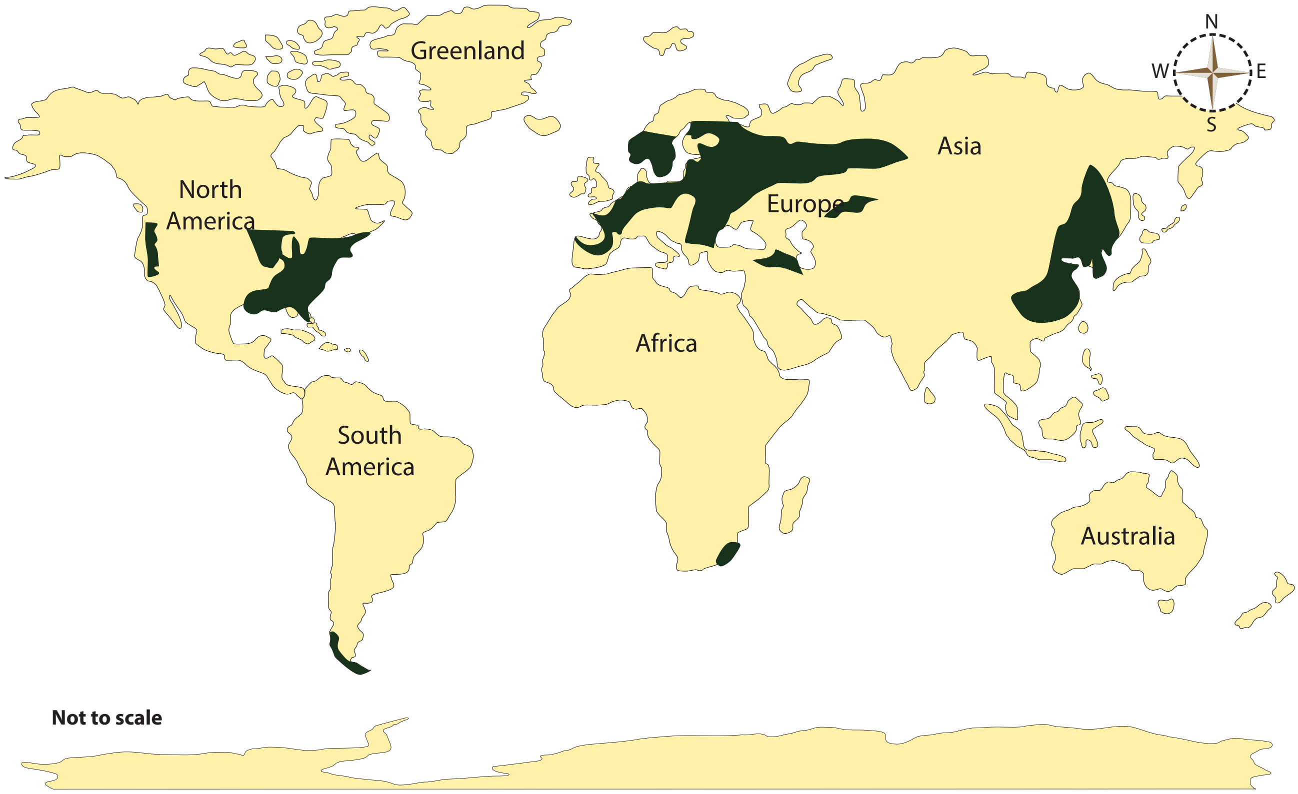


Figure 7.9 Temperate Deciduous Forest Biome

that receive very little sunlight are found mosses, azaleas and mountain laurels.

Inhabiting the temperate deciduous forest are ants, insects, flies, bees, wasps, cicadas, walking sticks, moths, butterfly, dragon flies, mosquitoes and praying mantises.

Frogs, toads, snakes and salamanders are some of the reptiles in this biome. Common birds found in this biome are woodpecker, robin, jays, cardinals, owls, turkeys, hawks and eagles. Small mammals like rabbits, otters, monkeys, beavers, squirrels and porcupine are also seen in this biome along with bears, grey fox, wolves, white tailed deer and moose. Animals that live in this biome adapt to the changing seasons. Some animals migrate or hibernate in winter.

Most of this forests on the earth are cleared for agriculture. The soil here is very fertile. This is one of the most important agricultural regions of the world.

Grasslands

Grasslands are found bordering the deserts and make up for one fourth of the natural vegetation of the earth. Those that lie in the low latitudes are called tropical grasslands and the ones which lie in the mid latitudes are called temperate grasslands.

Kangaroo in Australian savanna

iv Tropical Grassland Biome or Savanna Biome

The tropical grass land biome is generally referred to as the Savanna biome. A savanna is a rolling topography that features vast open grasslands scattered with small shrubs and isolated trees. It is found between the tropical rainforest and desert biome. Tropical grassland biomes are mainly found in Africa, South America and Australia. Tropical grasslands in Africa is known as the savannas. Tropical grasslands are called as llanos in Columbia and Venezuela and as Campos in Brazil of South America.

Savanna biomes experience warm temperature year around. It has very long and dry winter season and a very wet summer season. The grass here is very tall often one or two metres tall scattered with small shrubs and isolated umbrella shaped trees like the acacia and the baobab trees which store water in their trunks.

Most of the animals in the savanna have long legs, like the giraffe and kangaroo. The carnivorous animals like lions, leopards, cheetahs, jackal and hyenas live in this biome. Zebras and elephants are also found in this biome.

African Savanna

Baobab tree

In many parts of the savannas of Africa people have started using the grassland for grazing their cattle and goats. Due to overgrazing in this region most of the tropical grasslands here are lost to the Sahara desert year after year.

v. Temperate Grassland Biome or Steppe

The temperate grassland biomes are generally found in the interior of the continents in the mid latitudes. These grassland biomes are found in the transitional zone between the humid coastal areas and the mid latitude deserts.

The temperate grasslands are known as Steppes in Europe and Asia, Prairies in North America (Canada and USA), Pampas in South America, Veldts in South Africa, Downs in Australia and Puszta in Hungary. The annual range of temperature is quite large with summer temperature reaching as high as 38°C and winter temperatures falling down to -40° C. The rainfall is moderate from 25 cm to 50 cm. Grasses form a major part of the vegetation in the temperate grasslands.

The height of the grasses depends upon the amount and distribution of rainfall.

Bison in Prairie

Prairie Dogs

The animals in this area include the bison, wolves of the Prairies of North America. The other animals and birds are coyotes, prairie dog, foxes, mice, rabbits, badgers, rattle snakes, pocket gophers, weasel, grasshoppers, quails and hawks.

Sahara Desert

Thar Desert

vi. Tropical Desert Biome

A tropical desert is the hottest and driest place on earth where rainfall is very scanty and irregular. This biome is typically found in the western parts of the continents within the tropics.

In the northern hemisphere, the Afro – Asian deserts form the longest belt which includes the Sahara desert, Arabian desert and the Thar deserts. In North America the tropical deserts cover, California, Arizona and New Mexico states of USA and it further extends to Mexico. The deserts in the southern hemisphere are, the Atacama desert west of Andes mountains in South America, the Namibian and the Kalahari deserts in southern Africa and the Great Australian desert in the central and southern parts of Australia.

The tropical deserts are not conducive for the growth of vegetation due to shortage of water. The plants found here are the *xerophytes* which have their own moisture conserving methods such as long roots, thick barks, waxy leaves, thorns and small leaves so as to avoid evapo-transpiration.

The main trees and bushes found in this region are acacia, cacti, date palm, kikar, babul etc.

Succulent

Cacti

The animals in this biome are limited in number. They are able to bear the drought and the heat of the desert. Animals like the camel, antelopes, fox, spotted hyena, fallow deer, cape hare, hedgehog etc., live in the desert.

The tropical desert biomes are agriculturally unproductive except in and near the oasis. In the oasis, cultivation is carried through irrigation either from streams or from underground sources. Date palms are widely grown here.

Oasis in Sahara

The people in the deserts are generally nomads living in tents and moving from place to place. They are the Berbers of North Africa, the Bedouins of the Arabian deserts, the Damara in Namibia, the Bushman of the Kalahari Desert and the Aborigines of Australia. They practice food gathering and hunting while some herd cattle, goats and camel and some of them practice very simple subsistence farming.

Bedouin Tent in Sahara

Settlement in Thar Desert

One of the toughest foot races in the world is held in Sahara every year in April. This race is called The Marathon des Sables (MDS) and participants have to cover a distance of 250km over Sahara desert in southern Morocco in a span of 7 days. About 1500 participants aged between 16 to 79 from all over the world participate in this race.

Source : Morocco World News

Vii. Taiga or Boreal Forest Biome

The taiga biome is the largest terrestrial biome and extends across Europe, North America and Asia. The taiga biome is also known as coniferous forest or boreal forest biome. It extends from about 50° to 55° North to 65 ° to 70° North latitudes. This region lies between the temperate grassland in the south and the polar tundra in the north. The taiga region is absent in the southern hemisphere mainly because of the narrowing of continents towards the South Pole.

This biome has short wet summer and long cold winters. The taiga region has low mean annual precipitation ranging between 35 cm and 60 cm and the rainfall occurs mostly in summer. It receives plenty of snow during winter.

The taiga or boreal forest biome consists mainly of evergreen coniferous forests. The important coniferous trees in this biome are pines, spruces, firs, maples and cedars. During the short summer season snow melts and this helps lichens, mosses and short grasses to grow and cover the ground. These are called 'meadows'.

Taiga is the home of some larger animals like moose, deer, and bears, while smaller animals like bobcats, squirrels, chipmunks, ermine, and moles are also found. Animals of the taiga have specialised adaptation including lot of thick fur or feathers and the ability to change colours during different seasons example ermine.

Coniferous forest

Siberian Tiger

Fact File

The **ermine** is a small mammal, which is covered with thick dark brown fur in summer. This changes to white in the winter, an adaptation which helps the ermine to blend into its surroundings and makes it more difficult for the predators to spot them.

Ermine

Moose

Lumbering is the main occupation of the people in areas which are easily accessible. The softwood from the coniferous forests is widely used in the manufacture of wood pulp and paper, newsprint, matches, furniture and building materials.

The hunting of fur bearing animals like musk rats, ermine, and silver fox are important economic activities. The taiga forest is endangered due to logging and mining by humans. When trees are cut down in the taiga it takes a very long time to restore itself because of the very short growing season.

Viii Tundra Biome

Tundra is a Finnish word which means barren land. The tundra region is a vast bowl lying beyond the Arctic Circle (66.5° North latitude) in the northern hemisphere along the shores of the Arctic Ocean. The Arctic tundra extends southwards from North Pole to the Taiga forest. Tundra is also found in the high altitudes especially in the Alpine region.

Due to long and severe cold winters, this region is treeless and has very little vegetation. The growing season for plants is very short. Natural vegetation mainly consists of shrubs, sedges, grasses, mosses and lichens.

Bearberry

Lichen

Cotton Grass

Polar Bear

Arctic Fox

Caribou

Musk Ox

The main features of this climate in the tundra region are the general absence of insolation and presence of very low temperature throughout the year. The average annual temperature is about -12°C. The ground surface is covered with snow for at least 8 to 9 months in a year.

In this biome, the sub soil remains permanently frozen and is known as permafrost. Permafrost tundra covers vast barren areas of northern Russia and Canada. Algae and fungi are found on the rocky cliffs and rosette plants grow in rock and gravel beds. Spongy turf and lichen develop in the drier inland tundra.

Animals common to Arctic tundra are the polar bear, arctic wolf, arctic fox, arctic hare and arctic weasel. Large herbivores such as musk oxen, caribou and reindeer are found. Lemmings are also found in this Biome. Insects like moths, butterflies, beetles, mosquitoes and black flies are common in the Arctic tundra. Migratory birds include tundra swans, harlequin ducks, sand pipers, plovers, geese and gulls.

The Antarctic region is covered with ice sheets. It is too cold and dry to support vegetation. However, some portions of the continent have areas of rocky soil that support plant life. Vegetation comprises of mosses, lichens and liver worts. This area is referred to as Antarctic tundra. Seals and Penguins inhabit the shore areas of Antarctica.

7.5. Biodiversity

The term biological diversity was used as early as 1968 by wildlife conservationist Raymond F. Dasmann. Latter in 1988, entomologist E.O. Wilson used the term Biodiversity and this term has been used since then. Biodiversity refers to the variety of life on Earth. This includes the number of species of plants, animals and microorganisms along with the diversity of genes in these species. Moreover, it embodies the different ecosystems on the planet, for example forests, deserts, coral reefs and wetlands.

Biodiversity is the variability among living organisms. This includes diversity within species, between species, and between ecosystems. The variety of biodiversity or the number of species in a given area is referred to as species richness. Normally variety of life increases with size of area.

Biodiversity can be identified at three levels:

A. Genetic diversity

B. Species diversity and

C. Ecosystem diversity

A. Genetic diversity refers to the total number of genetic characteristics in the genetic makeup of a species. Example: Each human being is very different from others. Genetic diversity helps the population to adapt to changes in the environment or adapt to different environments. Domestication of dogs can be taken as a common example.

B. Species diversity is the number of different species of plants and animals that are present in a region. A community with more number of species enjoys species richness. Naturally undisturbed forests have greater species richness than reforested areas or plantations.

There are three types of Species:

a. **Endemic species** - is one whose habitat is restricted only to a particular area because of which it is often endangered. It differs from "indigenous," or "native," which although it occurs naturally in an area, is also found in other areas.

b. **Exotic Species** - is any species intentionally or accidentally transported and released by man into an environment outside its original range. These are often the most severe agents of habitat alteration and degradation, and a major cause of the continuing loss of biological diversity throughout the world.

c. **Cosmopolitan Species** – It is a species that is found to be distributed over most regions of the earth example: cats, dogs, human beings. The killer whale is considered as the most cosmopolitan species in the world.

C. Ecosystem diversity refers to the variety of life forms in a prescribed ecosystem. Ecosystems may be both terrestrial and aquatic. Distinctive terrestrial ecosystems include forests, grasslands, deserts, etc. while aquatic ecosystems are rivers, lakes, oceans etc.

In understanding biodiversity, the most common question that arises in our mind is how many different plant and animal species are there on earth? There can be no definite answer to this question. At present the conservation scientists have identified over 8.7 million species worldwide. Of this only about 2 million are known to us ranging from microorganisms to giant mammals and reptiles. New species are being discovered while many species are also disappearing from the face of the earth.

7.5.1. Biodiversity hotspots

Areas that are rich in species diversity are called as “Hotspots”. The hottest spots for species diversity are the tropical rainforests. Tropical rainforests comprise of only 7% of all land on earth, yet are home to nearly 50% of all the species on Earth! India is among the World’s 17 nations that are exceptionally rich in species diversity.

The British biologist Norman Myers coined the term ‘biodiversity hotspot’ in 1988. According to him, a biodiversity hotspot is a biogeographic region characterised both by exceptional levels of plant endemism and by serious levels of habitat loss. **Conservation International** (CI) adopted Myers concept of ‘hotspots’ and it made an extensive global study of hotspots in 1999. According to CI, to qualify as a hotspot a region must meet two strict criteria: (i) It must contain at least 1,500 species of endemic plants, and (ii) It must have lost at least 70% of its original habitat. In 1999, CI’s book ‘Hotspots: Earth’s Biologically Richest and Most Endangered Terrestrial Ecoregions’, identified 34 biodiversity hotspots in the different countries of the world.

Currently there are 34 biodiversity hotspots that have been identified and, most of them occur in **tropical forests** (Figure 7.10). They represent just 2.3% of Earth’s land surface, but between them they contain around 50% of the world’s **endemic** plant species and 42% of all terrestrial vertebrates.

826GGG

India has 4 **biodiversity hotspots**: the Western Ghats, the Himalayas, the Indo-Burma region and the Sundaland [includes Nicobar group of Islands].

CASE STUDY

Norman Myers (born 24 August 1934) is a British environmentalist specialising in Biodiversity **hotspots**. Professor Norman Myers was the first to alert global community to tropical deforestation, the mass extinction underway and environmental security.

Fact File

Endemism is an ecological word meaning that a plant or animal lives only in a particular geographical location, such as a specific island, habitat type, country or any defined zone. For example, The **Asiatic Lion** of the Gir forest of Gujarat. The **Kashmir Stag** known as Hangul, which is found in the riverine forests of Kashmir Valley and Chamba in Himachal Pradesh. The **Lion Tailed Macaque** is India’s most threatened monkey which is endemic to the Western Ghats of South India.

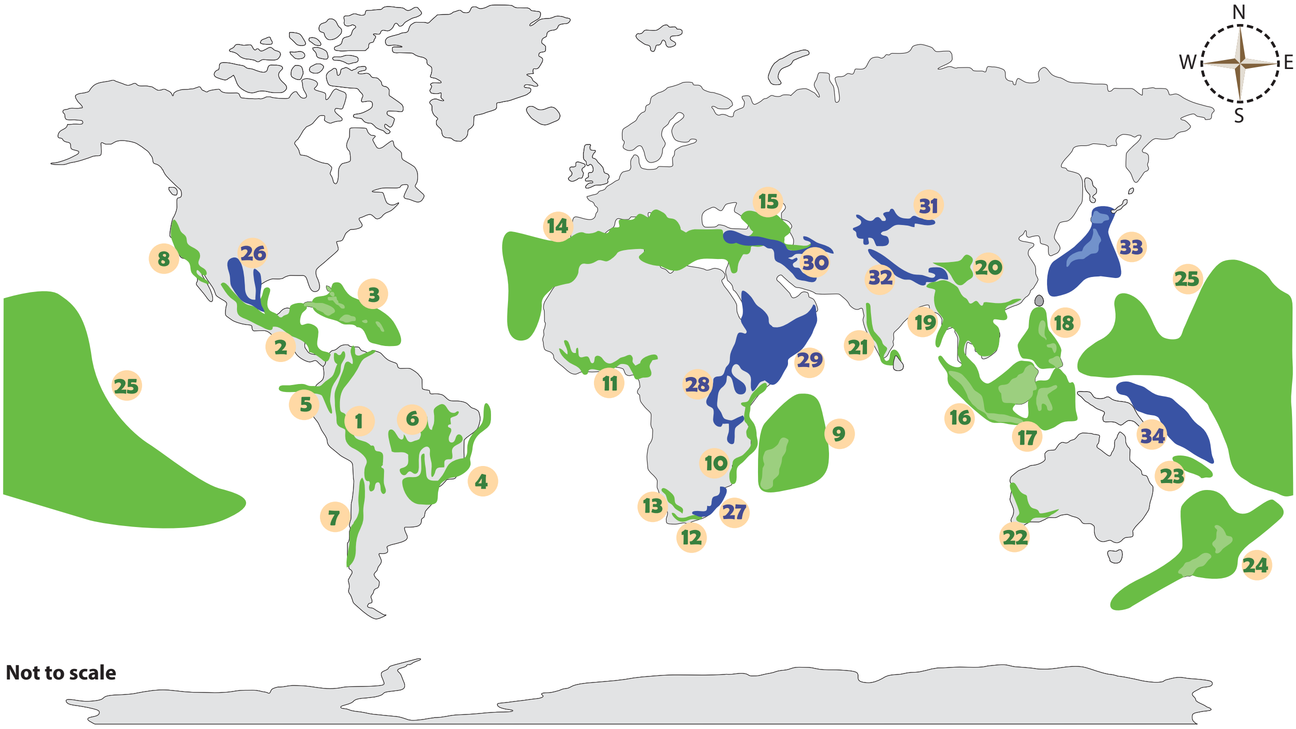


Figure 7.10 Biodiversity hotspots of the world

The 34 biodiversity hotspots of the World			
1	The Tropical Andes	18	The Philippines
2	Mesoamerica	19	**Indo-Burma**
3	The Caribbean Islands	20	The Mountains of Southwest China
4	The Atlantic Forest	21	**Western Ghats and Sri Lanka**
5	Tumbes-Chocó-Magdalena	22	Southwest Australia
6	The Cerrado	23	New Caledonia
7	Chilean Winter Rainfall-Valdivian Forests	24	New Zealand
8	Chilean Winter Rainfall-Valdivian Forests	25	Polynesia and Micronesia
9	Madagascar and the Indian Ocean Islands	26	The Madrean Pine-Oak Woodlands
10	The Coastal Forests of Eastern Africa	27	Maputaland-Pondoland-Albany
11	The Guinean Forests of West Africa	28	The Eastern Afromontane
12	The Cape Floristic Region	29	The Horn of Africa
13	The Succulent Karoo	30	The Irano-Anatolian
14	The Mediterranean Basin	31	The Mountains of Central Asia
15	The Caucasus	32	**Eastern Himalaya**
16	**Sundaland**	33	Japan
17	Wallacea	34	East Melanesian Islands

Do You Know?

Conservation International (CI) is an American non-profit environmental organization founded in 1987 in Virginia. Its goal is to protect nature as a source for food, fresh water, livelihood and a stable climate.

CI has helped to support 1,200 protected areas across 77 countries, safeguarding more than 601 million hectares of marine and coastal areas.

7.6 Endangered species

Rare, endangered or threatened plants and animals are elements of our natural heritage that are declining rapidly. If we cherish these species, like we do other rare and beautiful objects, these living organisms become treasures of the highest magnitude.

The International Union for the Conservation of Nature (IUCN) has identified and classified species based on the nature of their depleting numbers. The IUCN's Red List of Threatened Species, identified in 1964, is the world's most important inventory of the global conservation status of biological species.

Species are classified by the IUCN Red List into nine groups specified through criteria such as rate of decline, population size, area of geographic distribution, and degree of population and distribution fragmentation (Figure 7.11).

- Extinct (EX) – The species has disappeared and no known individuals remaining
- Extinct in the wild (EW) – Known only to survive in captivity, or as a naturalized population outside its historic range
- Critically Endangered (CR) – Species that have drastically dwindled and are at extremely high risk of extinction in the wild
- Endangered (EN) – High risk of extinction in the wild
- Vulnerable (VU) – High risk of endangerment in the wild
- Near threatened (nt) – Likely to become endangered in the near future.
- Least concern (lc) – Lowest risk widespread and abundant

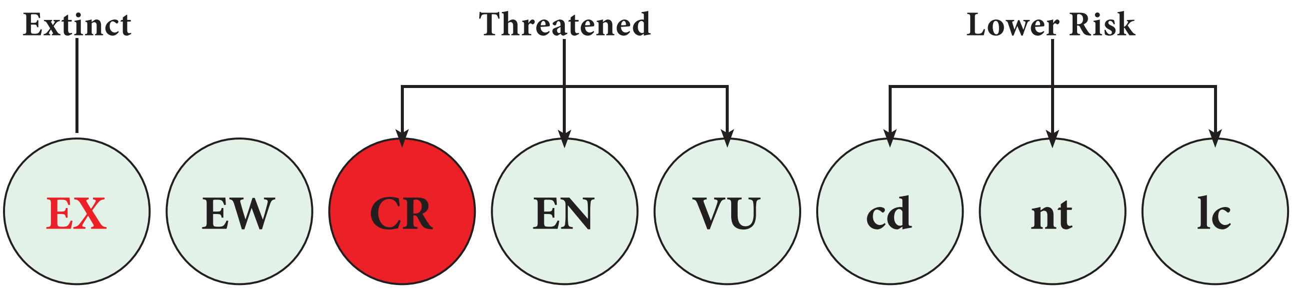


Figure 7.11 Species Classification by IUCN

- Conservation dependent (cd) – This group has now merged with near threatened.
- Data deficient (dd) – Not enough data to assess the risk of extinction of the species.
- Not evaluated (ne) – Species not yet been evaluated against the criteria.

In the context of the IUCN Red List, 'threatened' embraces the three categories of Critically Endangered, Endangered, and Vulnerable.

According to the IUCN those species that have dwindled drastically are called as Critically Endangered and are included as Red List. Species that have disappeared are called as extinct species. In the Red List of 2012 that was released on 19 July 2012 at Rio+20 Earth Summit 19,817 species were threatened with extinction.

Fact File

The IUCN Red List of Threatened Species (also known as the IUCN Red List or Red Data List), founded in 1964, is the world's most comprehensive inventory of the global conservation status of biological species. The International Union for Conservation of Nature (IUCN) is the world's main authority on the conservation status of species. A series of Regional Red Lists are produced by countries or organizations, which assess the risk of extinction to species within a political management unit.

A Hawaiian plant species called Alula locally referred to as cabbage on a stick has moved from Critically Endangered to Extinct in the Wild. It is one of the 38 Red Listed Hawaiian plant species with less than five wild individuals remaining. It used to grow on the windy sea cliffs of Kauai. Alula was destroyed by hurricanes Iwa and Inki in 1982 and 1992 leaving only less than 10 plants alive.

The majority of the great ape species are now Critically Endangered. The Eastern Gorilla the largest living primate is endemic to the Eastern Democratic Republic of Congo, south western Uganda and Rwanda. This species which was listed as Endangered has moved to Critically Endangered in 2016 due to an ongoing population decline. This decline is due to illegal hunting and destruction of forests for agriculture. If this trend continues, around 93% of Eastern Gorillas will be eliminated by 2054.

The **Pygmy Hog:** It is the smallest and rarest wild pig on earth and it is a **Critically Endangered** species previously spread across Bangladesh, Bhutan, India and Nepal. but now only found in Assam, India. In 1995, the Pygmy Hog Conservation Programme was started by Goutam Narayan of Ecosystems-India, with the help of the Assam government and now their numbers have increased to about 150.

There are many other critically endangered species in India and some of them are listed below

7.6.1. Critically Endangered species in India 2016

Arthropoda

- Rameshwaram parachute spider
- Peacock tarantula

Birds

- White-bellied heron
- Great Indian bustard
- Forest owlet
- Spoon-billed sandpiper
- Siberian crane
- Indian vulture
- Himalayan quail
- Pink-headed duck

Fish

- Wayanad mahseer
- Pondicherry shark
- Ganges shark
- Pookode Lake barb
- Common sawfish

Insects

- Pygmy Hog Sucking Louse

Reptiles and amphibians

- Madras spotted skink
- Gharial
- Toad-skinned frog
- Charles Darwin's frog
- White-spotted bush frog
- Munnar bush frog
- Ponmudi bush frog
- Anaimalai flying frog

Mammals

- Asiatic cheetah
- Namdapha flying squirrel
- Himalayan wolf
- Andaman shrew
- Nicobar shrew
- Northern Sumatran rhinoceros
- Chinese pangolin
- Pygmy hog
- Indian Javan rhinoceros
- Malabar large-spotted civet

7.6.2. The Recent Red List (2017)

The plant Alliumiatrouinum of the Mediterranean, belonging to the onion family was added to the IUCN Red List as **Critically Endangered** (CR) in 2017. Currently this plant is known to exist only on Mount Ochi in the southern part of Evvia Island, Greece. It is understood that the threat was from the numerous wind parks and wind turbines developed in the area.

An endemic species of small trees growing at low altitudes in New Caledonia called *Pittosporum brevispinium* has declined causing it to move from Endangered to **Critically Endangered** in 2017. The species decline has been attributed to conversion of dry forests to pasture land and degradation of forest by the Rusa deer.

The **Red-legged Fire Millipede** is found in the rainforests of Madagascar. It entered the IUCN Red List in 2017 as, **Critically Endangered (CR)**.The degradation of its habitat due to slash and burn agriculture and cutting of trees for firewood by local communities has caused its decline.

The IUCN Red List in 2017 declared the **Christmas Island Whiptail-skink** endemic to Christmas island as **Extinct.** The last known individual died in captivity in 2014. This dramatic decline and extinction was due to the impact of the introduction of Yellow Crazy Ant, Indian Wolf Snake and other new species on Christmas Island along with deforestation due to mining.

The status of the **Rodrigues Flying Fox** moved from Critically Endangered to **Endangered in 2017**. This was due to a number of conservation measures taken, such as, captive breeding programme involving 46 zoos around the world, restoration of natural habitat, watershed protection, and awareness rising through education programmes. Its population has increased from 4,000 in 2003 to about 20,000 individuals in 2016. The future survival of this species will depend on continued conservation efforts.

7.6.3. Causes of Extinction of Species

Extinction is defined as the permanent disappearance of an organism from the face of the earth. In other words, all members of a species have died. This means a loss of biodiversity. Extinction of species may take place (Figure 7.12) due to a variety of causes as given below:

1. Sudden and rapid changes of environmental conditions
2. The sudden outbreak of disease and pest infections.
3. Some sudden events like forest fires, volcanic eruption etc.
4. Direct hunting and persecution of species leading to 'selective mass extinction.
5. Ecological substitution by other species of large carnivorous animals which compete for the same food resources.
6. Climatic change accelerates the competition between large mammals for shelter and food.
7. Extinction of weak species during the course of competition with more powerful and stronger species.
8. Man-induced environmental changes also cause species extinctions.

Between 1600 and 1900 it is estimated that one species went extinct every four years. In modern times, the rate is soaring. The graph below (Figure 7.12.) shows how the rate of extinction of species has increased over the past 50 years. This could be attributed to the rapid increase in population during the same period of time.

According to IUCN the rate of extinction of mammals and birds had started much earlier by 1700 itself at a much faster rate as shown in the graph below (Figure 7.13).

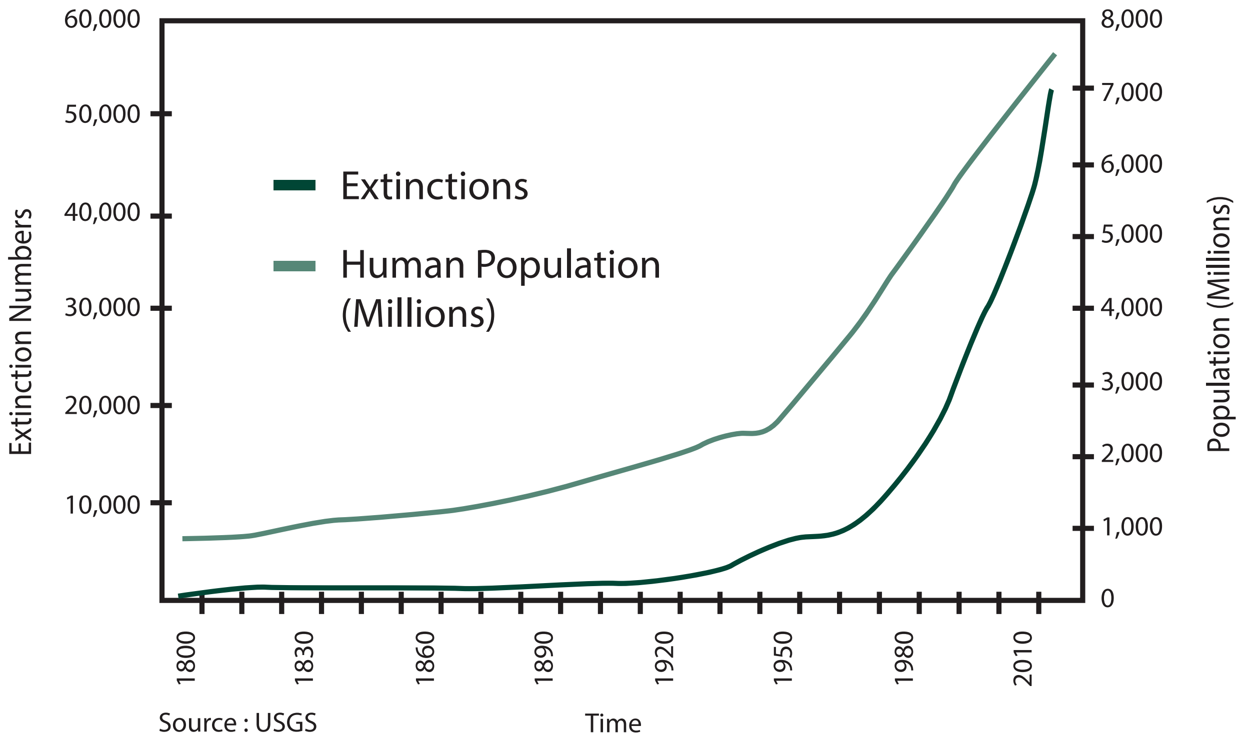


Figure 7.12 Species Extinction and Human Population

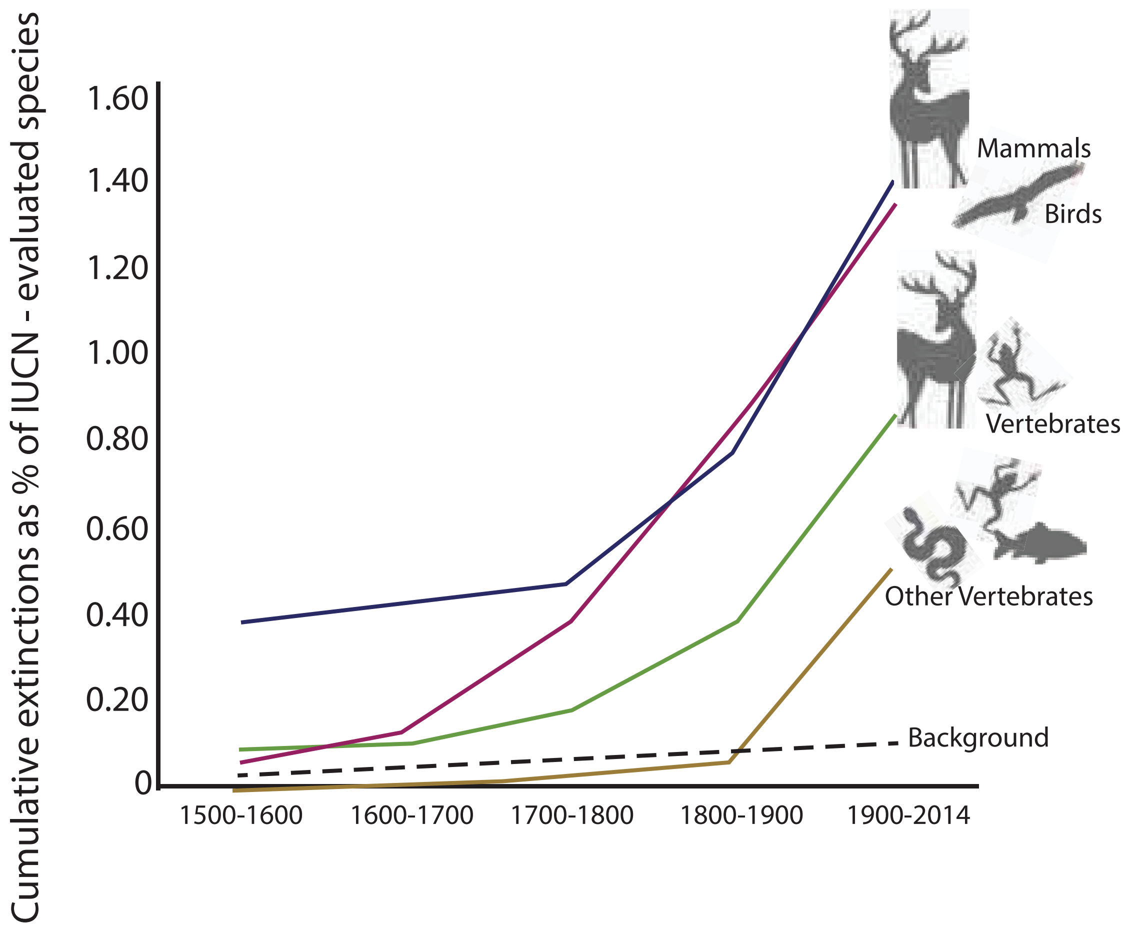


Figure 7.13 Rate of Extinction of animals and birds

7.6.4. Major Threats to Biodiversity

The following are some of the major threats to biodiversity:

a. Habitat destruction and degradation

b. Invasive alien species-these can destroy native species Example, lantana Camera plant in India.

c. Climate Change- Example, bleaching and loss of coral reefs due to global warming

d. Pollution of air, water and soil – Pollution can alter the growth and life of organisms in a great way.

e. Over exploitation of one resource – Over exploitation through Hunting or Poaching, Deforestation etc., can influence the life of all the interdependent species.

Despite rapid efforts in protecting terrestrial and marine habitats, world's diversity of species is still dwindling. Since the 1960's over 100,000 'protected areas' have been established. This represents 11,265,408 sq.km of land and 1,609,344 sq.km of ocean. Yet, terrestrial and marine species have declined over the same period. This suggests that the common conservation strategy of protecting areas of land and sea is inadequate.

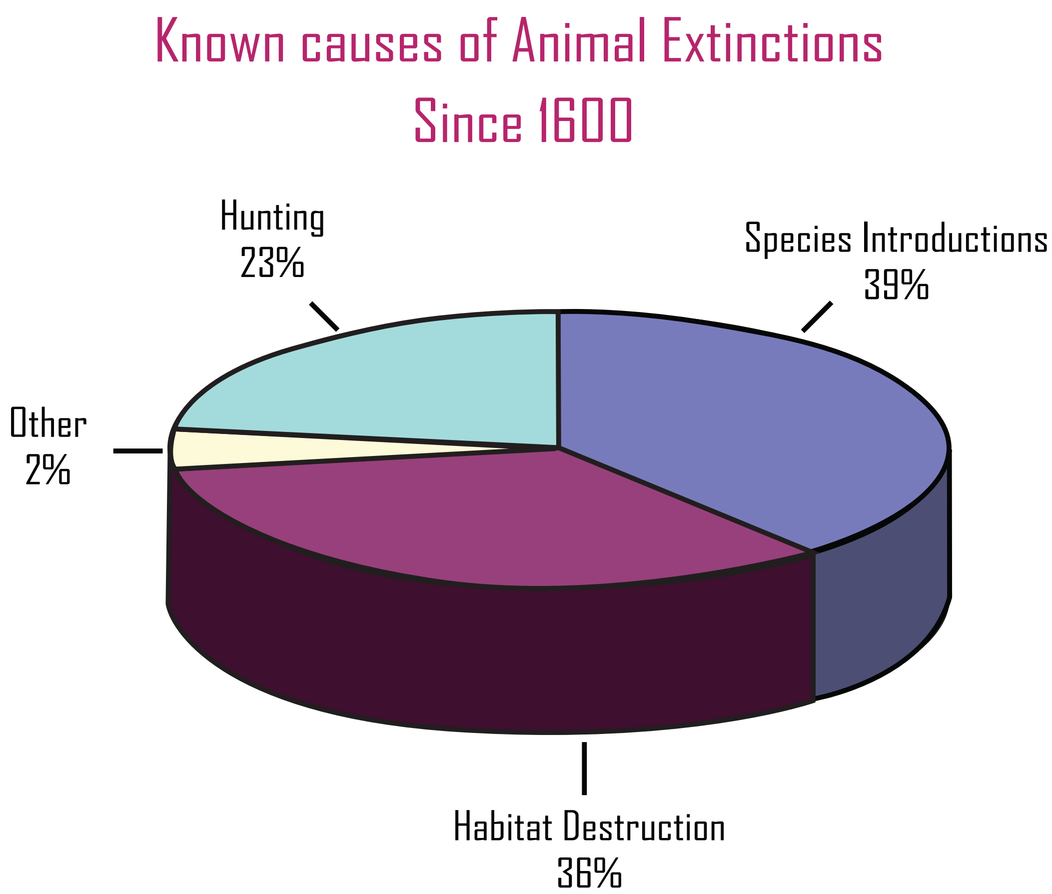


Figure 7.14 Causes of Animal extinction

7.7. Conservation of Biodiversity

Conservation of bio-diversity is the proper management of the biosphere by human beings in such a way that it gives maximum benefits for the present generation and also develops its potential to meet the needs of the future generations.

The three basic objectives of biodiversity conservation are :

(a) To maintain essential ecological processes and life supporting systems.

(b) To preserve the diversity of species.

(c) To make sustainable utilization of species and ecosystems.

There are two types of conservation methods (Figure 7.15) namely in-situ and ex-situ conservations.

In-situ conservation means the conservation of species within their natural habitats. This strategy involves identification of species rich areas and adopting methods to protect it in the form of National Park or Wildlife Sanctuary or Biosphere Reserve etc. In this way biodiversity can be conserved in their natural habitat from human activities.

Ex-situ conservation involves maintenance and breeding of endangered plants and animals under partially or wholly controlled conditions in specific areas like zoo, gardens, nurseries etc.

Other examples of ex-situ conservation include:

(i) Seed gene bank

(ii) Field gene bank

(iii) Botanical gardens

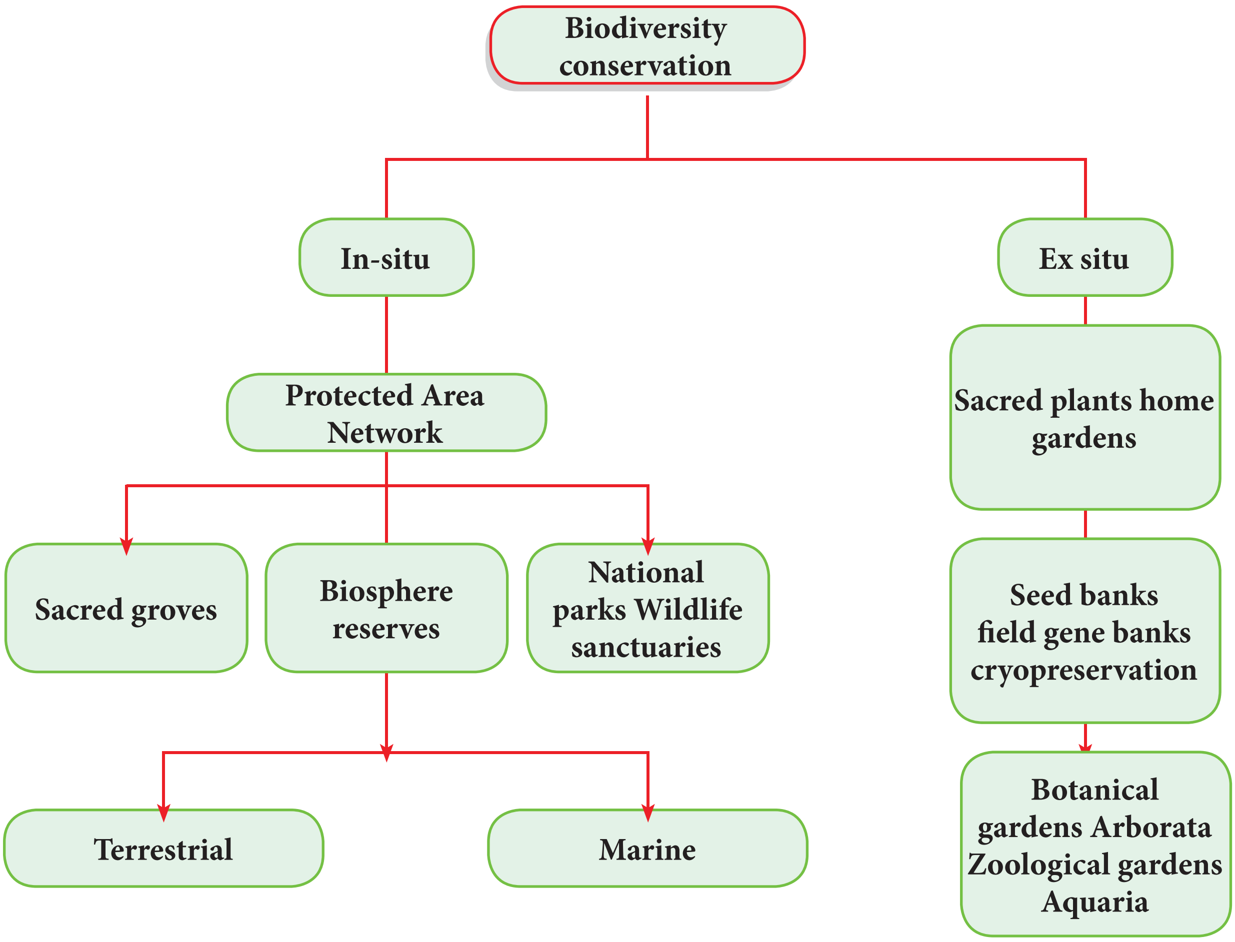


Figure 7.15 Biodiversity Conservation methods

7.7.1. Biodiversity conservation in India

India is one of the 17 mega bio-diverse countries of the world (according to Conservation International). With only 2.4% of the world's land area, 16.7% of the world's human population and 18% of livestock, it contributes about 8% of the known global biodiversity. India has a number of globally important endangered species like Asiatic lion, Asian elephant, one-horned rhinoceros, Gangetic river dolphin, snow leopard, Kashmir stag, dugong, gharial, great Indian bustard, lion tailed macaque etc. The following steps have thus been taken to protect and manage the wildlife of the country.

1. The Government of India enacted the **Wild Life (Protection) Act 1972** with the objective of effectively protecting the wild life of this country and to control poaching, smuggling and illegal trade in wildlife and its derivatives.
2. The **National Board for Wildlife (NBWL)** chaired by the Prime Minister of India, provides for policy framework for wildlife conservation in the country.
3. The **National Wildlife Action Plan (2002–2016)** was adopted in 2002, emphasizing the people's participation and their support for wildlife conservation.
4. The Indian Constitution lays the subject of forests and wildlife in the **Concurrent** list thus laying the responsibility of wildlife conservation on both the Centre and the State.

Table.7.1 Specialised projects in India

Sl.No	Name of the Project	Year
1	Project Tiger	1973
2	Operation Crocodile	1975
3	Project Rhinoceros	1987
4	Project Snow Leopard	–
5	Project Elephant	1988
6	Project Sea Turtle	1999

5. **Specialised projects:** To save the endangered species of animals, specialised projects are being implemented with international cooperation (WWF, UNDP, UNEP, IUCN) as well as on a stand-alone basis like the following: (Table 7.1)

More recently, the Black Buck (chinkara) the Great Indian Bustard and the snow leopard have been given full or partial legal protection against hunting and trade throughout India.

6. The Protected Areas of India

Protected areas are those in which human occupation is small and exploitation of resources is limited. These are defined according to the categorization (Table 7.2.).

There are 4 categories of the Protected Areas in India.

- National Parks,
- Wildlife Sanctuaries,
- Conservation Reserves, and
- Community Reserves.

Figure 7.16 Biosphere reserves in india

Table 7.2 Protected Areas of India (Jan 2017)

Protected Areas	Number	Total Area in sq Km	% of the Country
National Parks (NPs)	103	40500	1.2
Wild life Sanctuaries (WLSs)	537	118005	3.6
Conservation Reserves (CRs)	67	2350	0.1
Community Reserves	26	47	0.01
Total Protected Areas (PAs)	**733**	**160902**	**4.91**
Source: ENVIS Centre on Wildlife & Protected Areas (http://www.wiienvis.nic.in/Database/ConservationAreas_844.aspx)			

National Park

1. National parks in India are IUCN category II protected areas.
2. A National park is an area with ecological, geomorphological and natural significance with rich fauna and flora, designed to protect and to develop wildlife or its environment.
3. Activities like grazing, hunting, forestry or cultivation etc. are strictly prohibited.
4. No human activity is permitted inside the national park.
5. India's first national park was established in 1936 as Hailey National Park, now known as Jim Corbett National Park, Uttarakhand.
6. There are 103 national parks in India (National Wildlife Database, April 2015).

Wildlife Sanctuary

1. The difference between a Sanctuary and a national park lies mainly in the rights of people living inside. In a Sanctuary, certain rights are allowed but in a national park, no rights are allowed for grazing of any livestock. In a wildlife Sanctuary, the Chief Wildlife Warden may regulate, control or prohibit certain activities.
2. There are a total of 537 wildlife sanctuaries in India.

Conservation reserves and community reserves in India:

1. These terms denote the protected areas of India which typically act as buffer zones between established national parks, wildlife sanctuaries and reserved and protected forests of India.
2. They are called as '**Conservation Reserves**' if they are uninhabited and completely owned by the Government of India but used for subsistence by communities.

They are called '**Community Reserves**' if a part of the land is privately owned.

7. **Biosphere Reserves**: A biosphere reserve is an area of land or water that is protected by law in order to support, sustain and conserve ecosystems.

   Biosphere Reserves of India protect very large areas of natural habitat that are much bigger than national parks or wildlife sanctuaries. Biosphere reserves may cover multiple national parks, sanctuaries and reserves which are contiguous.example, the Nilgiri Biosphere covers: Bandipur National Park, Mudumalai Tiger Reserve, Silent Valley National Park, Nagarhole National Park and Mukurthi National Park.(Figure 7.16)

- Biosphere reserves are traditionally organized into 3 interrelated zones, known as: Core area, Buffer zone, and Transition zone.
- Presently, there are 18 notified biosphere reserves in India. Ten out of the eighteen biosphere reserves are a part of the World Network of Biosphere Reserves, based on UNESCO's Man and the Biosphere (MAB) Programmed list.

8. Some Other Important Conservation Sites

1. **Tiger Reserves** – Project Tiger was launched by the Government of India in the year 1973 to save the endangered species of tiger in the country. Starting from nine (9) reserves in 1973 the number has now grown to fifty (50) in 2016. Table 7.2. gives a list of conservation sites and their numbers in India.

9. Role of communities: Communities are playing a vital role in the conservation and protection of wildlife in India, example:

1. **Sariska Tiger Reserve:** In Sariska tiger reserve Rajasthan villagers have fought against mining by citing the wildlife protection act. In many areas, villagers themselves are protecting habitats and explicitly rejecting government involvement.
2. **Bhairodev Dakav Sonchuri:** The inhabitants of five villages in the Alwar district of Rajasthan have declared 1200 hectares of forests as the Bhairodev Dakav Sonchuri declaring their own set of rules and regulation which do not allow hunting, and are protecting the wildlife against any outside encroachments.
3. **Bishnoi villages:** In and around Bishnoi villages in Rajasthan, herds of blackbuck, nilgai and peacocks can be seen as an integral part of the community and nobody harms them.

7.7.2. The Role of GIS in Conservation of Nature

Recently Geographic Information System (GIS) has been used as a tool to identify new areas that need to be conserved. In the last 15 years Remote Sensing and GIS has been used to developed gap analysis as a method to identify biodiversity (i.e., species, ecosystems and ecological processes) that is not adequately conserved within a protected area network or through other effective and long-term conservation measures. Gap analysis is a method of comparison of actual performance with potential or desired performance. It was thus developed in response to recognition, that protected

Table7.3 Important Conservation Sites In India (Dec 2016)

Reserves/Conservation Sites	Numbers	Total Area in Sqkm.
Tiger Reserves	50	71027
Elephant Reserves	32	69583
Biosphere Reserves	18	87492
RAMSAR Wetland Sites	26	12119
Natural World Heritage Sites	07	11756
Important Coastal and Marine Biodiversity Areas	107	10773
Marine Protected Areas	131	9801
Potential/ Important Bird Areas	563	–

Source: ENVIS Centre on Wildlife & Protected Areas (http://www.wiienvis.nic.in/Database/ConservationAreas_844.aspx) areas of all types and in all parts of the world do not fully protect biodiversity. Gap analysis is usually applied to fairly large areas of study.

Activity

Identify community conserved areas in Tamil Nadu and prepare a poster.

Highlight:

In 1798, in a small village called **Vedanthangal** near **Chennai,** the British soldiers shot some storks in the local wetland. The villagers stormed the Collector's office and made him issue an order not to harm the nesting birds. This took place long before the concept of conservation of biosphere entered our thoughts. India has experienced many such incidents only some of which have been recorded.

Biodiversity is necessary for our existence as well as valuable in its own right. This is because it provides the fundamental building blocks for the goods and services that provide us with a healthy environment.Biodiversity includes fundamental things to our health like fresh water clean air and food products, as well as many other products like timber, medicine and fibre.

Biodiversity also includes various other important things and services such as cultural, recreational and spiritual nourishment that play an important role in maintaining our personal life and social life.

It is therefore the duty of every citizen to conserve this valuable life on earth, the most precious gift we can pass on to the future generations.

CASE STUDY

The Asiatic Cheetah of India Becomes Extinct

Cheetah is found in Africa and Asia. It is the fastest land animal on Earth. The Asiatic cheetah, is slightly smaller than the African cheetah. It has a fawn-coloured body with black spots and distinctive black "tear marks" running from the corner of each eye down the side of its nose.

The Asiatic cheetah also known as the Iranian cheetah is a **Critically Endangered** subspecies surviving today only in Iran. It was once found in the Arabian Peninsula, Near East, Kyzyl-Kum desert, Caspian region, Pakistan and India.

Asiatic cheetahs were once widespread across the continent but were eradicated in India, where they were hunted for sport. The spread of farming also greatly reduced their numbers in the 19th and 20th centuries. Eventually the animal was wiped out in Asia to which it was once native.

Cheetah has been known to exist in India for a very long time. They were kept by Kings and princes, but hunting led to their extinction in the country. In 1948, Maharajah Ramanuj Pratap Singh Deo shot three of the last cheetahs in India, in Surguja, State of Madhya Pradesh which is present day Northern Chhattisgarh.

The Indian government had plans to reintroduce cheetahs back in India in 2009 but this project has not yet been taken up.

GLOSSARY

Boreal: Relating to the region of the earth just south of the Arctic, especially its plants and animals.

Coral polyps: Tiny, soft-bodied organisms related to sea anemones and jellyfish. At their base is a hard, protective limestone skeleton called a calicle, which forms the structure of coral reefs. Reefs begin when a polyp attaches itself to a rock on the sea floor, then divides, or buds, into thousands of clones.

Ecologist: A person who studies the natural relationships between the air, land, water, animals, plants, etc.

Endemic: Native or restricted to a certain place.eg. Lion-tailed macaque endemic to the Nilgiris.

Entomologist: A person who studies or is an expert in the branch of zoology concerned with insects.

Ex-Situ Conservation: Ex-situ conservation is the preservation of components of biological diversity outside their natural habitats. This involves conservation of genetic resources using many techniques and facilities.

Habitat: The natural home or environment of an animal, plant, or other organism.

Lagoon: A stretch of salt water separated from the sea by a low sandbank or coral reef.

Oasis: A small area in a desert that has supply of water and is able to support vegetation. An oasis forms when groundwater lies close enough to the surface to form a spring or to be reached by wells.

Permafrost: A thick subsurface layer of soil that remains below freezing point throughout the year, occurring chiefly in Polar Regions.

Poaching: Trespassing, especially on another's game reserve, in order to steal animals or to hunt.

Sedges: Any grass like plant, typically growing on wet ground and having rhizomes, triangular stems, and minute flowers. Sedges are found to grow in cold regions,

Vulnerable: Exposed to the possibility of being attacked or harmed or destroyed;

Evaluation

I. Choose the best answer

1. Who first proposed the term 'Ecosystem' ?
   a. E.O. Wilson
   b. I.G. Simmon
   c. A.G. Tansley
   d. Raymond F Dasmann

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2. What is the main source of energy for the earth ?
   a. Moon　b. Stars
   c. Sun　d. Tides
3. What is the position of a rabbit in a food chain?
   a. Primary consumer
   b. secondary consumer
   c. tertiary consumer
   d. Quaternary consumer
4. Which organism eats both plants and animals?
   a. Herbivores
   b. Carnivores
   c. Omnivores
   d. Detritivores
5. Which of the following is found in the desert biome?
   a. Eucalyptus　b. Pine
   c. Teak　d. Cacti
6. Which of the following are native tribes inhabiting the tropical evergreen forests of Africa?
   a. Yanomani　b. Pygmies
   c. Tikuna　d. Aborigines
7. The largest number of plant species are found in ______________ biome.
   a. Savannah　b. Desert
   c. Tropical rain forest　d. taiga
8. The Temperate grasslands of North America.
   a. Prairies　b. Steppes
   c. Pampas　d. Downs
9. The Taiga biome extends over the latitudes ______________ .
   a. 0° to20° North and South
   b. 30° to 50° N
   c. 50° to 65° N
   d. beyond 65° N
10. Which of the following is not covered by the Nilgiri Biosphere?
    a. Bandipur National Park
    b. Nagarhole National Park
    c. NamdaphaNational park
    d. Mukurthi National park

II. Give short answers:

11. What is a Biosphere?
12. What is meant by biogeochemical cycle?
13. Mention the types of biomes.
14. Name the different types of coral reefs.
15. How many Biodiversity Hotspots are there in India? Name them.

III. Give answers in a paragraph:

16. What are Consumers? Explain the types of consumers.
17. Write a short note on energy pyramids.
18. What is meant by Species Diversity? Explain
19. Describe how the Asiatic Cheetah became extinct in India.
20. Write a note on National Parks with examples.

IV. Give detailed answers:

21. Mark the areas of the Tropical Rain forest Biomes on the given world map and mention any four characteristics of them.
22. Distinguish between the Tropical Desert and the Tundra biomes.
23. Explain how species are classified in the Red List of the International Union for Conservation of Nature (IUCN).

Project

1. Observe life forms in your local area and draw a food web.
2. Complete the following table

Sl No	Biome	Location	Climate	Plants and their Adaptation to Environment	Animals and their Adaptation to Environment
1.	Tropical Evergreen Rain Forest				
2.	Tropical Monsoon Forests				
3.	Temperate Deciduous Forests				
4.	Tropical Grasslands Or Savannah				
5.	Temperate Grasslands or Steppe				
6.	Deserts				
7.	Taiga or Boreal Forests				
8.	Tundra				

3. Collect pictures of endangered species of Tamil Nadu and prepare a poster.

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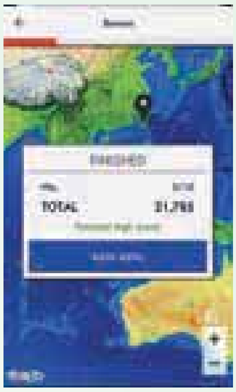
ICT CORNER

Biosphere Facing Surface

Explore and evaluate yourself in World's biosphere.



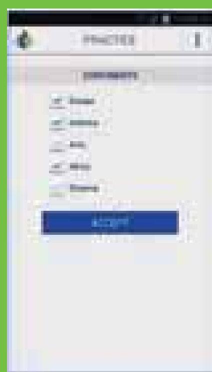
Steps

- Use the URL or scan the QR code to download and install "Geography Learning Trivia Quiz" app in smartphone.
- Click on the 'clock' to watch the timeline.
- Enter your name,Select Difficulty level and continents to be evaluated in the quiz.
- Answer the quiz by pinning the balloon on the map, complete the quiz and review the answers. Check your progress in biosphere using achievement tab and leaderboard tab.

Step 1

Step 2

Step 3



Step 4

Website URL:

https://play.google.com/store/apps/details?id=com.yamlearning.geographylearning&hl=en

*Pictures are indicative only.

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Unit VIII

Natural Disasters - Public Awareness For Disaster Risk Reduction

Chapter Outline

8.1 Introduction
8.2 Public awareness for disaster risk reduction
8.3 Disasters and rules of action for disasters
8.4 Earthquake
8.5 Landslide
8.6 Cyclone
8.7 Flood
8.8 Drought
8.9 Lightning

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Learning Objectives:

- *Define the terms – Disaster Risk Reduction, Resilience and Public Awareness.*
- *Understand the need for public awareness for disaster risk reduction.*
- *Explain the rules of actions for disasters.*
- *Learn and experience the various mock drills for disasters.*

8.1 Introduction

On an average, 232 million people are affected by different types of disasters every year. In recent years disaster risks have been on the rise due to factors such as population growth, unplanned urbanization, environmental degradation, conflicts and competition for scarce resources, climate change, disease epidemics, poverty and pressure from development within high-risk zones. Hence, disaster risk reduction is the need of hour.

Recognizing the importance of Disaster Risk Reduction in 2005, 168 governments and all leading development and humanitarian actors signed the Hyogo Framework for Action (HFA), committing themselves to a ten-year multi-stakeholder and multi-sector plan to invest in disaster risk reduction as a means to building disaster-resilient societies.

Public awareness campaigns can be started modestly and tailored to meet the needs of specific populations and target groups. These approaches can be integrated into almost all existing initiatives, whenever and wherever they take place. They can build on and support existing volunteer mobilisation and peer-to-peer communications. To support this, it requires strong and unified disaster reduction messages and clear and targeted information, education and communication materials.

8.2 Public awareness for disaster risk reduction

There are four key approaches to public awareness for disaster risk reduction: Campaigns, participatory learning, informal education, and formal school-based interventions.

Let's take formal school based interventions to learn in detail.

Formal school-based interventions: The focus of formal school-based interventions cover two areas: school disaster management and disaster risk reduction in school curricula. These are considered to be formal because accountability and responsibility for school safety and curricula belong exclusively to education authorities, so they require support for long-term planning and capacity building.

School disaster management: The primary goals of school disaster management are to ensure the safety of students and staff. Sustained school disaster management requires the familiar participatory and ongoing process of identification of hazards and risks, mitigation and reduction of risks, and developing response capacity.

A school disaster management plan, developed at the school level, should be the living document that expresses the awareness of public for disaster risk reduction. Every school has to setup the following school disaster committees:

1. Coordination Committees
2. Awareness generation Team
3. Search Rescue and Evacuation Team
4. Site safety Team
5. First Aid Team
6. Warning and Information Team
7. Bus safety Team
8. Water / Food Arrangement Team.

All the teams should participate in the mock drill.

Mock drills

Mock drills form a vital part of the school disaster management process, and provide an intensive learning experience. They should be followed by reflection and assessment by all members of the school community. Lessons learned are incorporated into the school disaster management plan, and goals set for improvement next time. Depending on hazards faced, there are several major types of drills that can be practiced:

Disasters and Rules of actions during disasters

8.3.1 Earthquake

An earthquake is sudden, rapid shaking of the ground caused by the shifting of rocks beneath the earth's surface. Earthquakes strike suddenly without warning and can occur at anytime. The impacts of the earthquakes include deaths, injuries and damage of property. You have learned

CASE STUDY

Nepal – India Earthquake

The **April 2015 Nepal Earthquake** (also known as the **Gorkha Earthquake**) killed nearly 9,000 people and injured nearly 22,000. It occurred on 25 April, with a magnitude of 8.1 Richter scale. Its epicentre was east of Gorkha District at Barpak. It was the worst natural disaster to strike Nepal since 1934 Nepal–Bihar earthquake.

The earthquake triggered an avalanche on Mount Everest, killing 21 people making April 25, 2015 the deadliest day on Nepal's history. The earthquake triggered another huge avalanche in the Langtang Valley, where 250 people were reported missing.

Figure 8.1. Nepal Earthquake, 2015

Students' activity

Mock drill: Earthquake.

In case we are inside the class when earthquake occurs, instruct loudly "earth quake position – drop, cover, and hold on". Drop down on your knee. Cover your head, neck and face. Go under a table to protect your head.

about occurrence of the earthquake and other related information in the earlier part of the book.

Rules of actions during an earthquake:

1. Stay calm, do not panic.
2. If you are in a building, sit down on the floor under a table or any other furniture and firmly hold on to it until the earthquake has stopped.
3. If there is no table nearby, cover your face and head with your hands and sit on the floor in a corner of the room.
4. Keep away from glass windows, glass doors and things that can fall down.
5. Do not try to leave the building quickly; during earthquakes people mostly die because they try to run out of the

building and become trapped under ruins if the building is destroyed.

6. Do not go to the staircase, a balcony or an elevator.
7. If you are in the street, keep away from buildings; try to get into an open space and avoid power transmission lines.
8. If you are at home, turn off electrical equipment and gas quickly.
9. If you are in chemistry class or a laboratory where chemicals are stored, try to leave the room because chemicals may cause injuries;

After earthquake:

1. First check if you have any injuries, and then check the condition of the surrounding people. If you cannot do this, wait for the rescue team;
2. After the earthquake when you leave the shelter, do not return for 2-3 hours because the quakes may repeat (an aftershock).
3. Check if there is fire; in case of a mild one try to extinguish it.
4. Be cautious about the possibility of gas leakage and damage caused to electrical wiring.
5. Be careful while opening wardrobe doors to take necessary items;
6. Use only lanterns; do not use an oil lamp or a candle.
7. Listen to the radio to receive information about the earthquake.

8.3.2 Landslide

A landslide is defined as the movement of a mass of rock debris down a slope. Landslides are caused by the direct

Figure 8.2. Drop, Cover, Hold-Mock drill

influence of gravity. Landslides can be caused by rainfall, snowmelt, stream erosion, and flood, earthquakes, volcanic activity, disturbance by human activities, or any combination of these factors.

Landslides cause property damage, injury and death and adversely affect a variety of resources. For example, water supplies, fisheries, sewage disposal systems, forests, dams and roadways can be affected.

During a Landslide

1. Listen for any unusual sounds that might indicate moving debris, such as trees cracking or boulders knocking together.
2. If you are near a river, be alert for any sudden increase or decrease in water flow and for a change from clear to muddy water. Such changes may indicate landslide activity upstream, so be prepared to move quickly.
3. Be alert especially when driving. Embankments along roadsides are particularly susceptible to landslides.
4. Disconnect the power supply in the areas of landslide.

After the Landslide

1. Stay away from the slide area. There may be danger of additional slides
2. Check for injured and trapped persons near the slide, without entering the direct slide area.
3. Direct rescuers to their locations.
4. Listen to local radio or television for the latest emergency information
5. Watch for flooding, which may occur after a landslide or debris flow.

8.3.3 Cyclone

The major natural disaster that affects the coastal regions of India is cyclone and as India has a coastline of about 7516 km; it is exposed to nearly 10 percent of the world's tropical cyclones.

About 71 percent of flood prone areas are in ten states (Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Pondicherry, Andhra Pradesh, Orissa and West Bengal). The islands of Andaman, Nicobar and Lakshadweep are also prone to cyclones.

Districts in Tamil Nadu which are frequently affected by cyclones: All the 13 coastal Districts of Tamil Nadu are affected by cyclonic storms which occur during May-June and in October-November months. These Districts are: Tiruvallur, Chennai, Kancheepuram, Villupuram, Cuddalore, Nagapattinam, Tiruvarur, Thanjavur, Pudukkottai, Ramanathapuram, Tuticorin, Tirunelveli and Kanniyakumari.

On an average, about five or six tropical cyclones form in the Bay of Bengal and Arabian sea and hit the coast every year. Out of these, two or three are severe.

When a cyclone approaches to the coast, a risk of serious loss or damage occurs from severe winds, heavy rainfall, storm surges and river floods. The effect of a storm surge is most pronounced in wide and shallow bays exposed to cyclones such as in the northern part of Bay of Bengal. Most cyclones occur in the Bay of Bengal

Figure 8.3. Forces of Cyclonic wind

Figure 8.4. Effects of Cyclone

followed by those in the Arabian Sea and the ratio is approximately 4:1. During the cyclonic of cyclonic storms, wind speed is between 65 km/h and117 km/h.

Rules of action before a cyclone

1. Go to high-lying places from low-lying areas
2. Those residing in old buildings should temporarily relocate to safer buildings; Jewels and documents should be kept in safe custody.
3. Battery-operated radio, plastic torch-light, lamp, kerosene, match-box should be kept safely for future use.
4. Keep in ready all the first-aid kit and material available with you.
5. Keep in stock foodstuffs, material, fuel, drinking water and life-saving drugs needed for the next week.
6. It is also important to take cattle and other pets to safer places.
7. It is important to know that if we see quickly approaching storm clouds it is possible to predict strong winds several minutes in advance.

During a cyclone

1. If you are in a building during a strong gust, it is necessary to close and fasten windows and doors. It is better to stay in the rooms.
2. Turn off all electrical devices.
3. Protect yourself with your hands or a scarf. Protect the eyes, nose and mouth from dust.
4. If you are in a wildlife area, try to find a place protected from the wind. If there is no such place nearby, lie down on the ground.
5. If you are in a car it is better to stay there and close the windows. Do not park the car under unstable objects that can break down and fall on the car.

After cyclone

1. Turn off electricity, gas and water and unplug all electric appliances.
2. Beware of snakes and other animals immediately after the cyclone.
3. Do not go for sightseeing.

4. Stay away from damaged power lines, falling trees and flood water.
5. Boil and purify water before drinking.

8.3.4 Flood

Flood destructions have always brought miseries to numerous people, especially in rural areas. Flood results in the outbreak of serious epidemics, specially malaria and cholera. Simultaneously, scarcity of water also arises. It has a drastic effect on agricultural produce. Sometimes, water remains standing over large areas for long span of time hampering the Rabi crops.

India is one of the most flood prone countries in the world. The principal reasons for flood lie in the very nature of natural ecological systems in this country, namely, the monsoon, the highly silted river systems and the steep highly erodible mountains, particularly those of the Himalayan ranges. The average rainfall in India is 1,150 mm with significant variation across the country. The annual rainfall along the western coast and the Western Ghats, Khasi hills and over most of the Brahmaputra valley amounts to more than 2,500 mm. Twenty-three of the states (29) and union territories (6)

DO YOU KNOW?

Mock Drill means Practicing of something that can happen in future so that it can be easily dealt with in.

Fact File

Tropical Cyclone Vardha hit Chennai on 12 December, 2016. National Disaster Management Authority (NDMA) reports that at least 10 people have died in Tamil Nadu.

Maximum sustained wind speeds of over 130 km/h were recorded, and the storm has caused severe damage to parts of the city of Chennai. Over 4,000 trees have been uprooted, power lines downed and buildings damaged.

NDRF teams clear up damage after Cyclone Vardha. Photo: NDRF in the country are subject to floods and 40 million hectares of land, roughly one-eighth of the country's geographical area, is prone to floods. The National Flood Control Program was launched in the country in 1954.

Do's before flood

1. Keep furniture and electrical appliances on beds and tables
2. Put sandbags in the toilet bowl and cover all drain holes to prevent sewage back flow.

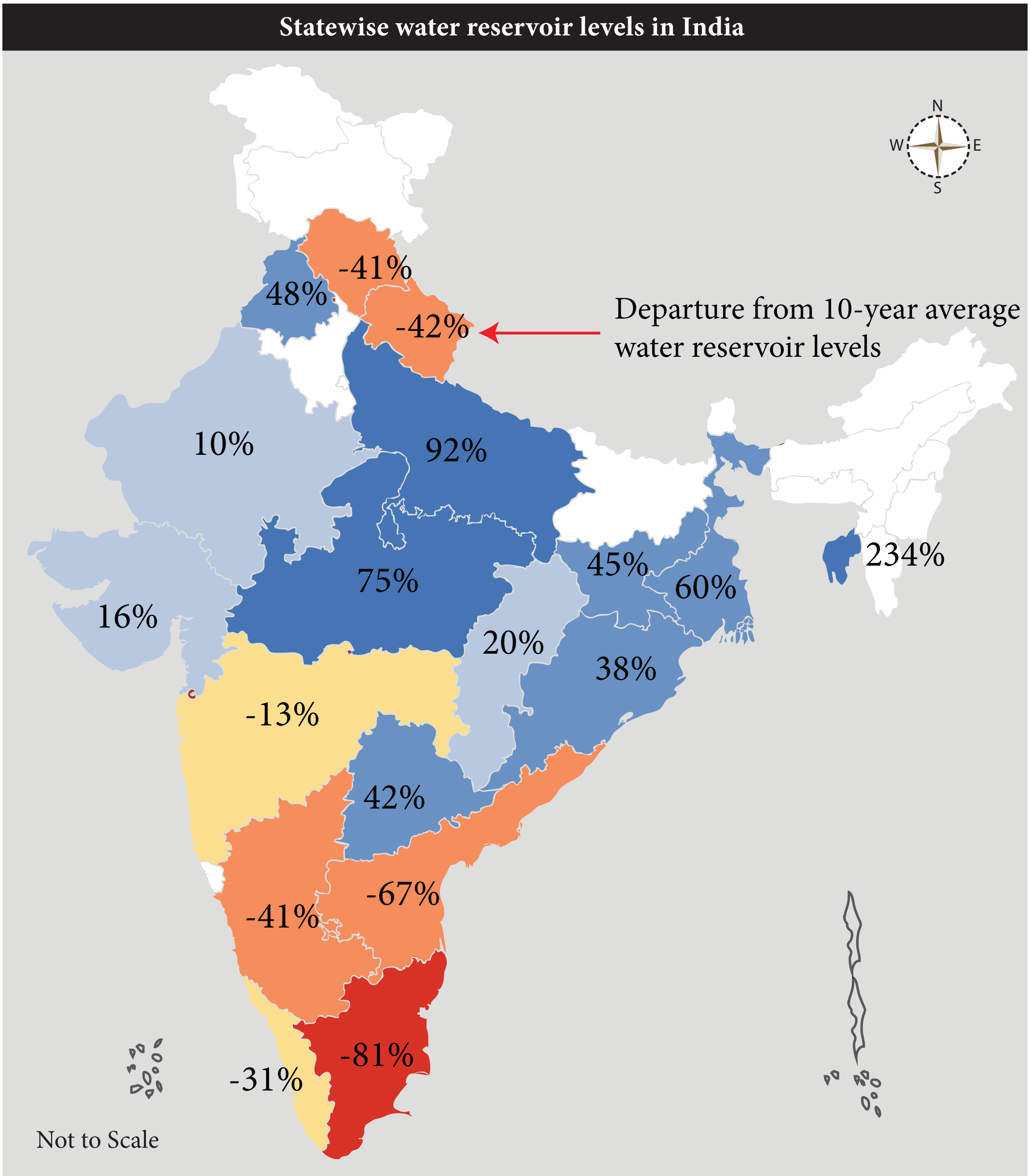

Figure 8.5. Statewise water reservoir levels in India

3. Keep your mobile charged
4. Listen to radio or watch television for the latest weather bulletin and flood warnings.
5. Keep strong ropes, a lantern, battery operated torches, extra batteries ready.
6. Keep umbrellas and bamboo sticks with you for protection from snakes.

8.3.5 Drought

The above map shows most the acute shortage of water in Tamil Nadu in 10 years. (2017)

Figure 8.6. Crops affected by Drought

Drought is a period of time (months or years) during which a part of the land has shortage of rain, causing severe damage to the soil, crops, animals, and people. It sometimes causes even death. During drought high temperature is experienced. Such conditions may affect our health.

The primary cause of drought is deficiency of rainfall and in particular, the timing, distribution and intensity.

In India around 68 percent of the country is prone to drought. Of the entire area 35 percent receives rain falls between 750 mm and 1,125 mm which is considered drought prone while 33 percent areas receive rainfalls less than 750 mm is considered to be chronically drought prone.

Figure 8.7. Drought condition

Rules of action before, during and after Drought

Before drought:

1. Rainwater harvesting should be followed.
2. Sewage water should be recycled and used for domestic purpose.
3. Building canals or redirecting rivers for irrigation.
4. Utilise water economically.

During drought:

1. Wear cotton clothing and a hat.
2. In case of overheating, immediately move to a shady area.
3. Consume adequate amounts of water stay.

After drought:

1. If anyone faints after sunstroke, emergency medical measures should be taken.
2. Contact local government agencies to receive information about disaster and assistance for the population.

8.3.6 Lightning

Lightning is an atmospheric electrostatic discharge (spark) accompanied by thunder, which typically occurs during thunderstorms, and sometimes during volcanic eruptions or dust storms. Lightning generates 10-20 ampere current

> **DO YOU KNOW?**
>
> - You can hear thunder from about 16 km of its starting point.
> - Lightning bolts travel at the speed of up to 80,000 km / second.
> - The average length of a single lightning bolt is 3-4km.

and it is therefore fatal. It is especially dangerous for people in an open area.

Lightning strikes often have fatal consequences. On an average, 2000 people die from lightning in the world every year. Lightning mostly strikes tall things, such as trees that break down and catch fire or it may strike power transmission lines and antennas fastened on roofs and buildings which causing fire. The air temperature, when lightning occurs, is as hot as 9982.2 °C.

8AF4C9

Thunder is the sound caused by lightning. A charged, superheated lightning bolt creates a “resonating tube” as it travels. The air in the tube rapidly expands and contracts causing vibrations that we hear as the rumble of thunder.

Lightning strikes can explode a tree. Imagine 15 million volts of electricity hitting

> **DO YOU KNOW?**
>
> - Lightning flashes more than 3 million times a day or 40 times a second worldwide.
> - An average lightning bolt can release enough energy to operate a 100-watt light bulb for more than three months straight (about 250 kilowatt-hours of energy).

a tree branch. The heat travels through the tree, vaporizing its sap and creating steam that causes the trunk to explode.

Before lightning

1. If you are planning to go to the countryside, check the weather forecast.
2. If a thunderstorm is expected it is better to postpone the trip.
3. It is good if you can estimate the distance to the front line of a thunderstorm. In order to do this you must check the time interval from the moment you see the lightning until you hear thunder. Lightning always precedes thunder. We know that the sound speed travels on average about 1km every 3 seconds. Reduction of the time interval between the sight of lightning and the resulting thunder means that the danger is approaching and protective measures must be taken. If there is no interval between lightning and thunder means, it means that the cloud is already over your head.

During Lightning:

1. If you are in a building it is necessary to close windows, doors, ventilation pipes and chimneys.

Figure 8.8. Lightning

2. It is necessary to turn off the telephone, TV set, and other electrical equipment because lightning may strike electrical cables and pass through wiring.
3. Do not take a shower because both water and metal conduct electricity.
4. Do not light the fireplace because the heat coming from the chimney may attract lightning.
5. It is better to stay away from electric wires, lightning rods, water pipes, antennas and windows.
6. If you are in an open area during a thunderstorm, do not stand under a tall tree. Lighting is most damaging for tall trees. It is better to stay 30-40 meters away from them. Avoid trees that are standing separately. Remember that lightning does not strike bushes.
7. If the area is open, it is better to find a lower place or a cavity and squat there. It is dangerous to stand or lie down on the ground, because this increases the exposure area.
8. It is necessary to get rid of metal items such as a bicycle, coins etc.
9. Do not stand under an umbrella.
10. Do not run during the occurrence of lightning; move slowly towards a shelter because the air flow may attract lightning;
11. If you are in a car, do not get out. It is better to close the windows and turn of the antenna. Do not park your car under tall trees or any structures that may fall down and hit you.
12. If there is an injured person next to you, remember that the victim may lose consciousness. It is necessary to provide first aid.
13. Cover your mouth with a wet cloth in order to protect your lungs.

Student activity

Read the following rules for lightning and practice the mock drill as given below.

1. Follow the 30/30 rule.
2. If there are less than 30 seconds between thunder and lightning, you are in danger.
3. Get inside and stay there until 30 minutes after the last lightning flash.
4. practice lightning crouch
5. If you see or feel lightning and there is nowhere to go for shelter, immediately squat down.
6. Balance on the balls of your feet, touch your heels together.
7. Cover your ears.
8. This way the charge may go through your back in to the ground without harming your vital organs.

A-Z GLOSSARY

1. **Disaster**: A serious disruption of the functioning of a society involving human, and material, and impacts that exceed the ability of the affected society to cope using its own resources.
2. **Disaster risk reduction**: The practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters.
3. **Mitigation** : The lessening of the adverse impacts of hazards and related disasters
4. **Preparedness**: The capacity developed by organizations, to effectively anticipate, respond to, and recovers from the impacts of disaster events.
5. **Prevention**: The outright avoidance of adverse impacts of hazards and related disasters.
6. **Public awareness:** The extent of common knowledge about disaster risks, the factors that lead to disasters and the actions that can be taken, to reduce vulnerability to hazards.
7. **Resilience**: The ability of a society exposed to hazards to resist, absorb, adapt to and recover from the effects of a disaster.
8. **Hyogo Framework for Action** – A global blueprint for disaster risk reduction efforts between 2005 and 2015 – by providing specific operational guidance for promoting disaster risk reduction.

Evaluation

I Choose the best answer from the given below.

8ANZDH

1. On an average ________ million people are affected by different types of disasters every year.

   a) 423 b) 232

   c) 322 d) 332

2. The Hyogo Frame work for Action (HFA) was signed by the 168 governments and other actors in ________

a) 2006 b) 2008

c) 2005 d) 2002

3. There are ______ key approaches to public awareness for disaster risk reduction

a) 8 b) 6

c) 9 d) 4

4. 33 percent of total areas in India which receives rainfalls less than -------- is considered to be chronically drought prone.

a) 650 mm b) 750 mm

c) 850 mm d) 950 mm

5. It is important to practice Drop, Cover, Hold for

a) Fire b) Earthquake

c) Lightning d) Flood

6. One among the given occurs mostly in the slope of high lands

a) Earthquake b) Flood

c) Landslide d) Lightning

7. When lightning occurs, the air temperature is

a) 9982.2 ^{0}C b) 8892. 2 ^{0}C

c) 9892. 2 ^{0}C d) 9899.2^{0}C

8. If there are less than _____ between thunder and lightning, you are in danger.

a) 40 sec b) 60 sec

c) 50 sec d) 30 sec

9. In India around __________ % of the country is prone to drought in varying degrees.

a) 78 % b) 68 %

c) 87 % d) 67 %

10. During disaster consider the most appropriate from the given below.

a. Think that the life is more valuable

b. Think that things are more valuable.

c. Think that life and things are equally valuable

d. Think that life is less valuable than things.

II. Give a short note on

11. Public awareness for disaster risk reduction.

12. Hyogo Frame work for Action (HFA)

13. What are the causes of landslide

14. 30/30 rule for lightning.

15. Drought.

III. Write the short answer

16. Mention any three rules of action for landslide.

17. Write the rules of action before drought.

18. What are the rules of action after cyclone?

19. Name the districts of Tamil Nadu vulnerable to frequent cyclone.

IV. Write in detail

20. Write any three Do's and Don'ts for earthquake.

21. Describe the ways and means of how to protect ourselves from lightning and thunder.

22. Explain the rules of action during landslide.

V. Mock drill exercise

1. Prepare a school disaster management plan focusing on the following mock drills that can be

scheduled to be conducted by the various committees.

2. Drop, cover, hold mock drill for earthquake
3. Mock drill for lightning.

VI. Group discussion

1. Discuss in group how you can manage drought condition before it occurs.

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Unit IX

Maps and Scale

Chapter Outline

Learning Objectives:

- *Know about the types of maps and scales.*
- *Convert the scales from one form to another.*
- *Draw the various types of scale.*
- *Identify the components of the map.*

9.1 Introduction

A map is a visual representation of an entire world or a part of the earth, represented on a flat surface drawn to scale. Maps attempt to represent both physical and cultural features like relief, climate, natural resources, political boundaries, roads, population, economic activities and so on.

Components of a map

Basic Components of a map are title, legend, direction, scale and source. It gives the extent of latitude and longitude of the area mapped.

Title

Title tells about the content of the map and is placed mostly at the top centre or at the bottom centre of the map.

Scale

The scale of the map is ratio between two places on the map and their corresponding distance in the ground. It can be expressed as statements, representative fraction, or as linear scale. The scale of a map should be placed at a prominent place. It can be placed just below the title or somewhere at the bottom.

Legend

It explains about different signs and symbols used in a map and is usually placed at the left or right corner at the bottom of the map.

Direction

It is a convention that top of the map is oriented towards north and this is

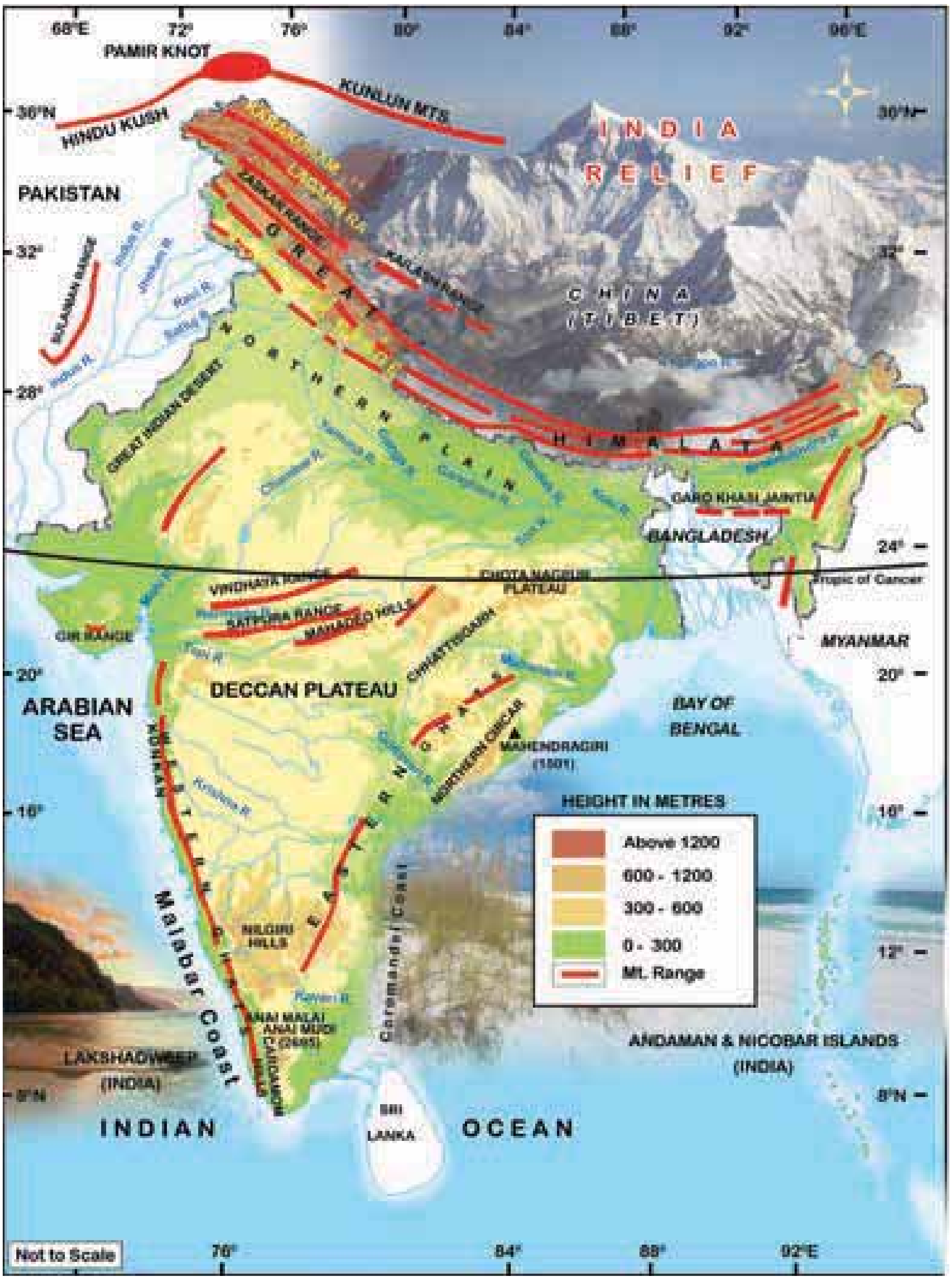


Figure 9.1 Physical map of India

represented by an arrow pointing upward placed at the top right corner of the map. Sometimes a Compass Rose is used instead of an arrow to show the direction.

Source

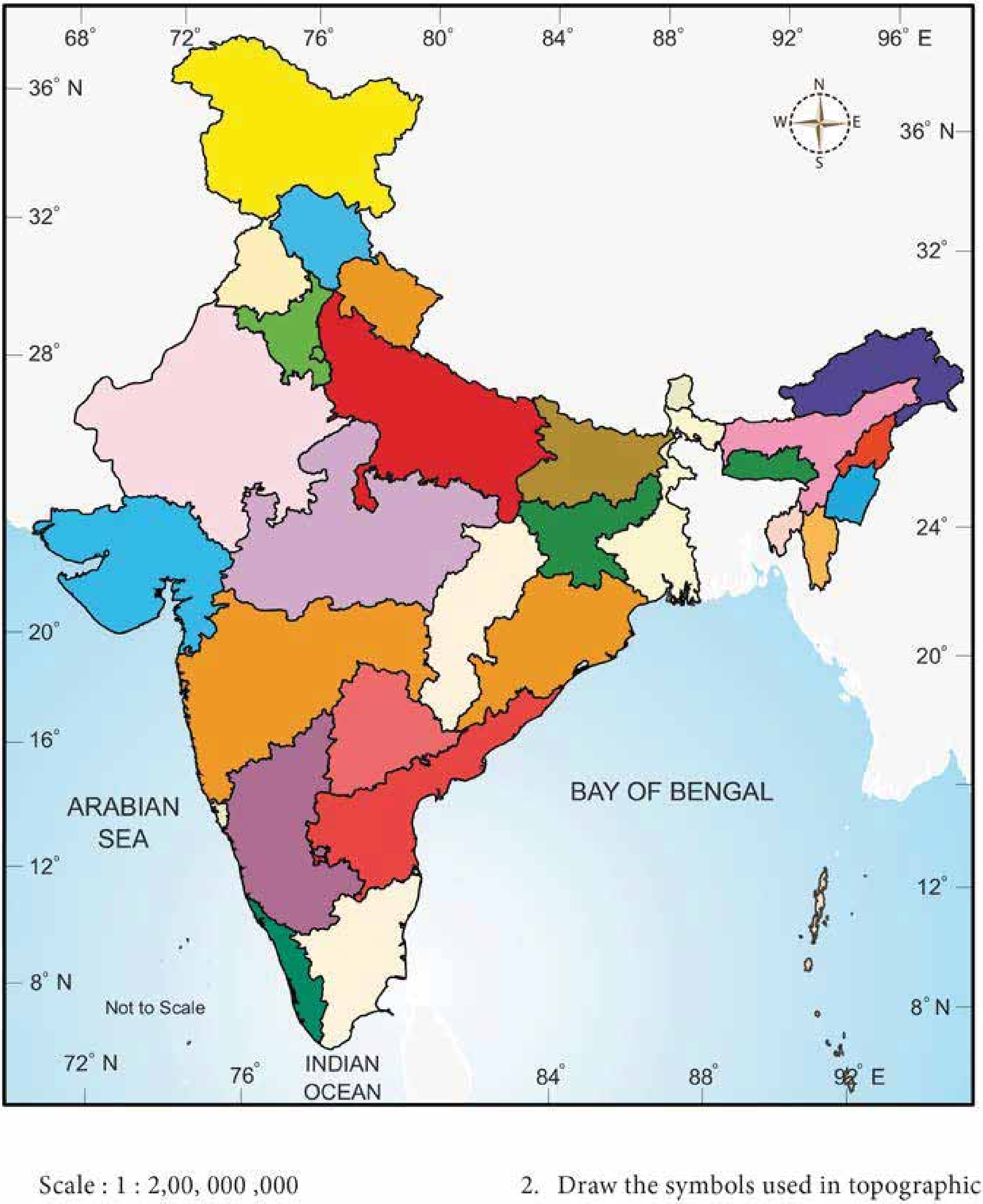
Every map must give the source of the data used. The source should normally be given outside the frame of the map on the bottom right. On the bottom left the name of the author, publisher, place of publication and year of publication should be given.

1. Based on the details given below, mark the components of the map in their appropriate place in the map of Tamil Nadu.

   Title: Tamil Nadu - Distribution of rainfall during Northeast Monsoon 2017

Excercise

Refer the map (Figure 9.1) and label the components of a map on the outline map of India



Scale : 1 : 2,00, 000 ,000

Legend low rainfall, moderate rainfall, heavy rainfall

Latitude 88N to 138N. Longitude 748 to 808 E

2. Draw the symbols used in topographic sheet to show various categories of
   a. railway lines
   b. roadways
   c. water features

d. physical features

e. cultural features

f. vegetation

9.2 Scale

The scale is defined as the ratio between the distance of two points on the map and their corresponding distance on the ground. The scale is an essential element in all types of maps. The scale of the map permits the user to convert distance on the map to distance on the ground.

A map scale provides the relationship between the map and the whole or a part of the earth's surface shown on it. We can also express this relationship as a ratio of distances between two points on the map and their corresponding distance on the ground. The scale can be represented as a fraction where the numerator refers to map distance and the denominator refers to ground distance.

There are at least three ways of which representing scale. They are:

1. Statement Scale
2. Representative Fraction (R. F.)
3. Graphical or Bar Scale

1. Statement Scale

The scale of a map may be indicated in the form of a written statement. For example, if on a map a written statement appears as stating 1 cm represents 10 km, it means that on that map a distance of 1 cm is representing 10 km of the corresponding distance on the ground.1 inch equals 16 miles. This example tells us that 1 inch on the map represents 16 miles on the ground. This is the easiest scale to understand because it generally uses familiar units.

Example : 1 centimetre 5 10 kilometres

Simple statement has the following characteristics :

1. If the numerator is in centimeters, then the denominator is in metres and kilometres.
2. If the numerator is in inch, then the denominator is in miles.

2. Representative fraction (RF)

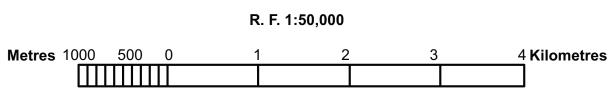
It shows the relationship between the map distance and the corresponding ground distance in the same units of length. R. F. is generally shown as a fraction. For example, a fraction of 1 : 40,000 shows that one unit of length on the map represents 40,000 of the same units on the ground i.e; 1 cm or 1 inch on the map represents 40,000 cm and 40,000 inches, respectively on the ground.

RF is represented as 1/40,000 or 1:40,000

3. Graphic or bar scale

In this type of scale the map distances and the corresponding ground distances are marked using a line bar with primary and secondary divisions on it. However, unlike the statement of the scale method, the graphical scale stands valid even when the map is reduced or enlarged. This is the unique advantage of the graphical method of representing scale.

Example:



Example

Statement of Scale into R. F.

1. Convert the given Statement of Scale of 1 inch represents 5 miles into R. F.

   Solution

   The given Statement of Scale may be converted into R. F. using the following steps.

   1 inch represents 5 miles

   or 1 inch represents 5 3 63,360 inches

   (1 mile 5 63,360 inches)

   or 1 inch represents 316,800 inches

   Answer R. F. 1 : 316,800 or 1/316800

R. F. into Statement of Scale

2. Convert R. F of 1 : 200,000 into Statement of Scale (In Metric System)

   Solution

   The given R. F. of 1 : 200,000 may be converted into Statement of Scale using the following steps :

   1 : 200,000 means that 1 unit on the map represents 200,000 units on the ground.

   or 1 cm represents 200,000 /100,000 (1 km 5 100,000 cm)

   or 1 cm represents 2.0 km

   Answer 1 cm represents 2 km

3. Convert the given Statement of Scale into Representative Fraction (R. F.).

   a. 5 cm represents 10 km

   b. 2 inches represents 4 miles

   c. 1 cm represents 100 metres

a. 5 cm represents 10 km

Step 1: convert into same units of measurement

(1 Km 5 100000 cm)

Step 2: 10 km 5 1000000 cm Therefore 5 cm: 1000000 cm

Step 3: simplify the ratio

1: 1000000/5

Answer : R.F. 5 1: 200000 or 1/200000

b. 2 inches represents 4 miles

Step 1: convert into same units of measurement

(1 mile 2 63,360 inches)

Step 2: 4 miles 5 63,360 3 4 5 253440

Therefore 2 inches: 253440 inches

Step 3: simplify the ratio

1: 253440/2 5 126720

Answer : R.F. 5 1: 126720 or 1/126720

c) 1 cm represents 100 metres

Step 1: convert into same units of measurement

(1m 5 100 cm)

Step 2: 100 m 5 10000 cm Therefore 1 cm: 10000 cm

Answer : R.F. 5 1: 10000 or 1/10000

Construction of the Graphical/Bar Scale

1. Construct a graphical scale for an R.F. 1 : 50,000 and read the distances in kilometre and metre.

(NOTE: By convention, a length of nearly 15 cm is taken to draw a graphical scale.)

Calculations

To get the length of line for the graphical scale, these steps may be followed:

R.F. 5 1 : 50,000 means that 1 unit of the map represents 50,000 units on the ground

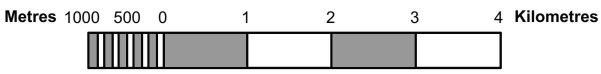
or 1 cm represents 50,000 cm or 0.5 Km (1 Km 5 100000 cm). Therefore, 10 cm represents 5.0 km

Construction

The graphical scale may be constructed by following these steps:

Draw a straight line of 10 cm and divide it into 5 equal parts these are the primary division. Mark the first division as 0. Assign the value of 1 km for the four divisions starting from 0. Therefore the primary scale has 4 divisions and is 4 km long.

Divide the extreme left side division into 10 equal parts and mark each division by a value of 100 metres, beginning from 0. This is the secondary scale representing 1000 mts.



Exercise

1. Convert the statement into RF.
   a. 1 cm 5 10 km
   b. 1 cm 5 5 km
   c. 1 cm 5 1 km
   d. 1 cm 5 50km
   e. 1 cm 5 100 km
2. Convert the RF into statement:
   a. 1: 100000
   b. 1: 50000
   c. 1: 250000
   d. 1: 5000000
   e. 1: 30000
3. Construct a graphical scale for the following:
   a. 1 cm 5 10 km
   b. 1 cm 5 5 km
   c. 1 cm 5 1 km
   d. 1 cm 5 50km
   e. 1 cm 5 100 km

9.3. Measurement of distance between places

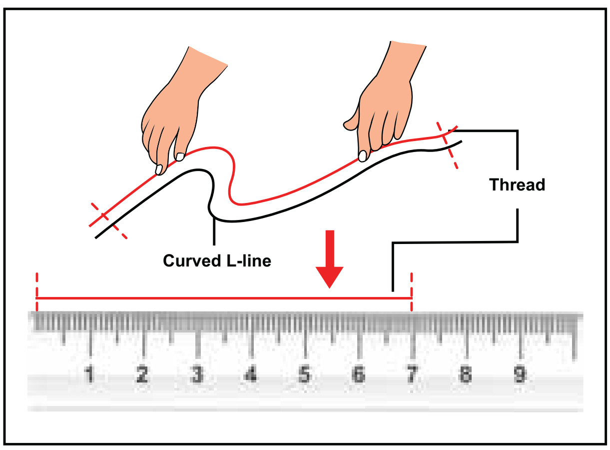
The linear features shown on the maps can be classified into two broad categories, i.e. straight lines and erratic or zigzag lines.

Straight line features

The measurement of straight line features like roads, railway lines and canals is simple. It can be taken directly with a pair of dividers or a scale placed on the map surface.

Erratic or zig zag lines

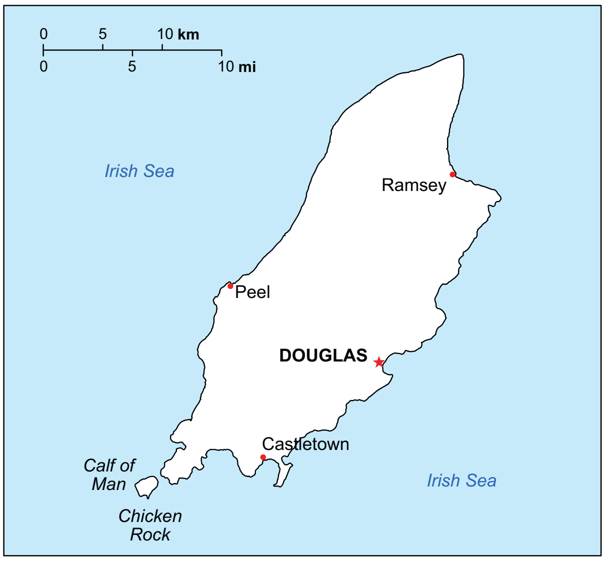
However, care should be taken to measure distances , along erratic paths, such as roads, boundaries, coastlines, rivers and streams. The distances along all such features can be measured by placing a thread at the starting point and carrying it along the line up to the end point. The thread is then stretched and measured to determine the distance. It can also be measured by using a simple instrument called Rotameter. The wheel of the 'rotameter' is moved along the route or line from start to end and the reading noted down.



Measuring a curved line using a thread and a ruler

Example

a. Measure the straight line distance between the towns Peel and Castle town.



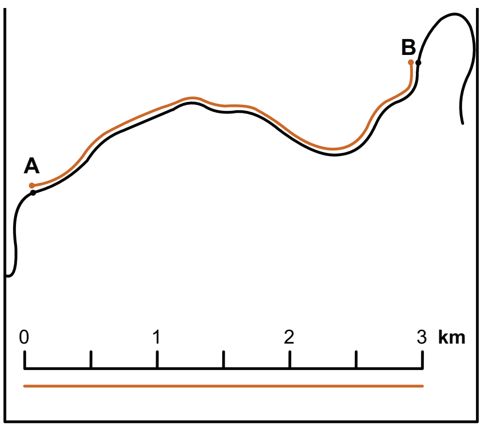
Step 1. Measure the distance between the towns Peel and Castle town with a scale or thread in cm.(example if it is 2.9 cm)

Step 2. Note the scale of the map in this case 1 cm 5 10km

Step 3. Multiply the measured distance with the scale of the map.(2.9 3 10km 5 29km)

Answer : The distance between the two urban centres is 29 km

a. Measure the irregular line distance between the points A and B.



Step 1. Measure the distance between the two points with the help of a thread.

Step 2. Place the thread on a scale and read the measurement in cm. (example if it is 3.2cm)

Step 3. Note the scale of the map in this case 1 cm 5 1 km

Step 4. Multiply the measured distance with the scale of the map. (3.2 3 1 km 5 3.2 km)

Answer : The distance between the two points is 3.2 km

Exercise

1. Measure the road and railway distance between your nearest town and Chennai city from Tamil Nadu in your atlas.
2. Measure the length of Tamil Nadu coastline .
3. Measure distance between any two nearest villages in a topo sheet.

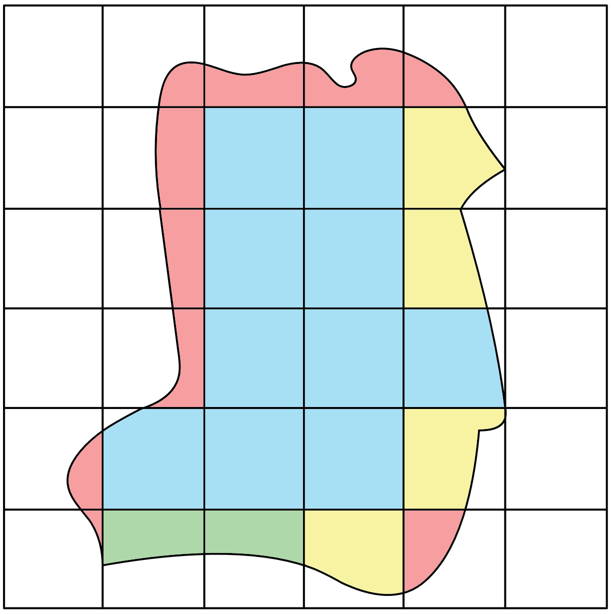
Activity

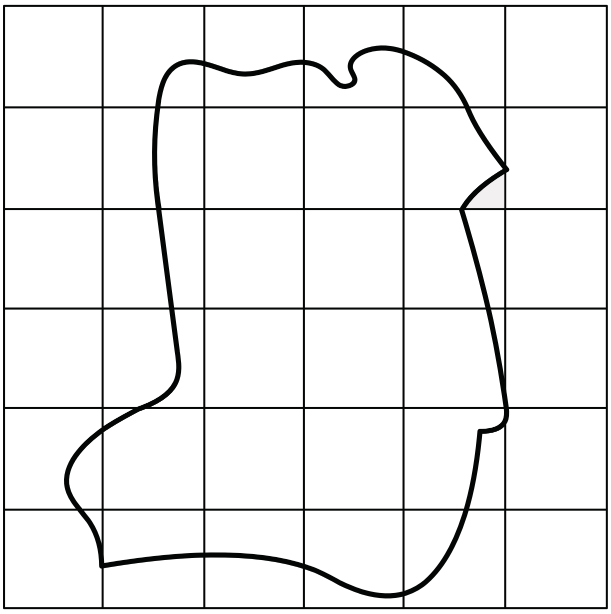
https://support.google.com/maps/answer/1628031?co 5 GENIE...hl 5 e

Using this link measure distance between any two selected places of your choice.

9.4 Measurement of Area

The measurement of a geographical area can be carried out on a map. There are number of methods used to measure area on a map. One of the simplest methods is by means of similar squares.





Square method: The square method is the most common method to measure area. In this method, the area to be measured is covered by squares by placing a sheet of graph paper beneath the map on an illuminated tracing table or by tracing the area onto the graph sheet. The squares pertain to a scale.

Example:

Calculate the area of the given map whose scale is 1 centimetre 5 1 kilometre cover the given area with a set of squares of side.

Area of 1 small square 5 1 km^2

Step 1: Count the number of full squares first 5 10 (shaded green) 1 small square 5 1 cm^2

Step 2: Next, count the numbers of the fractional squares

¾ square (yellow) 5 4,

½ square (pink) 5 2 and

¼ square (blue) 5 8)

Step 3: Calculate the total number of squares 10

(10 3 1 5 **10**,

Number of 3/4 square

4 3 3/4 5 **3**

Number of 1/2 squares

2 3 1/2 5 **1** and

number of 1/4 squares

8 3 1/4 5 **2**)

Step 4: Add all these values

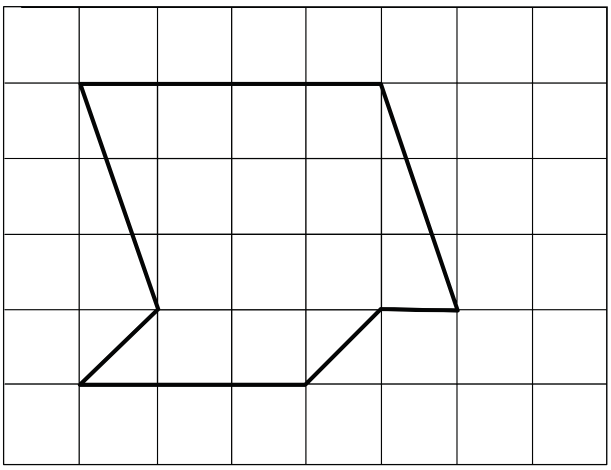
(**10** 1 **3** 1 **1** 1 **2** 5 **16** squares)

Step 5: Multiply 16 with the scale of the map

16 3 1 km^2 5 16 km^2

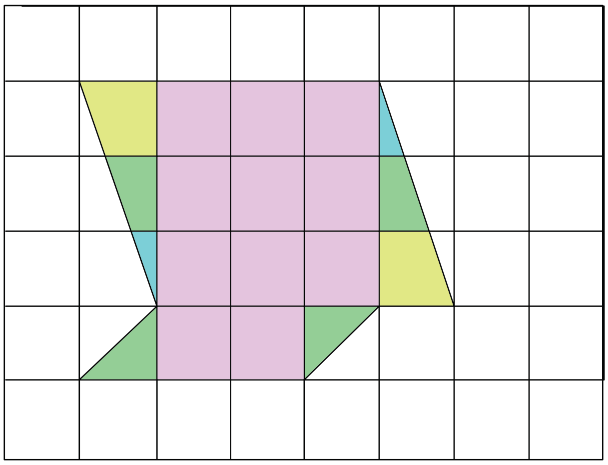
Hence the area of the given place is 5 16 square Km.

Example:



Measure the given area using square method: scale is 1 centimetre 5 1 kilometre (area of one small square 5 1 square Km)

Solution:



Step 1: Count the number of full squares first 5 11

Step 2: Next, count the numbers of the fractional squares

¾ square 5 2,

½ square 5 4 and

¼ 5 2

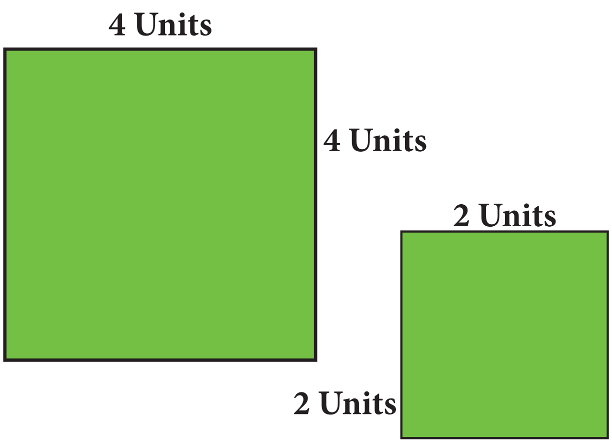
Step 3: Calculate the total number of squares

(11 3 1 5 11

Number of 3/4 square:

2 3 3/4 5 1.5

Number of 1/2 squares:



4 3 1/2 5 2 and

number of 1/4 squares:

2 3 1/4 5 0.5)

Step 4: Add all these values

(**11** 1 **1.5** 1 **2** 1 **0.5** 5 **15** squares)

Step 5: Multiply 15 with the scale of the map

15 3 1 5 15 km^2

Hence the area of the given place is 5 **15 square Km.**

Activity

https://www.makeuseof.com › Internet

Measure the area of any selected village/plot /area of your choice using this link.

9.5 Enlargement and reduction of maps

In the process of compiling maps cartographers are often required to either reduce or enlarge maps. Reduction or enlargement involves change in the size.

An enlargement provides the same map but proportionally larger than the original.

A reduction gives the same map that is proportionally smaller than the original.

The above image or map has been reduced by ½ .The amount that an original image has been enlarged or reduced is called a **scale factor,** or an **enlargement** or **reduction factor**. It is the constant factor by which all dimensions of an object are enlarged or reduced in a map. If shapes have been reduced by half, the scale factor is ½.

The ratio between the area of a map on one scale and its area to another scale is equal to the square of the ratios between the scales of the original and enlarged or reduced maps.

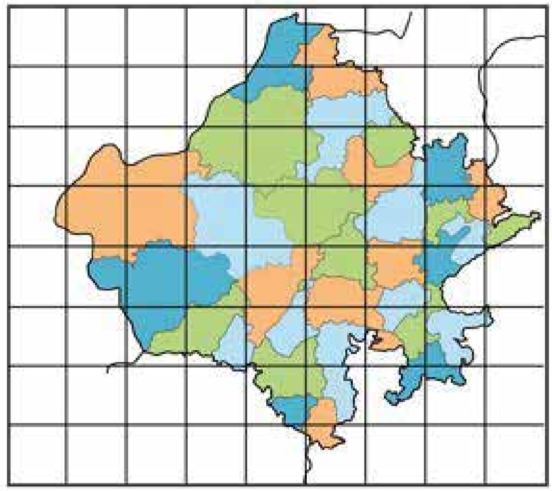
Graphical Method

Graphically maps can be enlarged or reduced with the help of similar squares.

The square method is the most common and simplest method for enlargement and reduction of maps. In order to enlarge a map, cover the original map with a set of squares of equal sides. The side of the squares has to be enlarged proportionally to that the original map. The side of the square of the new map has to be determined using the formula.

Step 1: Draw a network of squares on the original map, each side being 1 cm. in length.

Map of Rajasthan



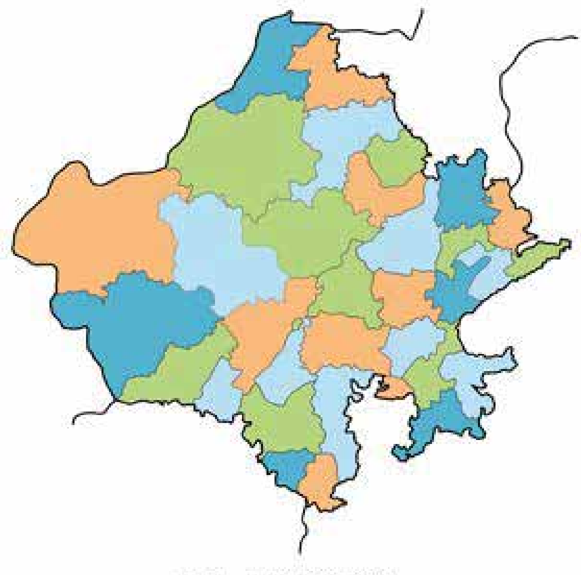
R.F= 1:16,000,000

Scale of the new map $5\frac{\text{New scale}}{\text{old scale}}3$ Side of the square of the original map.

Example:

This is a map of Rajasthan drawn on a scale of 1/16,000,000 and is to be enlarged on the scale of 1/8,000,000.

Map of Rajasthan



R.F= 1:16,000,000

To enlarge the given map on the scale of 1/8,000,000:

Step 2: Calculation

When the scale is 1/16,000,000 the side of the small square is one cm.

For Scale of the map 1/16,000,000 side of the small square 51 cm

Therefore, If scale is to be 1/8,000,000 side of the small square of new map 5 x

$$X\ 5\ \frac{1/8{,}000{,}000}{1/16{,}000{,}000} \text{ x } 1 \text{ cm}$$

$$X\ 5\ \frac{1 \text{ x } 16{,}000{,}000}{1 \text{ x } 8{,}000{,}000}\ 5\ 2\text{cm}$$

When the scale is 1/8,000,000 the side of the small square will be 2cmNow draw a network of squares, each side measuring 2 cm. The number of squares will be the same as on the original map. Now transfer the outline of original map on the enlarged map square by square.

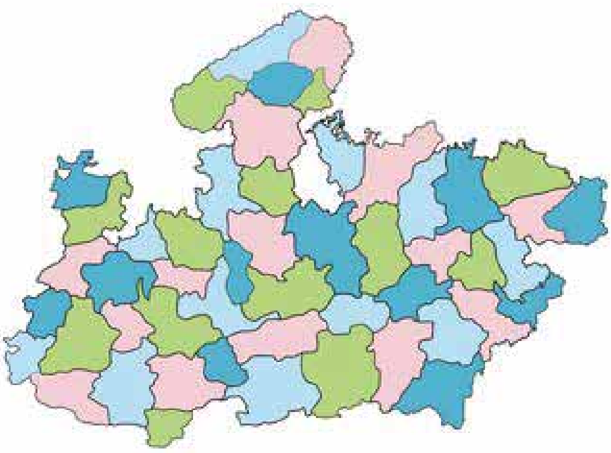
Example :

This is a map of Madhya Pradesh drawn on a scale of 1/8,000,000 and is to be reduced on the scale of 1/16,000,000.

To reduce the given map on the scale of 1/16,000,000.

Step 1: Draw a network of squares on the original map, each side being 1 cm. in length.

Map of Madhya Pradesh



R.F 5 1:8,000,000

Step 2: Calculation

When the scale is 1/8,000,000, the side of the small square is one cm.

For Scale of the map 1/8,000,000, side of the small square 51 cm

Therefore, If scale is to be 1/16,000,000 side of the small square 5 x

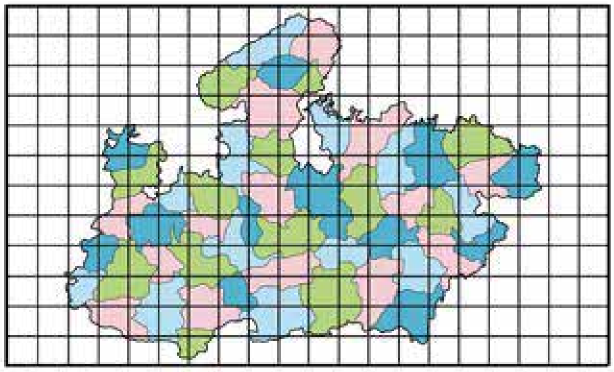
$$X\ 5\ \frac{1/16,000,000}{1/8,000,000} \times 1 \text{ cm}$$

$$X\ 5\ \frac{1 \times 8,000,000}{1 \times 16,000,000} 5\ \tfrac{1}{2}\text{cm}$$

When the scale is 1/16,000,000, the side of the small square will be ½ cm

Now draw a network of squares each side measuring 1/2 cm. of equal number as on the original map and transfer its outline on the reduced map square by square.

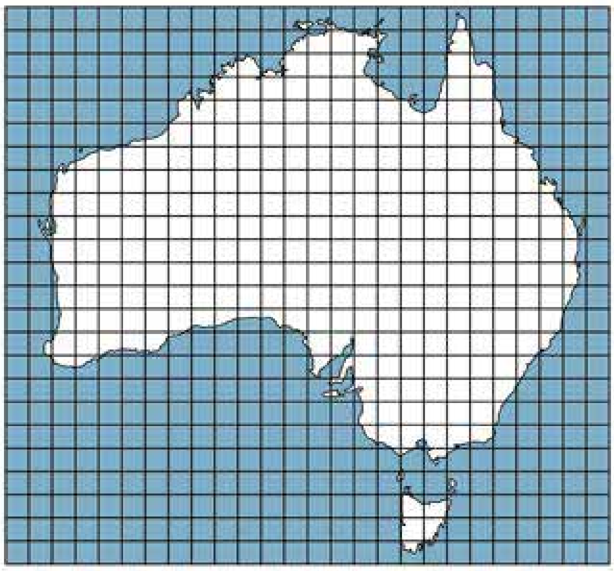
Map of Madhya Pradesh



R.F= 1:16,000,000

Example:

This is a map of Australia drawn on the scale of 1/32,000,000 and is to be enlarged on the scale of 1/16,000,000. The side of each square is ½ cm.



R.F= 1:32,000,000

Calculation

To enlarged the given map on the scale of 1/16,000,000:

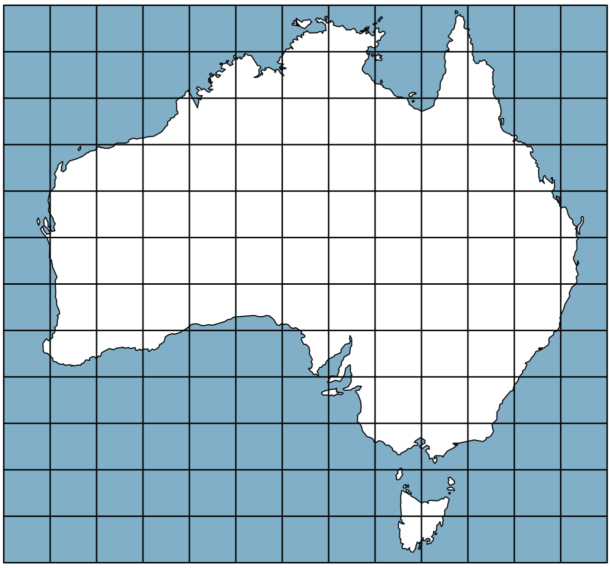
In the given map, when the scale is 1/32,000,000 the side of the small square is ½ cm.

Therefore, If scale is to be 1/16,000,000 side of the small square 5 x

$$X\ 5\ \frac{1/16{,}000{,}000}{1/32{,}000{,}000}\ x\ ½cm$$

$$X\ 5\ \frac{32{,}000{,}000}{16{,}000{,}000} 5\ ½cm$$

When the scale is 1/16,000,000 the side of the small square will be 1 cm. Now draw a network of squares, each side measuring 1 cm. The number of squares will be the same as on the original map. Now transfer the outline of original map on the enlarged map.



R.F= 1:16,000,000

Exercise:

Trace the outline of any two districts of Tamil Nadu from your atlas and enlarge and reduce the same.

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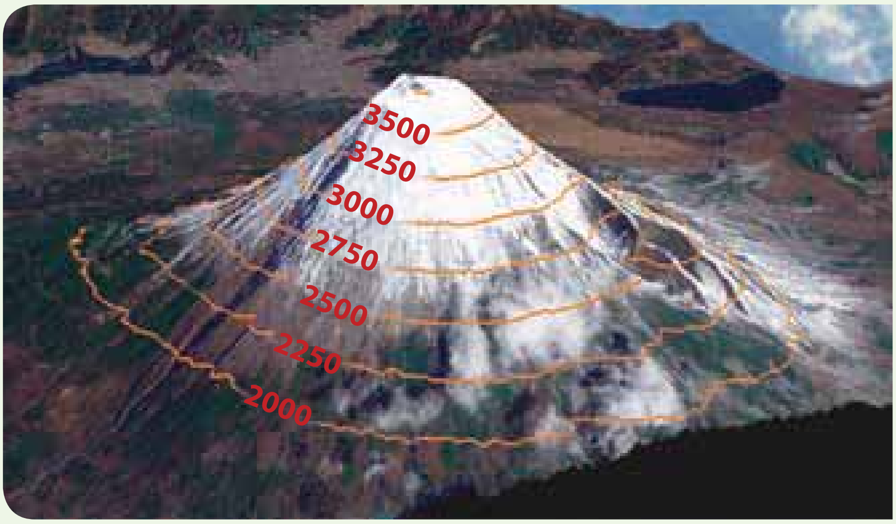
Unit X

Representation of Relief Features and Climatic Data



Chapter Outline

Learning Objectives:

- *Understand how to identify different landscapes.*
- *List types of measuring landscapes*
- *Draw cross section of contours and identify landforms.*

10.1 Introduction

A map gives all the information about a place according to the scale and projection used for mapping. A two dimensional map is capable of representing the third dimension - relief (elevation and slope) by various methods which has been in practice from ancient times.

10.2 Methods of Representing Relief Features

The important methods of representing relief features are hachures, contours, form lines, spot heights, bench marks, trigonometrical points, hill shading, layer-colouring, and so on. Each method has its own merits and demerits in depicting the relief of the land.

Hachures are small lines drawn to represent slopes. The lines are drawn thicker to represent steeper slopes and thinner for gentle slope. The slopes above 45° is depicted completely in black colour.

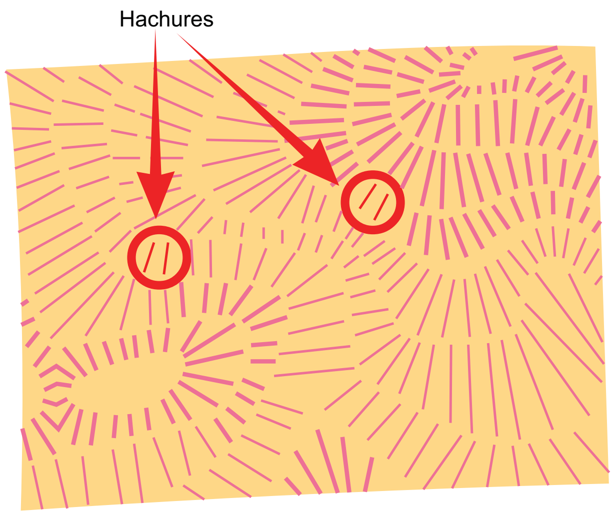


Figure 10.1 Hachures

Contours are imaginary lines connecting places having same elevation above mean sea level. They are drawn in brown colour.

Form lines are like contours representing features that are not actually surveyed. They are shown by broken lines.

Spot heights are heights of places surveyed and they denote the actual height above mean sea level. They are shown in maps as dots with their respective values written beside it.

Bench marks represent the actual height of a tall structure like a tall building, pillar, bridges or any other object of permanent nature. They are marked with the letters BM with the respective height.

Trigonometrical Stations are points included in the triangulation survey and

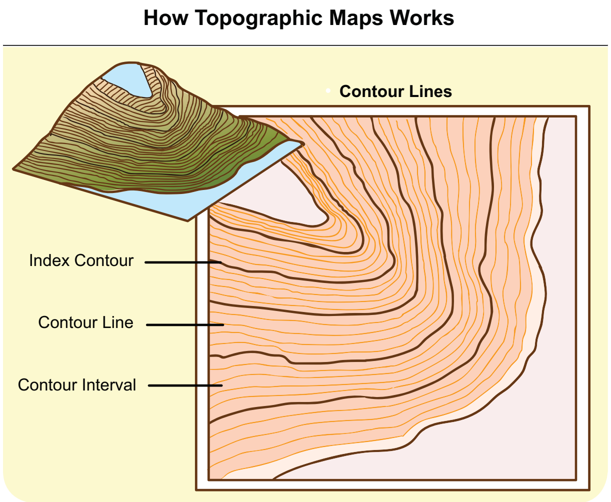


Figure 10.2 Contours

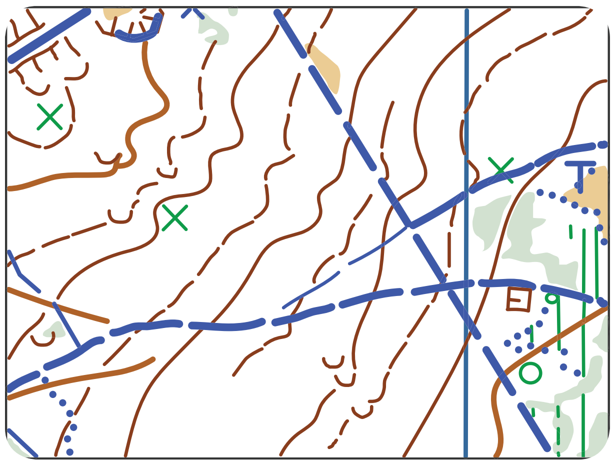


Figure 10.3 Form lines

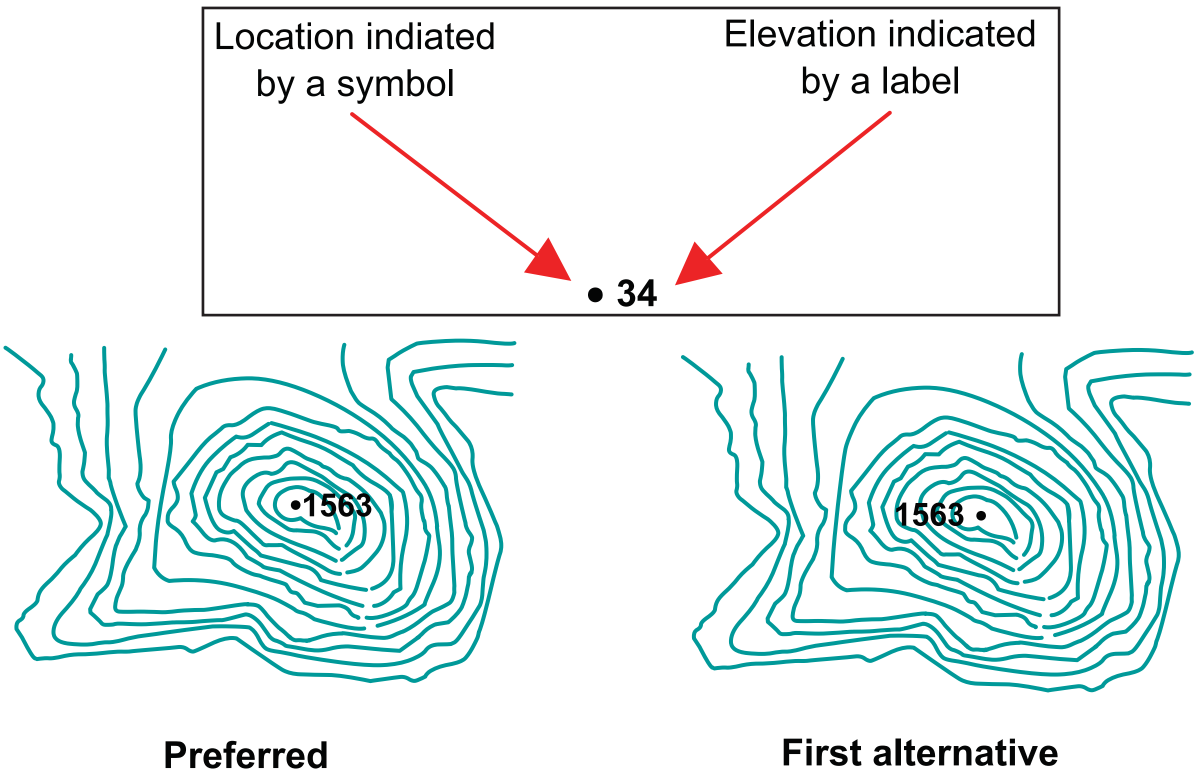


Figure 10.4 Spot heights

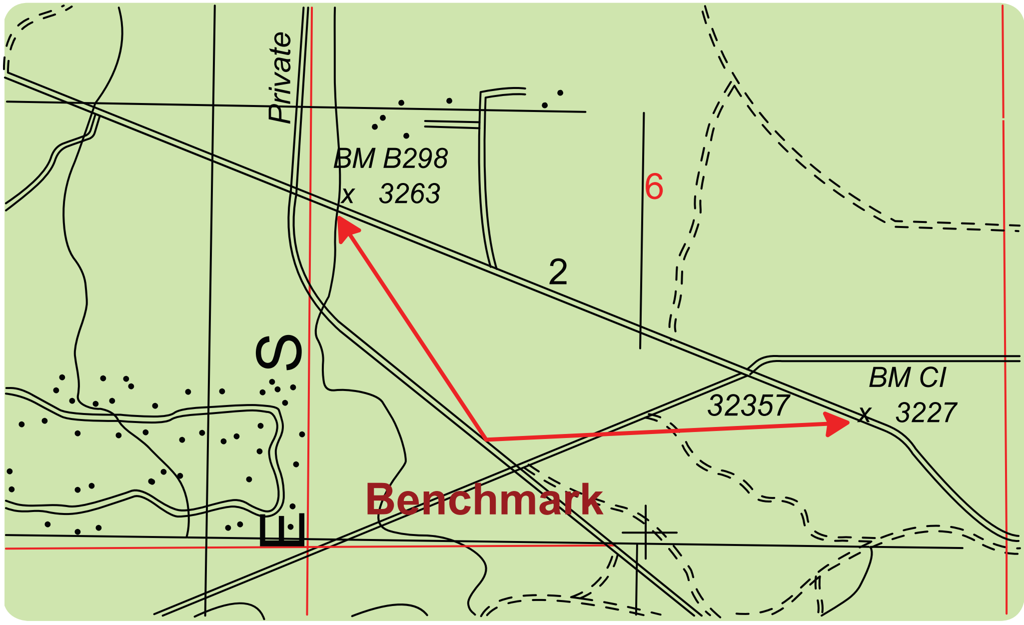


Figure 10.5 Benchmark

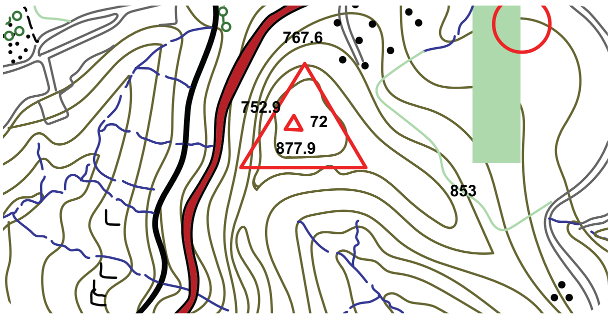


Figure 10.6 Trigonometrical Stations

are marked in the map with a triangle with the actual height of the place.

Hill Shading (levels of gray) is a method of representing relief on a map by depicting the shadows that would be cast by elevated areas if light wre shining from a certain direction.

Layer Colouring is a method showing relief in layers and each layer is given a different colour. Physical maps in atlas and wall maps use this method to show relief features. Ocean depth is also shown in various shades of blue. There is an international recognition for colours used in these maps. Accordingly blue represents water bodies, green for plains, various shades of brown for highlands and white for snow covered peaks.

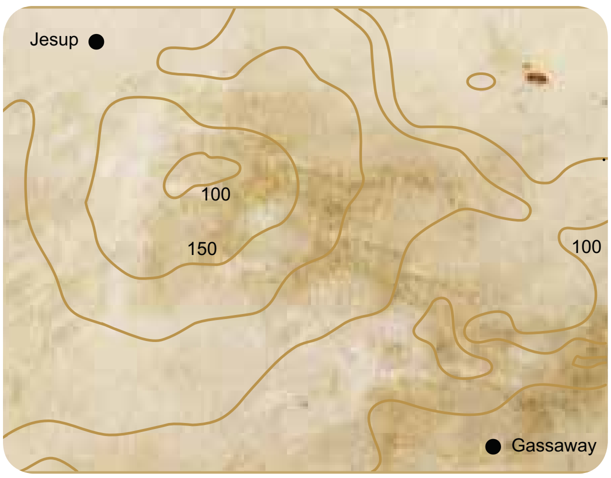


Figure 10.7 Hill Shading

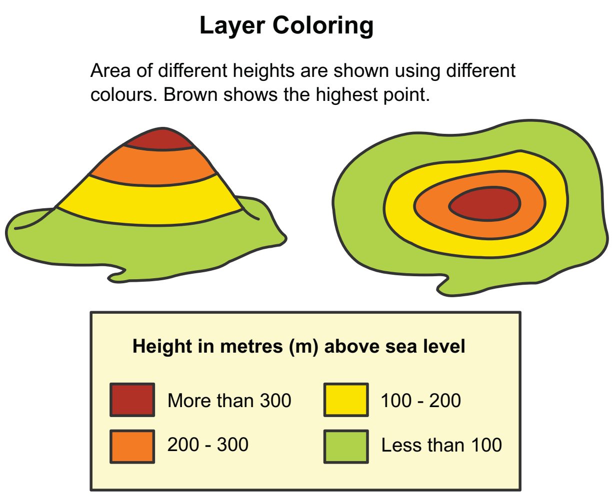


Figure 10.8 Layer colouring

Contours

Contour is universal method to show the relief. The unit of measurement of contour is generally metres above the mean sea level. Contour has an advantage that it does not hide the other features drawn on the toposheet. Reading contours is a skill that helps us to understand the actual landscape. The skill can be obtained by understanding the salient features of contours. They are as follows:

1. Contours are drawn at regular intervals in brown colour. Generally 20m interval is followed in 1:50,000 and 100m interval in 1:250,000 toposheet.
2. Every fifth contour is a dark line to enhance map reading.
3. The value of contour is printed by breaking the contour line andalso given at the edge of the toposheet.
4. Generally contours never cut or cross each other. In case of water fall and cliffs contours almost ouch a same point or a line. In over hanging cliff the contours cut each other.

Figure 10.10 gives the general features shown by contours.

Drawing Cross Section from Contours

The following figure shows the way two adjacent hills are shown by contours.

a) Two adjacent hills shown by contour

Drawing cross section of the contours allows one to know the exact landform

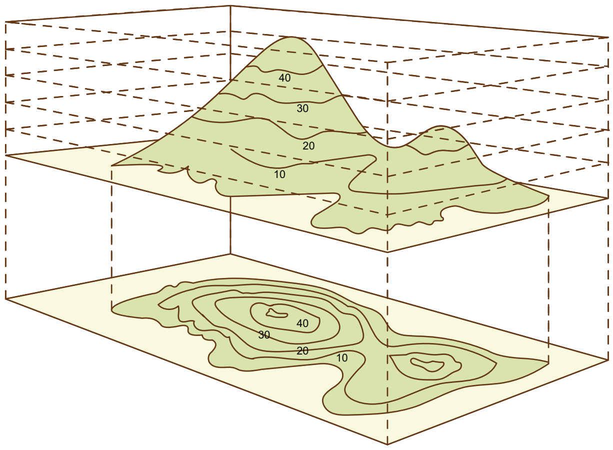


Figure 10.9 Two adjacent hills

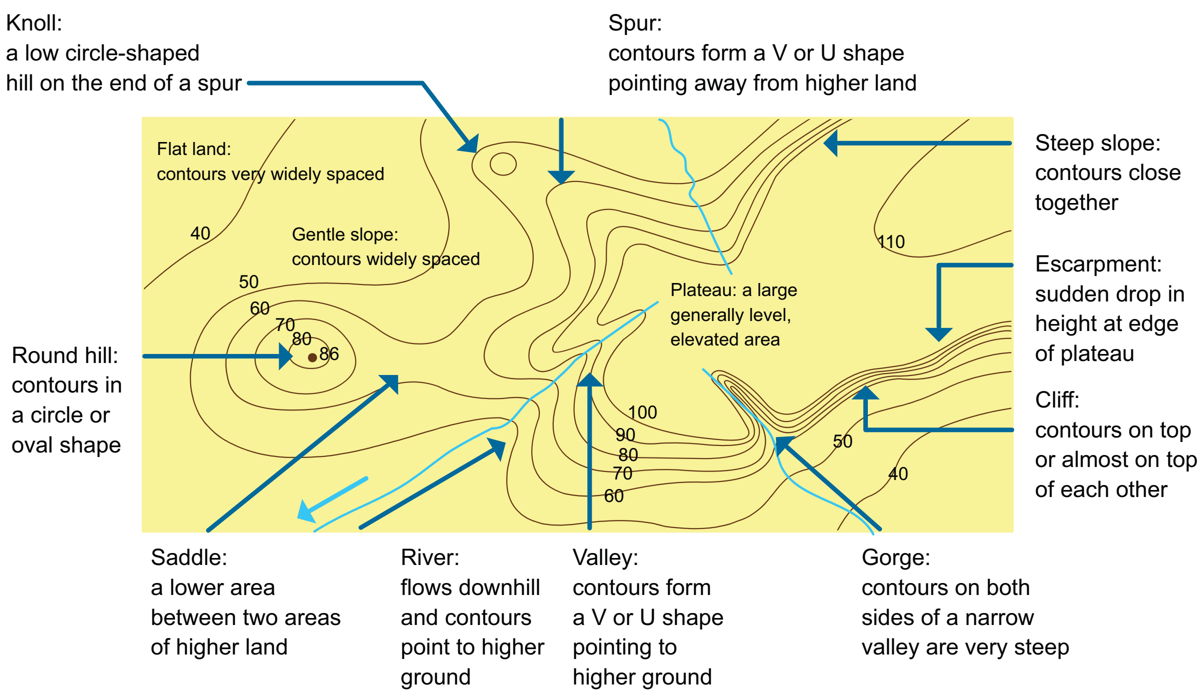


Figure 10.10 Contours of different land features

depicted in the toposheet. Drawing cross section involves selecting a section within the portion of the contour, marking the intersections of these selected contours on suitable vertical scale and joining these points to indentify the land form. Generally closely spaced contours indicate that the slope is steep, and widely spaced contours indicate that the slope is gentle. The following pictures show contours and cross sections of a hill and a depression.

Steps to be followed to draw contours and the cross section:

1. Draw the contours in brown colour.
2. Draw a line AB for which the cross section has to be drawn.
3. Below the contour draw required number of horizontal lines of equal distance and interval (2mm) to represent all the contour values given in the diagram
4. Write the value of all the contours in such a way that the lowest value of the contour forms the base line and the values increase according to the contour interval given in the diagram.
5. Draw vertical lines from each intersection point on the line AB with the contours to the horizontal line representing its value.
6. Join all these points to identify the feature shown.
7. Shade the feature in black to complete the cross section.

General instruction to identify features shown in contours:

- **A hill** is shown by circular contours with height less than 1,000 m.
- **A plateau** is an elevated land represented by inner most contour roughly rectangular in shape and closer outer contours. The height may generally vary from 300m to 600 metres. If a plateau is enclosed by mountains, it is called intermontane plateau and when it is formed in the foot hills it is called piedmont plateau.
- **A ridge** is an elongated and steep sloped high mountain with two or more peaks shown by elliptical contour lines. A narrow low depression between two peaks is called **Col**. Saddle is similar to a col but higher, broader and gently sloping from peaks of a ridge.

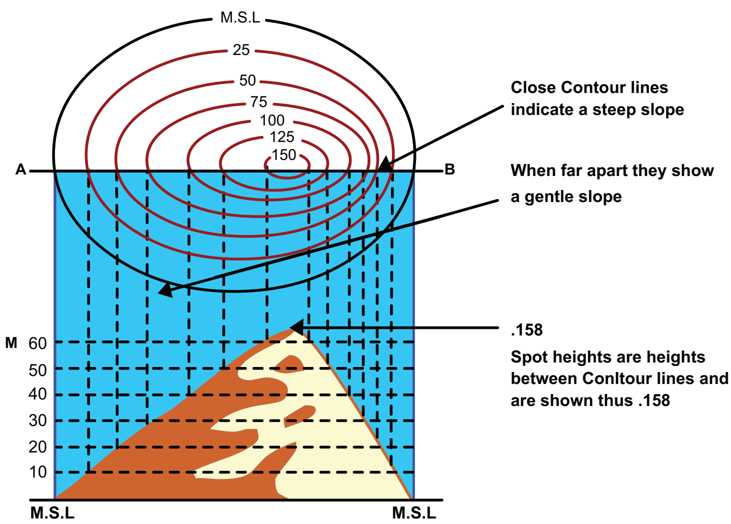


Figure 10.11 Hill

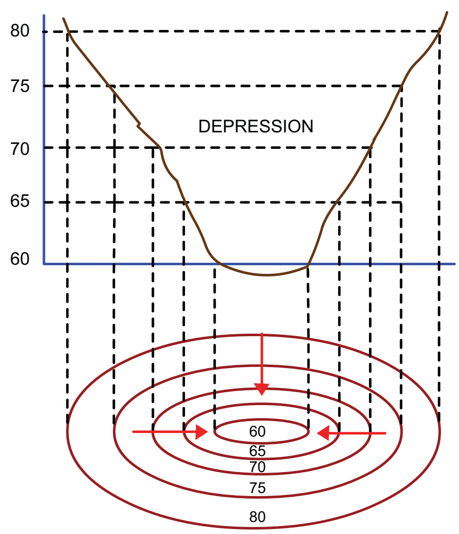


Figure 10.12 Valley

- **A valley** is a long depression with steep slope formed by the vertical erosion of the river within the stretch of upland. The contours bend sharply across the river in a 'V' shape with the apex pointing towards higher elevations.
- **Spurs** are projection of land from higher to lower ground. Contours bend smoothly with the apex of the 'V' pointing towards lower ground.
- **A waterfall** occurs when there is a sudden difference in height of the river valley.A **waterfall** is a place where water flows over a vertical drop or a series of steep drops in the course of a stream or river. It is represented by contours meeting at a same point on the hill slope. The difference between the value of the highest and the lowest contour touching the same point gives the height of the waterfall.
- **A cliff** is a steep sloped exposure of a valley or coast. If it is near sea we call it sea cliff.
- **Gorge** is a very steep valley at higher elevations formed by river erosion. It can be identified by closely converging contours in the river course.
- **A volcano** is represented by closed contours with the innermost contours having lesser values than the surrounding, denoting the crater depression.

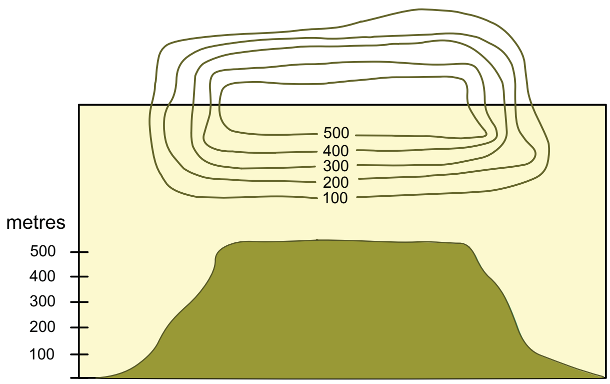


Figure 10.13 Plateau

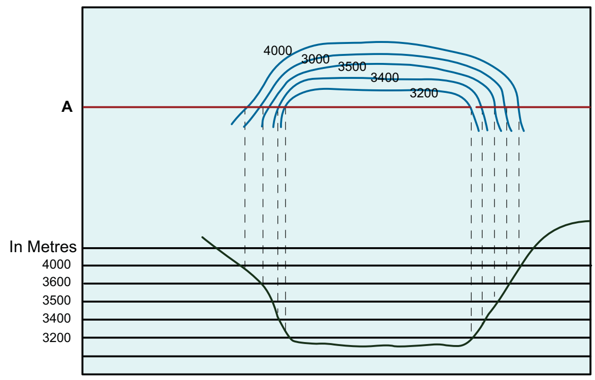


Figure 10.14 Inter montane plateau

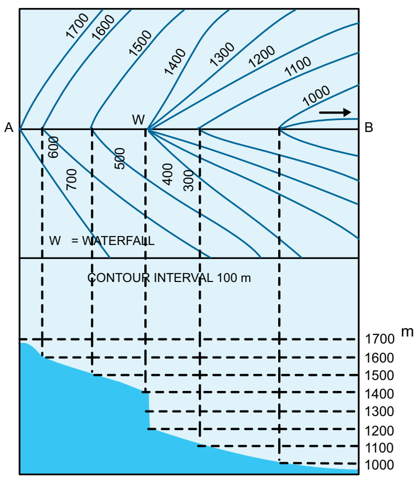


Figure 10.15 Waterfall

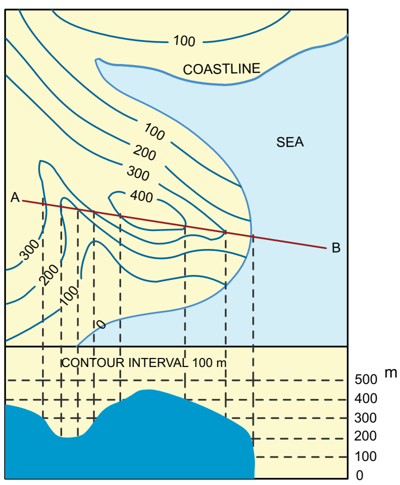


Figure 10.16 Sea cliff

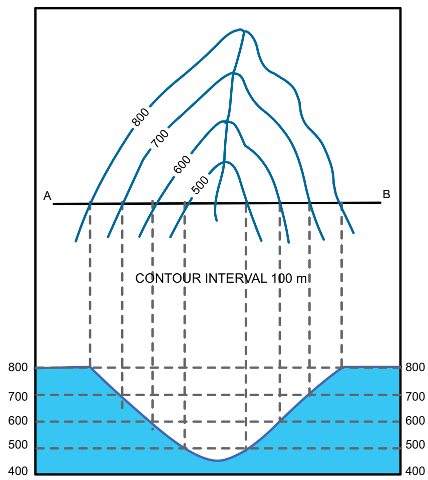
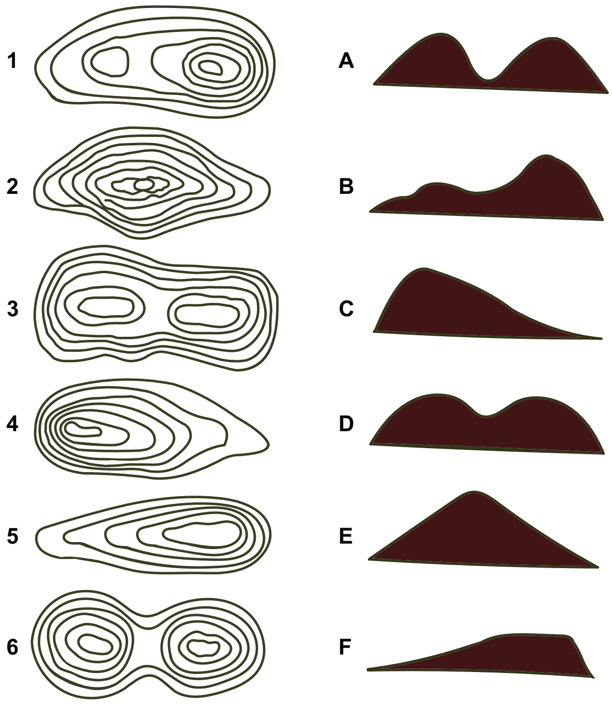


Figure 10.17 V-Shaped valley

Exercise 1

Match the following



10.3 Profile Diagram

Contour diagram and cross section are drawn for selected features of the earth. In a continuous landscape one may be interested to visualize the general sky line for an area along a selected path. Profile or a section is a method which helps to visualize the relief feature for a larger area drawn along a selected base line.

Types of Profiles

Profiles drawn for three or four selected individual base line are called **Serial profiles**. When profile sections of all serial profiles are drawn on a same vertical baseline it is named as **superimposed profile**. When one of the serial profile is kept as a base and the elevated portions of successive profiles are drawn it is known as **projected profile**. The line joining the topmost elevated portions of all the serial profiles drawn on a same base line gives the sky line or summit line for that region. This is termed as **composite profile**.

Steps to Draw Profiles

Trace the contours in the toposheet for a size of 10 cm by 10 cm with the contour height.

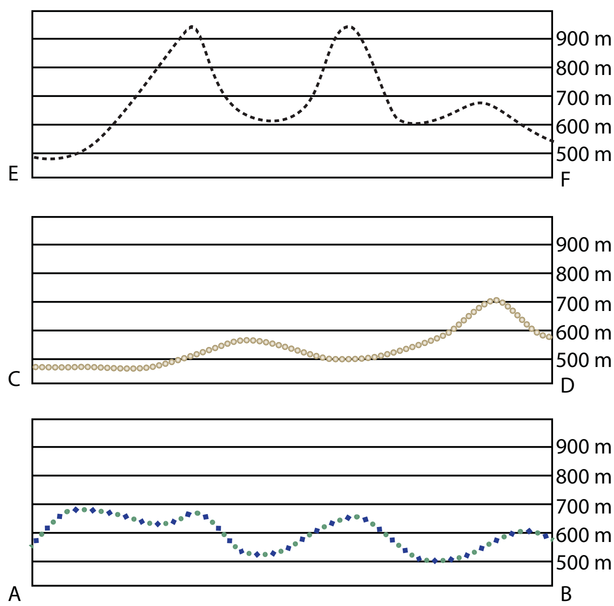
Select four base lines at a distance of 2.5 cm each. Name them as AB, CD and EF.

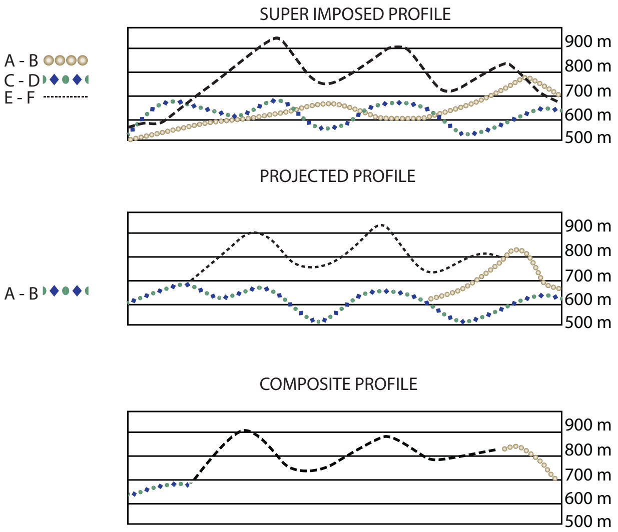
Draw the horizontal lines to represent contour with suitable vertical exaggeration.

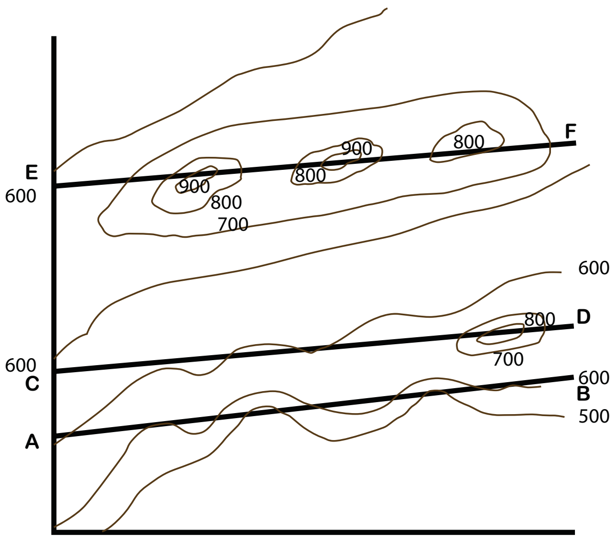
On this vertically exaggerated figure carefully draw cross sections separately for all the selected lines (AB, CD and EF) as described in the previous section. They are named as **serial profile**. Draw each section in different colour for better visualisation.

For **super imposed profile** draw the sections of each line on one vertically exaggerated line with the same colours used as before.

Draw a common vertically exaggerated base line. First draw the cross section of AB line. Next while drawing the cross section of CD line draw only those parts which are the higher than AB line. Next draw the cross section of line EF which







Exercise 2

lies above the CD line. Draw these cross sections with the respective colours drawn in serial profiles for better understanding and visualization. This figure gives the **projected profil**e of the selected region.

Composite profile gives the topmost portion of each line joined as one line on the same vertically exaggerated base line.

This gives the effect of the landscape seen from a distance.

Exercise 2

Draw serial profile, superimposed profile, projected and composite profile for the given contour diagram.

10.4 Climatic Diagrams

Climatic diagrams show specific weather element for a specific station for a specific time. Graph, bar charts, combination of graph and bar and wind roses are few climatic diagrams drawn to represent climatic data. Mean monthly temperature of stations can be shown in simple graph. Comparison of maximum, minimum temperature with mean monthly temperature can be done by drawing a multiple graph. Generally rainfall is shown as bar diagram for individual station. Special climatic diagrams combine both bar and graph to show the climatic variations among stations.

Examples

1. Draw graph to show the average maximum and minimum temperature for Chennai city.

In the x axis,mark the months of the year. 1 cm = one month

In the y axis, mark the temperature after selecting suitable scale considering the lowest and highest temperature of the station. (1 cm = 2 degrees Celsius)

Temperature / Month	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Maximum Temperature in °C	29.3	30.9	32.9	34.5	37.1	37.0	35.3	34.7	34.2	32.1	29.9	28.9
Minimum Temperature in °C	21.2	22.2	24.2	26.6	28.0	27.5	26.4	25.9	25.6	24.6	23.1	21.9

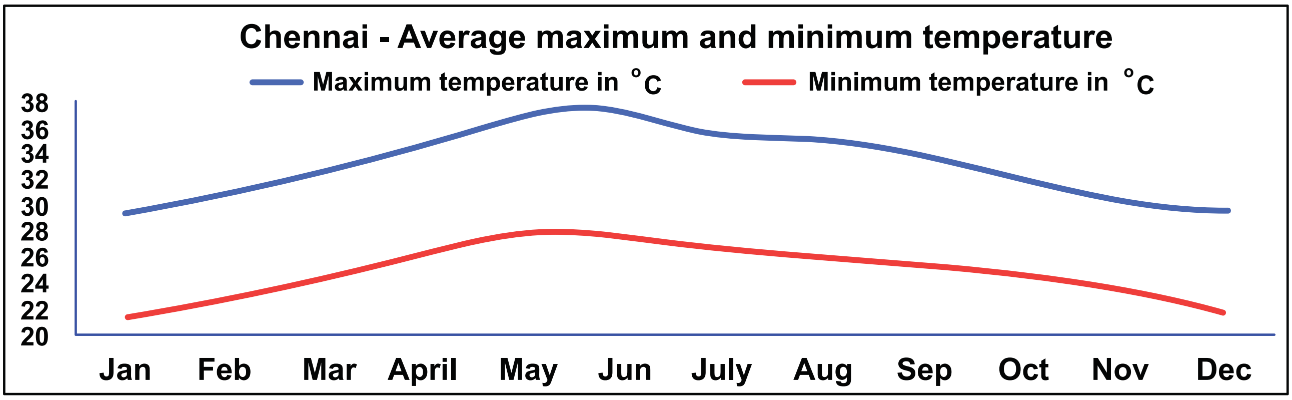


Figure 10.18 Chennai - Average maximum and minimum temperature

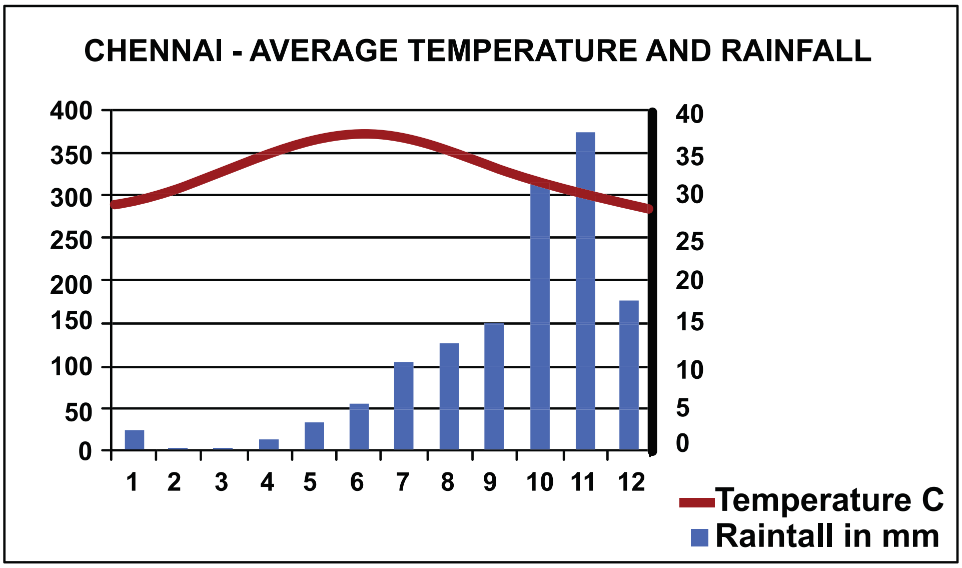


Figure 10.19 Chennai - Average temperature and rainfall

10.5 Ombrothermic Diagram

Climate diagrams are diagrams that summarize trends in temperature and precipitation for at least 30 years. They allow to establish the relationship between temperature and precipitation and to determine the length of dry, wet, and extremely wet periods.

Ombrothermic diagram also called as Walter Lieth diagram is one such climatic diagram used to compare the average wetness and dryness for an area of interest. The data must be average for nearly thirty years.

1. On graph paper, draw the x-axis marking each of the months starting with the coldest month. Remember to start in January if you are plotting data collected in the northern hemisphere or in July if the data is from the southern hemisphere.
2. Label the months on the x-axis.
3. Draw two y axes one for temperature in degree Celsius and another for rainfall in mm.
4. The scale must be chosen in such a way that line marking 10°C should be equal to 20 mm of rainfall in the other axis.

Rainfall scale should be twice the value of temperature scale selected.

5. Draw a graph with red colour corresponding to the temperature data.
6. Draw a graph with blue colour corresponding to the rainfall data.
7. When the temperature line runs above the precipitation line there is a **dry season** and the area between the lines should be illustrated by **filling it with dots**
8. When the temperature line runs below the precipitation line there is a **wet season** and the area between the lines should be illustrated by **filling it with vertical lines**
9. There is a practice of colouring the portions which exceed 100 mm, precipitation as a period with excess water with black colour**.**
10. The station name and its elevation should be mentioned in the top left, average temperature and average rainfall in the top right, extremes of temperature in the second line should be shown.

Inference: The station has the dry season between April and October; wet season from October to April and excess water between November and February.

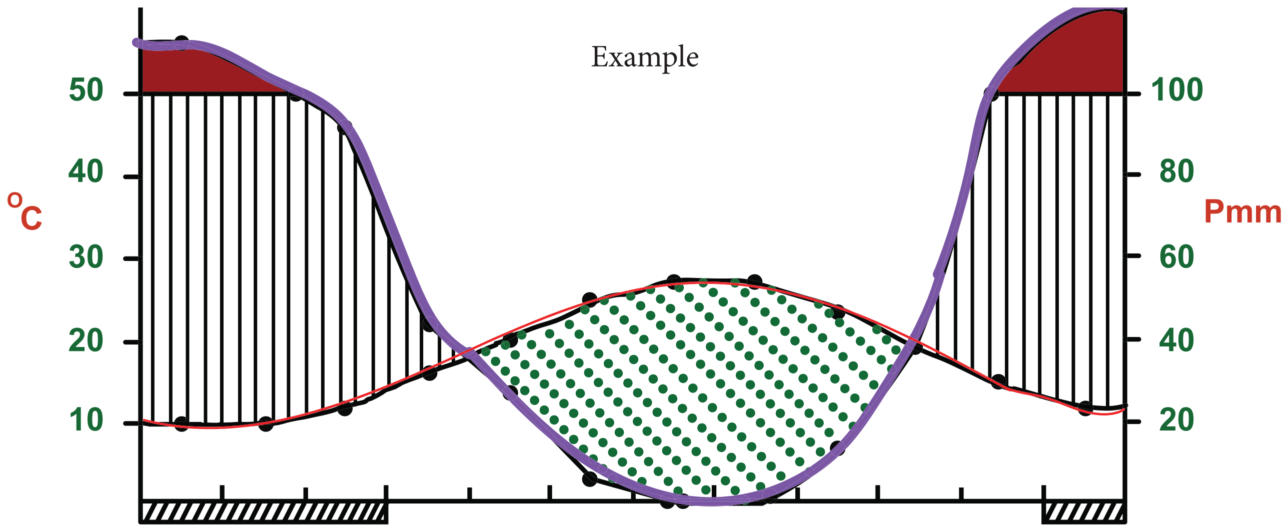


Figure 10.20 Ombrothermic diagram

Exercise 3

Draw ombrothermic diagram for the following stations and identify the dry, wet and excess water season for the following.

http://www.indiawaterportal.org/met_data/ This website provides climatic data for 100 years.

10.6 Wind Rose Diagram

Wind rose diagrams show wind data for a particular station. It is in the form of star shape so it is also called star diagram. Wind rose diagram is used to depict the wind direction and average frequency for a particular site. Wind data are generally collected at 10 m above ground and if required at various

Parameter/ Month	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Cuddalore												
Rainfall mm	15.54	10.44	12.48	20.96	57.1	41.24	64.4	99.28	147.17	204.22	165.07	133.76
Temp. °C	25.3	26.58	28.46	30.61	31.32	30.75	30	29.34	29.03	27.89	26.45	25.36
Coimbatore												
Rainfall mm	7.56	13.34	23.04	85.78	178.47	481	492.64	315.2	202.82	263.57	153.53	44.03
Temp. °C	25.4	26.43	27.89	28.77	28.06	26.37	25.55	25.68	26.17	26.21	25.99	25.29
Karur												
Rainfall mm	8.14	16.72	23.73	62.44	96.94	90.68	122.52	106.8	144.68	213.49	135.09	67.64
Temp. °C	23.2	24.4	26.06	27.41	27.17	25.75	25.06	24.96	25.22	24.74	23.91	23.01
Tirunelveli												
Rainfall mm	14.9	31.45	24.32	85.27	128.5	195.7	147.82	118.9	116.18	203.96	163.37	68.79
Temp. °C	21.1	21.63	22.44	22.95	22.7	21.64	21.19	21.15	21.46	21.3	21.24	21.13
Vellore												
Rainfall mm	4.64	9.91	10.58	28.44	94.3	71.28	96.26	122.3	172.47	195.62	122.08	58.25
Temp. °C	23.2	25.08	27.46	29.69	30.04	28.51	27.56	27.11	26.92	25.9	24.33	23.07

Source: India Water Portal | Safe, sustainable water for all. www.indiawaterportal.org/ Exercise 3

height for specific purposes. They can be prepared for month-wise, season-wise or yearly as needed. Wind velocity can also be shown within this diagram. Sometimes they even include air temperature information. Wind rose diagram is vital for constructing runways in airports. The run way is generally oriented towards the prevailing wind. Wind rose diagram is an essential inclusion in pilots chart and sailing charts. Architects and builders need to analyse the wind rose diagram for proper ventilation. The concept of simple wind rose diagram is given below.

Exercise 4

Draw a wind rose diagram for the following data.

Wind Direction	Percentage of Days Wind Blowing from this Direction
North	27
North east	9
East	8
South east	14
South	10
South west	7
West	6
North west	15
Calm	4

Step 1: Select a suitable scale (in this case 1 cm = 10%)

Step 2: Draw a circle to represent the calm for this scale. (Draw a circle with 0.4 cm radius)

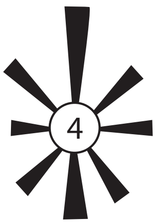
Step 3: Mark the directions in this circle using a protractor as shown in the figure. (considering 0° for north, 45° for NE, 90° for East, 135° for South east, 180° for South, 225° for South west, 270° for West and 315° for North west.

Step 4: Draw a bar with suitable with equal to the length of 2.7 cm in northern direction, 0.9 cm in the north eastern direction and so on to complete the diagram.

Step 5: Mention the calm in the centre, mention the scale chosen to draw the diagram and name the directions as instructed above.

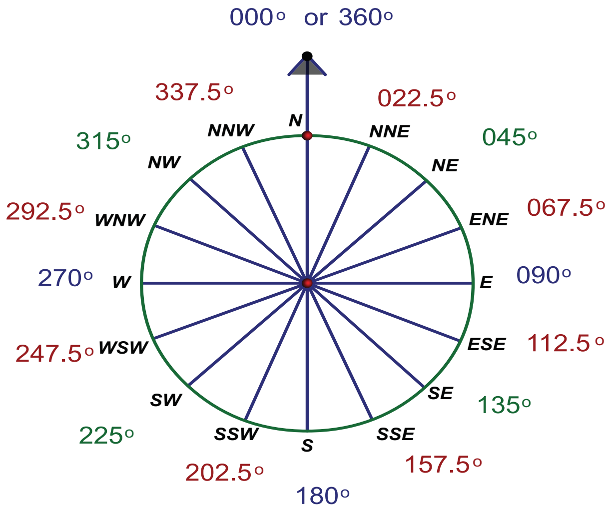
Wind Rose Diagram

Percentage of days wind blowing from various direction.



1 c.m = 10% of days

(4 c.m diameter)



Exercise 5

Draw wind rose diagram for the following stations.

Direction of Wind / Wind Blowing Days	Percentage of days wind blowing from this direction from the Stations			
	Kota	Delhi	Cuddalore	Cochin
North	10	4	6	2
North east	15	4	30	10
East	15	10	20	10
South east	10	8	8	6
South	2	4	6	25
South west	2	6	6	25
West	2	29	6	5
North west	4	3	6	7
Calm	40	10	12	10

Activity

Know about the wind rose diagram and its interpretation in this web site: https://www.envitrans.com/how-to-interpret-a-wind-rose.php

References

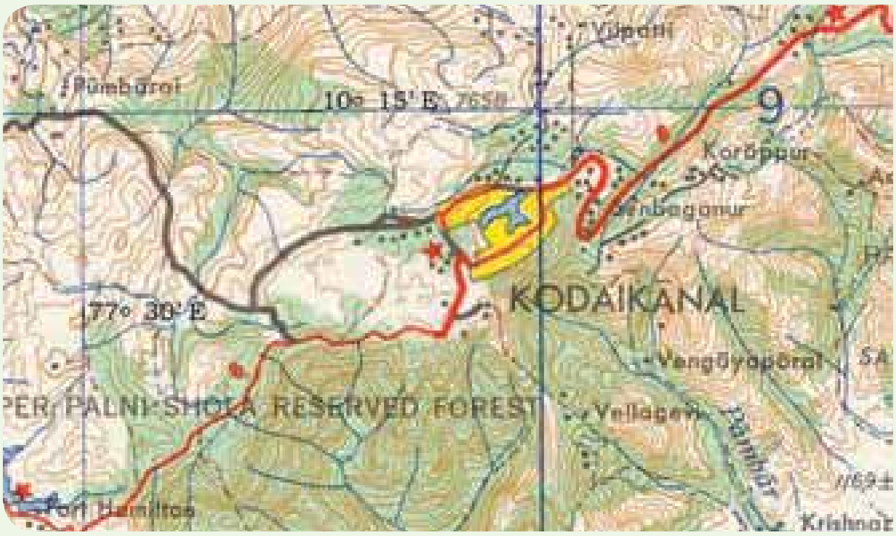
1. Singh R.L. and R. Singh (2001) Map Work and Practical Geography, Central Book Depot, Allahabad.
2. Singh L.R. (2013) Fundamentals of Practical Geography, ShardaPustak-Bhavan, Allahabad.

Web References

1. https://www.slideshare.net/TimCorner/earth-science-mappingtopographic-maps-ppt
2. https://www.slideshare.net/bala1957/use-of-toposheets-in-civil-engineering-projects

Unit XI

Interpretation of Topographical Map



Chapter Outline

Learning Objectives:

- *Understand the importance of conventional signs and symbols*
- *Appreciate the marginal information printed on the topo sheet*
- *Develop map reading skills*
- *Identify the various physical and cultural features in a topo sheet.*
- *Interpret a topographic sheet*

11.1. Introduction

A Map is a representation of a part or whole of the earth's surface on a two dimensional surface. A map is a good guide, but it requires some skill on the part of the map user to follow the direction and information given by it. Map reading in actually, denotes the formation of the visual picture of the ground depicted on a map. It requires good deal of practice. The best way to familiarise once self with the topography of a region is to compare the topographic map of the region with the actually area depicted through a field visit called ground truthing. It is not possible for anyone in their life time to collect direct information about the whole earth but the student can get a large amount of information about the earth from the topographic sheet or from these maps.

Topographical map commonly known as *topo sheets*, are special maps prepared by survey department that show a three-dimensional surface on a two-dimensional sheet of paper. In India the topographic sheets for the whole country are prepared by an organisation called as the 'Survey of India' (SOI). The sheets are prepared largely on a scale of 1:50,000. Maps on scale of 1: 25,000, 1: 250,000 and 1:1,000,000 or million sheets are also prepared.

11.2 Conventional signs and symbols

Features which have to be repeatedly represented on maps are depicted by special signs and symbols. The signs bear some pictorial resemblance to the original feature and their meaning is quiet clear. Some conventional signs need to be studied closely before they can be recognised.

Point, line and area symbols are used to depict various physical and cultural features. They can be in the form of alphabets, figures, signs or colour wash.

The Survey Of India (SOI) have standardised a set of conventional signs and symbols to be used in topographical maps.

Seven colours are commonly used in the maps of Survey of India.

- **Black** - All writings on the map except grid numbers (names, abbreviation such as DB, RS, PO), river banks, broken ground, dry streams, surveyed trees, heights and their numbering, railway lines, telephone and telegraph lines, lines of latitude and longitude, all boundaries, any written amplification (such as 'open scrub', 'metalled road under construction', 'meter guage' are given in black.
- **Brown** - Contour lines, their numbering, form lines, sand features and barren rocky areas such as hills and dunes are represented in brown.
- **Blue** – Blue colour is used to show water features or water bodies (Rivers, Lakes, ponds, tanks, wells, etc.,)
- **Green** - Wooded and forested areas shown as green wash, orchards, scattered trees and scrubs shown by green symbols.
- **Yellow** - Cultivated areas are shown as yellow wash.
- **Red** - Grid lines (East and North) and their numbering; roads, cart track and foot path, settlements, huts and buildings are shown in red.
- **White patches** - Uncultivated land and glaciated and snow covered areas in mountains. (Figure 11.1)

11.3 Open Series Maps

Survey of India (SOI) brings out two series of maps through the National Map Policy, 2005.

Defence Series Maps (DSMs) - These topographical maps (on Everest/WGS-84 Datum and Polyconic/UTM Projection) are on various scales (with heights, contours and full content without dilution of accuracy). These maps mainly cater for defence and national security requirements. This series of maps (in analogue or digital forms) for the entire country are classified by the Ministry of Defence.

Open Series Maps (OSMs) - OSMs are brought out exclusively by SOI, primarily for supporting development activities in the country. OSMs bear different map sheet numbers and are in UTM Projection on WGS-84 datum. Each of these OSMs (in both hard copy and digital form) become'Unrestricted'.

11.4 Marginal Information

Marginal information includes the topographical sheet number, its location, grid references, its extent in degrees and

A number of methods have been used to show the relief features of the Earth's surface on maps, over the years. These methods include hachure, hill shading, layer tints, benchmarks and spot heights and contours. However, contours and spot heights are predominantly used to depict the relief of an area on all topographical maps.

Figure 11.1 Conventional Signs and Symbols

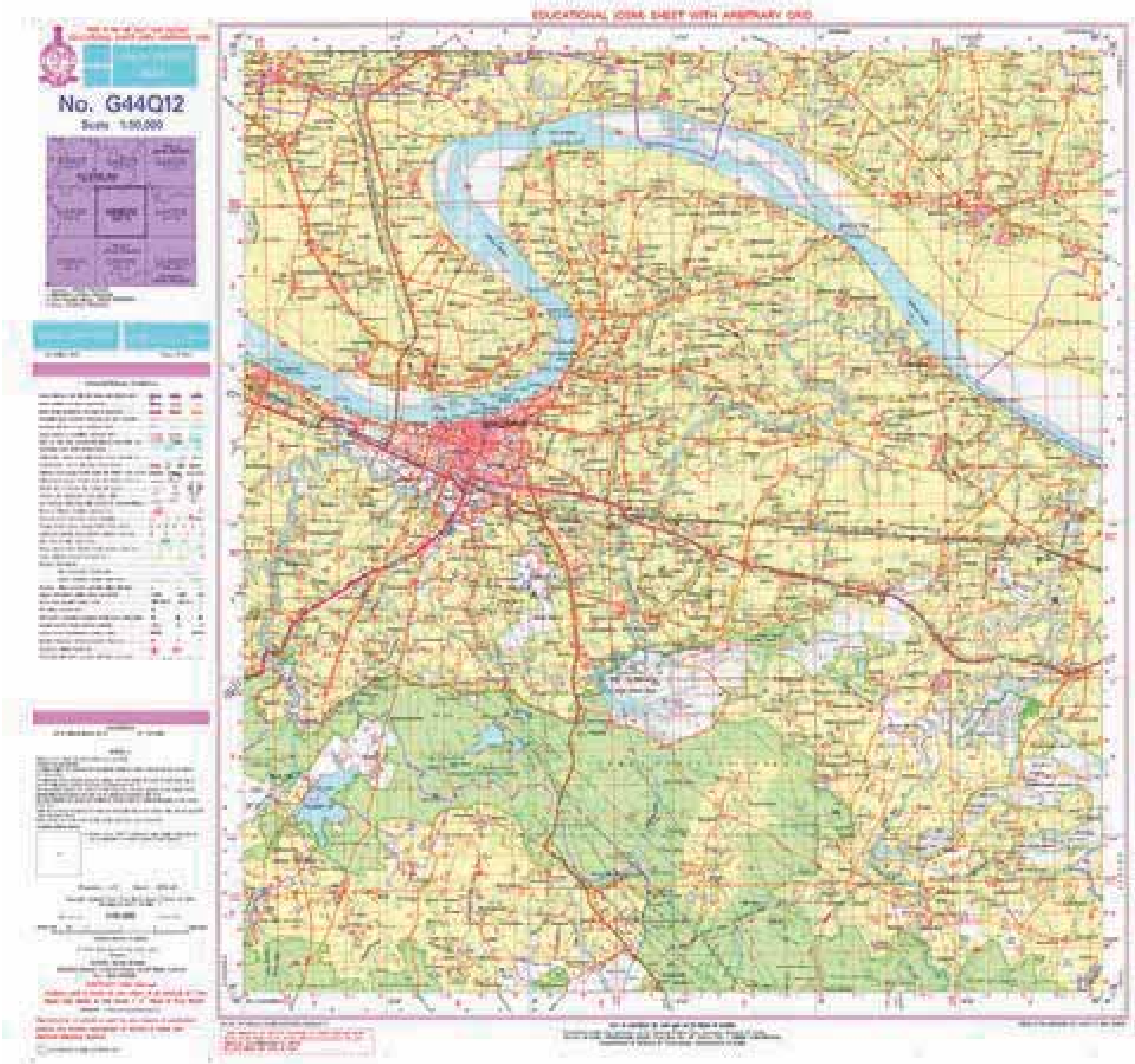


Figure 11.2 Open Series Map

minutes, scale, the districts covered, etc. Marginal information is classified in to:

- **Extra Marginal Information**- Serial Number, name of the State, District and other general information.
- **Intra Marginal Information** – Grid information, contour values, names of the next nearest places connected by transport lines and distance in Km.
- **Inter Marginal Information or Body of the Map–** depicts the topography by using various Signs and symbols

11.4.1 Extra Marginal Information

A. **Sheet Name:** The sheet name or title of the map is found in bold print at the top centre of the map and in the lower left area of the map margin. A map is generally named after the largest settlement contained within the area covered by the sheet or the name of the state, a part of which is covered by the map.

b. **Sheet Number :** The sheet number is found in bold print in both the upper right and lower left areas of the margin .

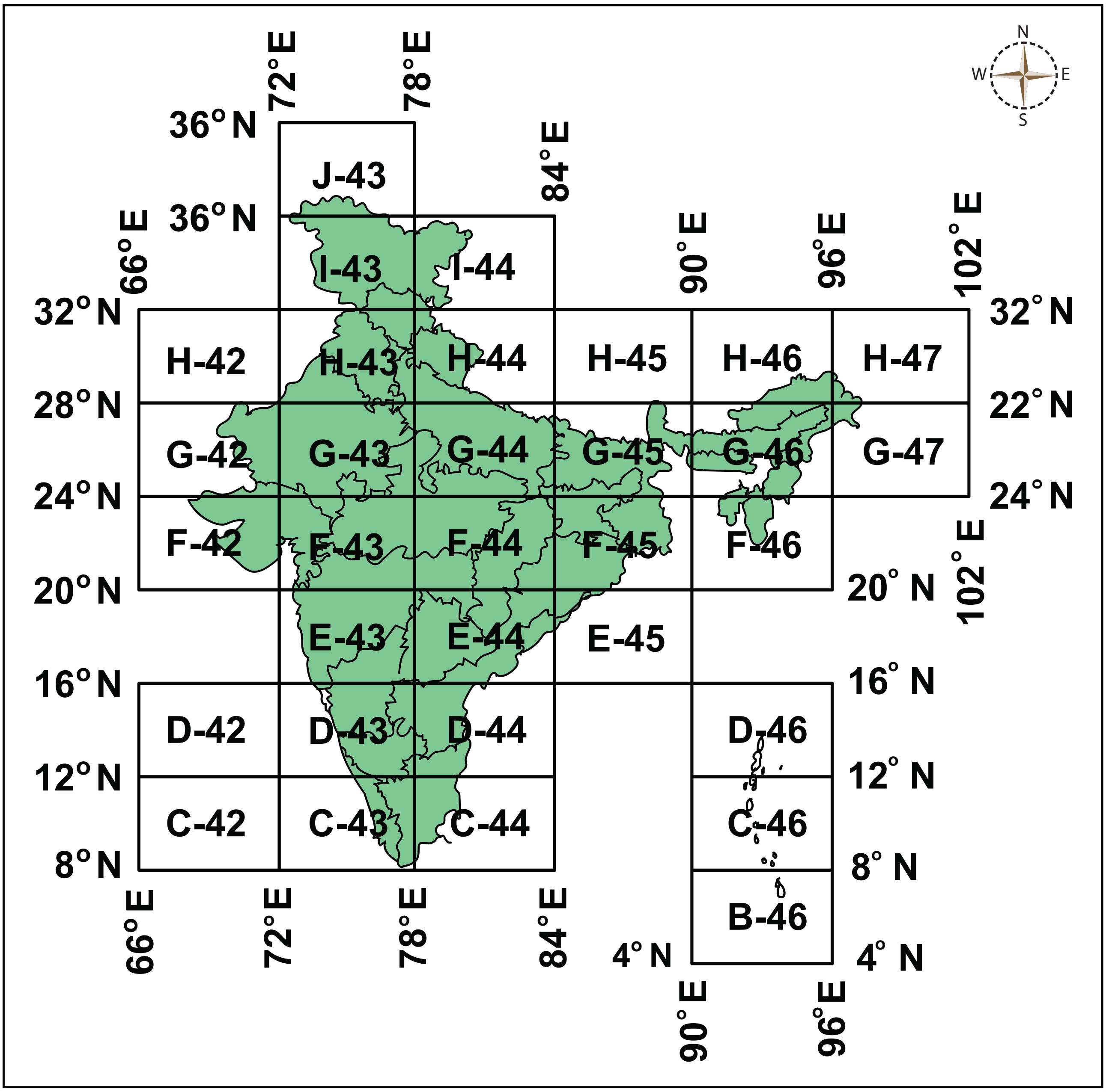


Figure 11.3 Index System

Sheet number helps us to understand the geographical extent covered by the sheet. It is also an indicator of map scale i.e. whether the map scale is 1:1000,000 or 1:250,000 or 1:50,000 or 1:25,000.

c. **District name :** The name of the districts or major political subdivisions covered in the map are given in the top left margin of the map .

d. **Edition Number:** The edition number is found in bold print in the upper right area of the top margin and the lower left area of the bottom margin. Editions are numbered consecutively; therefore, if you have more than one edition, the sheet with the highest number is the most recent.

e. **Magnetic Declination Diagram:** This is located in the top right margin or lower margin of large-scale maps and indicates the angular relationships between true north, grid north, and magnetic north. On maps of 1:250,000 scale, this information is expressed as a note in the lower margin.

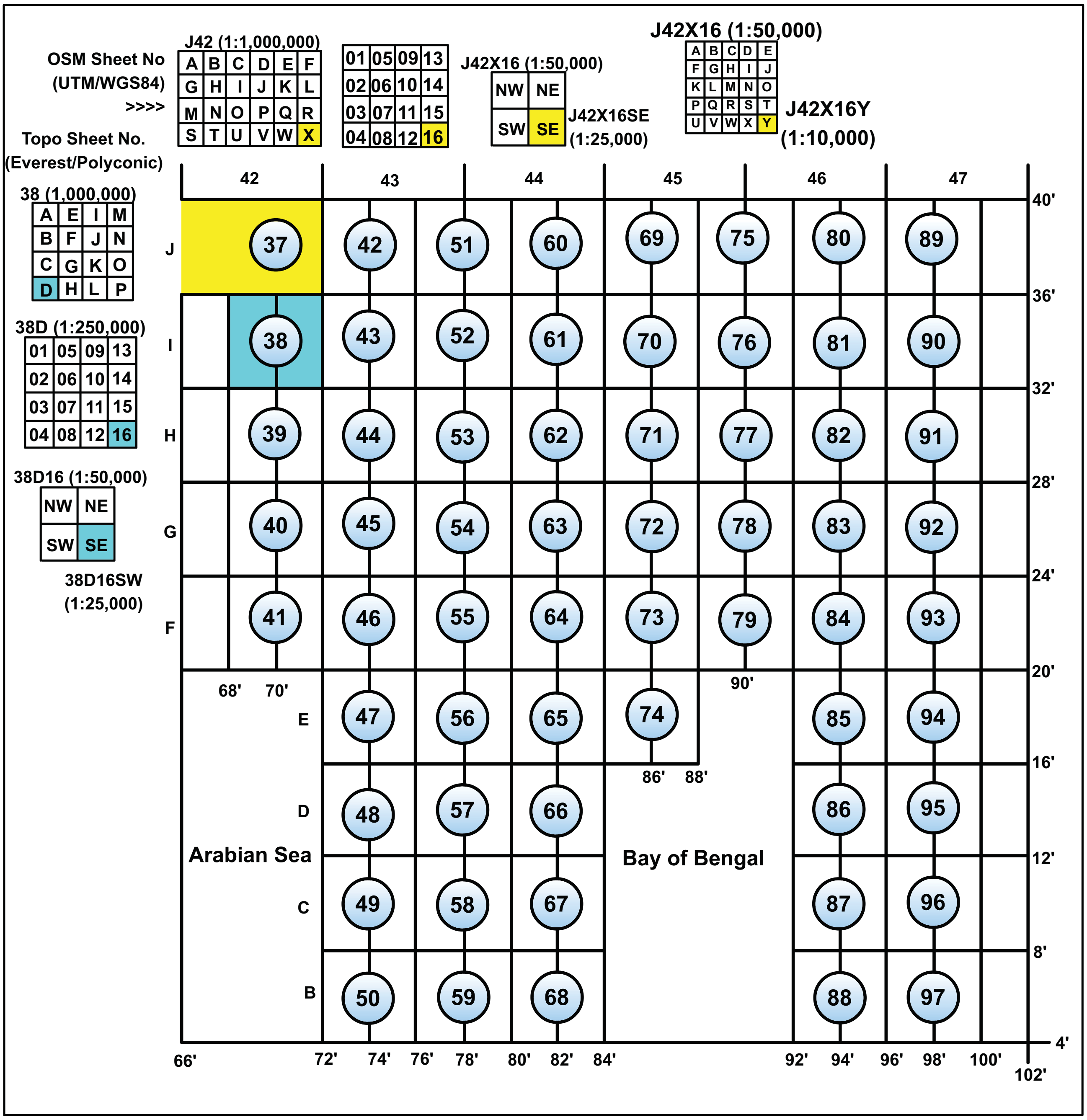


Figure 11.4 Index for conversion of Topo sheet No. to OSM sheet No.

f. Scale: The scale is found in the centre of the lower margin. The scale is represented as a representative fraction and also as a graphical scale. The representative fraction gives the ratio of map distance to the corresponding distance on the earth's surface. For example, the scale 1:50,000 indicates that one unit of measure on the map equals 50,000 units of the same measure on the ground. Graphical Scales are located in the centre of the lower margin. They are rulers used to convert map distance to ground distance. Maps have three or more bar scales, each in a different unit of measure. Care should be exercised when using the scales, especially in the selection of the unit of measure that is needed.

g. Index to Boundaries : The index to boundaries diagram appears in the lower right margin of all sheets. This diagram, which is a miniature of the map, shows the boundaries that occur within the map area, such as National, state, district or thasil boundaries.

h. Index to Adjoining Sheets : Maps at all standard scales contain a diagram that illustrates the adjoining sheets. On maps at 1:1000,000 and larger scales , the diagram is called the index to adjoining sheets. The diagram usually contains nine rectangles with the central rectangle representing the sheet under consideration.. All represented sheets are identified by their sheet numbers.

i. Contour Interval Note: This note is found in the centre of the lower margin normally below the bar scales. It states the vertical distance between adjacent contour lines of the map. When supplementary contours are used, the interval is indicated. In recent edition maps, the contour interval is given in meters instead of feet.

j. Legend : The legend is located in the lower left margin and lower right margin. It illustrates and identifies the topographic symbols used to depict some of the more prominent features on the map. The symbols are not always the same on every map. Always refer to the legend to avoid errors when reading a map.

k. Grid Reference Box: This box is normally located in the centre of the lower margin. It contains instructions for composing a grid reference.

l. Unit imprint and Symbol: The unit imprint and symbol is on the left side of the lower margin. It identifies the agency that prepared and printed the map with its respective symbol. This information is important to the map user in evaluating the reliability of the map.

11.5 Interpretation of Topo sheet

Study of Topographical Maps

Topographic maps are general reference maps. They are also called ordnance maps. These maps are ideal for researchers, planners, administrators, defence personal, hikers, tourists and for class room purpose. They give clear details of actually surveyed natural and manmade features. These maps are drawn to scale.

Geographical knowledge and clear understanding of conventional signs and symbols is essential to understand and interpret a Survey of India Topographical sheet.

A topographic sheet is usually interpreted under the following sub headings:

- Marginal information
- Relief
- Drainage
- Natural and
- Man made
- Vegetation
- Land use
- Settlement
- Transport and communication

Marginal Information

The marginal information includes the topographical sheet number, direction, its location, grid references, latitudinal and longitudinal extent in degrees, minutes and seconds, scale, the districts, covered, contour interval etc.,

Relief

Relief refers to the general topography of the area under study. First, the landforms like mountains, hills, plateaus along with the peaks, ridges should be identified and the general direction of slope can be determined. The contour values and patterns have to be studied. Spot heights, bench marks etc help in understanding the height of certain areas.

Drainage

Drainage of an area can be understood by observing the characteristics of the rivers, their tributaries, drainage pattern.

Vegetation

Important trees are shown by special symbols. Trees, grasses and shrubs are all shown in green colour. Agricultural land is shown in yellow colour.

Land use

Land use includes the use of land under different categories like agriculture, pasture, barren land and forest area. Other land use categories could be mining, industry, trade, tourism, fishing or cattle rearing. It also informs us about the presence (location) of airports, railway stations, schools offices, trade centres, electric substations, etc. Sometimes, land use is directly mentioned, for example, brick kiln, limestone quarry, etc. At other times it has to be inferred.

Settlements

The size, shape, pattern site, position and function of settlements should be considered while interpreting a topographical sheet because all these aspects are interdependent.

Settlements could be dispersed or scattered, compact or nucleated type. They may be radial or linear in pattern. They are also studied under the following heads, based on their size and the activities the population is engaged in.

Permanent settlements are shown by solid squares and temporary ones in outlines of squares.

- **Rural settlements**: They can be compact, semi compact, dispersed or linear, etc.
- **Urban settlements**: It is the capital city, administrative town, trade centre, port town, religious or tourist station or a hill station.

The basic occupations that the people are probably engaged in, can be understood after the land use pattern and the type of settlement have been understood.

Transport and communication

The means of transport and communication being used can be identified from the presence of national and state highways, district and village roads, cart tracks, camel tracks, footpaths, railways, waterways, telephone and telegraph lines, post offices, etc.

Roads are not drawn true to scale. Metalled roads are shown by double lines, and unmetalled by broken double lines. Foot path shown by red dots and cart track by single broken lines. Different kinds of railways are shown by different signs.

11.6 Interpretation of selected topo sheet

Mirzapur and Varanasi District, U.P
OSM Sheet No G44Q12 63K/12

Introduction

The OSM Sheet No G44Q12 63K/12 (Figure 11.2) covers major part of Mirzapur District and partly Varanasi District of Uttar Pradesh. It is based on the survey of 1970-71 and was published in 1978. It carries the scale of 1: 50,000 and covers area about 440 km² extending from 25° 0' latitude to 25° 15' latitude and 82°30' longitude to 82° 45' longitude.

Relief

It has two distinct physiographic units: 1. The Ganga Plain and 2. Vindhyan Plateau. The Ganga Plain extends on both sides of the meandering course of the Ganga. In the south it conterminates with the Vindhyan Plateau and is crisscrossed by the Chatar Nadi, Khajuri Nala and Ujhala Nala and their tributaries. It is a level plain with an average elevation of about 100 m above the mean sea level. The BM 84 m lies in eastern part of Mirzapur Town. The northern bank of the Ganga is comparatively lower than its southern counterpart by about 10 m. The eastern loop of the Ganga is wider, nearly 1.5km. or more in width and is marked by wide sandy shoals.

The Vindhyan Plateau covers the southern part of Mirzapur District. It covers nearly 50% of the total area of the sheet. It is essentially a dissected plateau with an average elevation of 160m above the mean sea level. The meeting point of the Ganga Plain and the Vindhyan Plateau is marked by 120m contour line. It has an undulating slope and is depicted with residual and flat-topped bulls like Deophulva followed by Murli (203 m), Rajghat (174m), Shakhar Pao (167 m). There are two ridges running parallel to each other and are separated by low saddles.

Drainage

The master stream of the area is the Ganga which has a meandering course and is fed by other tributaries and nalas, the main ones being the Chatar Nadi, the Khajuri Nala and Ojhala Nala. They are mostly seasonal in character and rain fed. The streams of the Vindhyan Plateau are also seasonal but have formed notches on its surface. They have formed some water-falls like the Vindhyan Fall and the Tanda Fall. The direction of the platue streams is by and large towards north where they ultimately join the Ganga.

Vegetation

The northern plain is mostly devoid of vegetation as the land has been cleared for purposes of agriculture. Only small patches of vegetation are found along the Chatar and the Harrai Nadia. Of course there are orchards and other planatations near the settlements. In the Vindhyan Plateau there are two main Reserved Forests, the Danti Reserve Forests and the Barkachha Reserved Forests. They are basically mixed scrub forests covering the hill slopes and tops.

Means of Irrigation: Wells and tanks are the main means of irrigation is this area. Recently tube wells and canals have also received attention in the northern Ganga Plain.

Settlements

The Ganga Plain is well settled, excepting the sandy and mashy tracts along the

Gana, particularly in the north-east sector and on both sides of the N.R. line between Khajuri and Chatar Nalas and opposite Vindhyachal. These tracts are annually visited by the floods of the driver. The density of village settlements is well marked along the metalled roads.

The Vindhyan upland is sparsely populated with a few large nucleated settlements where there is cultivated land and water supply sources like tanks exist.

The most important town of the area is certainly Mirzapur located on the southern loop of the Ganga and has crescent shaped urban structure. Next to Mirzapur stands the holy town of Vindhyachal characterised by temples, the most important being the vindhyavasini Temple. It extends between the N.R. main line and the Ganga. North of the Gnaga lay the market towns of Kachhwa, Chilh and Khamaria where bi-Weekly markets are held

Transport and cmmunication

It is served by two railways, viz. (1) N.R. Main line (broad gauge electrified) running from Mughalsarai and passing through the main stations of Pahara, Jhingura, Mirzapur and Vindhyachal and (2) N.E. Line (broad gauge) from Mirzapur Ghat (R.S) to Madhosingh (Varanasi – Allahabad). A loop-line also exists from Pahara to a quary about 2kms away.

The area is well connected by roads. The Allahabad-Mughal sarai metalled road runs across the region south of the N.R. Main line and passes through Mirzapur. The National Highway No. 7 (Great Deccan Road) runs from Mirzapur to Lohaghat (16km.) on its onward journey to Kanyakumari (2300 k.m) Another metalled road joins Mirzapur and southern parts of the district via Churk, Robertsganj and Pipri.Besides there are other roads like Jaunpur-Mirzapur Road, Chilh (Mirzapurghat)-Gopiganj Road and Mirzapur-Bhatauli Road. There are some unmetalled roads linking Mirzapur – Chunar and Mirzapur-Mharajganj. The Ganga Plain is, on the whole better served by roads as compared to its upland counterpart.

Exercises

Answer the following questions based on the given toposheet/ downloaded toposheet from Survey of India website - **http://www.surveyofindia.gov.in/pages/show/86-maps-data.**

1. What is the general settlement pattern of the map? Name it and draw the symbols in the settlement.
2. What is the contour interval of the map given?
3. Name any two modes of transport and communication.
4. Draw any 10 conventional symbols in the map.
5. Identify the landforms features and interpret them.
6. Identify the latitude and longitude of the toposheet.
7. Name any two types of vegetation found in the map.
8. Describe the drainage features.
9. What do the white patches of land signify?
10. What kind of economic activity is carried out in this area?

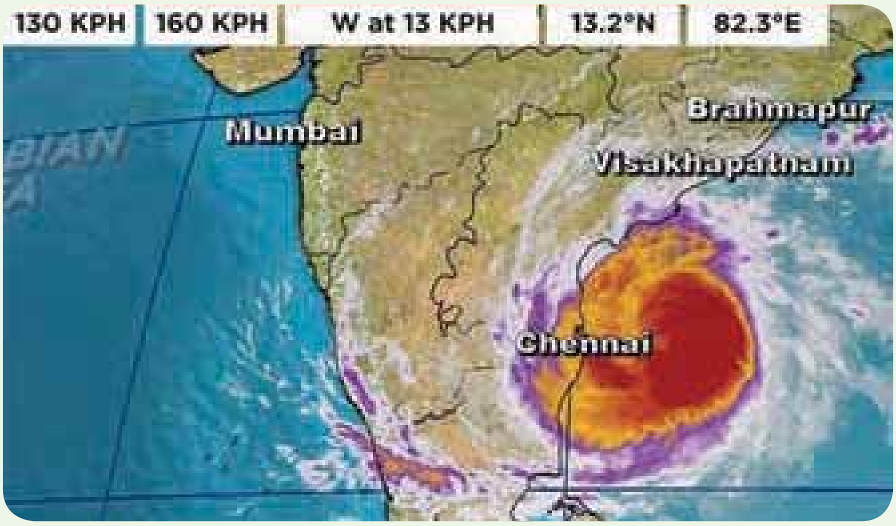
References

Practical Geography. R.L Singh

Practical Geography

Unit XII

Weather Maps



Chapter Outline

12.1 Introduction
12.2 Instruments for Measuring Weather Elements
12.3 Advancement in Measuring Weather Elements
12.4 Weather Symbols
12.5 Station Model
12.6 Reading Weather Map
12.7 Weather Map Interpretation
12.8 Weather Forecasting
12.9 Tracking of Cyclones

Learning Objectives:

- *Aware of weather instruments*
- *Identify weather symbols*
- *Ability to draw a station model*
- *Interpretation of weather map*
- *Enhance the knowledge about weather forecasting and cyclone tracking.*

12.1 Introduction

A weather map is a map of the world or part of it showing at a stated time, the weather conditions like temperature, pressure, direction and velocity of the wind, humidity, clouds, visibility, nature and amount of precipitation with the help of symbols. The trained observers in observatories or in meteorological station note the temperature, pressure, directions and strength of the wind, the amount of cloud and precipitation. These observations are entered on a weather map with symbols. Thus, weather map portrays the weather elements marked with recorded symbols for a region at a particular time. It reveals the prevailing weather condition.

12.2 Instruments for Measuring Weather Elements

Weather varies with the changes in weather elements such as temperature, pressure, wind, humidity, cloudiness, precipitation, sunshine and visibility. The weather is measured employing particular instruments and recorded in weather stations. The weather elements are listed below.

Temperature

Temperature is the hotness or coldness of a substance. The temperature of a particular place changes based on the factors like latitude, altitude, season, time of day, cloud cover, wind, location of the sea etc. Temperature is measured utilizing thermometers. There are Centigrade, Fahrenheit, Wet Bulb, Dry Bulb and Tele thermometers.

In Centigrade thermometer, the temperature of melting ice is taken as 0^0 C and the temperature of boiling water as 100^0C. In Fahrenheit thermometer, 32^0F represents the freezing point and 212^0F represents the boiling point of water. Wet Bulb and Dry Bulb thermometers are used to measure humidity in temperature. Tele thermometer is used to record temperature continuously within and outside the building. Thermograph produces a continuous trace of the changing temperature of a place.

Pressure

Pressure is defined as the weight of a unit column of air at any place. The barometer is an instrument to measure atmospheric pressure. While both Barometer and Aneroid Barometer measures atmospheric pressure above and below sea level, Altimeter measures air pressure at a height above sea level. Barograph provides a continuous record of air pressure. The unit of pressure is measured in millibars (mb). Globally, the pressure determines the wind and weather pattern. High pressure and low pressure are highly related with the increase or decrease in temperature.

Wind

The wind is moving air over the earth's surface. The air moves from high pressure to low pressure either vertically or horizontally. Wind vane records the direction of the wind and points out from which direction it blows. Cup Anemometer measures wind velocity, which is expressed in knots. Wind Sock is a device that indicates the origin of wind direction and speed.

Humidity

The amount of water vapour present in the atmosphere is termed as Humidity. It concentrates in the lower layer of the atmosphere. It varies from place to place and time to time. It may be classified as absolute, specific and relative humidity. Hygrometer is the instrument that measures the relative humidity. Hygrograph is an automatic instrument showing the change in relative humidity. Hygrothermograph records both humidity and temperature.

Cloudiness

Cloudiness indicates the amount of sky covered by clouds. Clouds are present in the lower atmosphere at varying altitude. Thay are varying in size and shape. The clouds are classified as high, middle and low clouds. Ceilometer is an instrument that uses a laser to determine the height of the cloud base. Ceiling projectors measure the height of the base of clouds above the ground. Cloud mirror measures the percentage of cloud cover. An Okta is a unit of measurement to describe the amount of cloud cover. The measurement of 0 Okta indicates clear sky and 8 Okta denotes completely overcast sky.

Precipitation

The water or ice particles reaching the ground surface from the atmosphere is known as precipitation. The various forms of precipitation are dew, mist, fog, sleet, drizzle, rain and hail. Conventionally, the amount of rain has been recorded by the instrument called Rain gauge. The amount of rain will be recorded in mm or cm or inches at a given time. The automated weather station (AWS) instrument records the rainfall with the help of sensors.

Sunshine

Sunshine means that the sun's rays lie within the visible spectrum that reaches the earth's surface. The amount or duration of sunshine in hours per day at a given region is measured using a sunshine recorder. The sunshine of a place depends on various seasons.

Visibility

Visibility means the transparency of the air in the particular place. It depends on the presence of water, ice, dust and smoke particles in the atmosphere. Visibility is measured by the distance at which prominent objects can be seen and the details discerned. The scale of visibility varies from zero, when objects cannot be easily seen beyond 25 metres, to visibility 9, when objects can be easily seen at a distance of 50 kilometres. Scale 0 to 3 indicate Fog, scale 4 represents Haze or Mist, scale 5 to 9 represents poor to Excellent visibility.

12.3 Advancement in Measuring Weather Elements

In recent days, weather stations use weather balloons, aircraft and ships to carry the instruments for measuring the temperature, pressure, humidity in the lower atmosphere. Weather radars are used to locate precipitation, type, intensity.

Radiosonde (an instrument carried by balloon or other means to various levels of the atmosphere and transmitting measurements by radio) is an instrument used to measure the vertical profiles of temperature, dew point and winds. It estimates the wind direction, velocity based on radar tracking.

Weather satellites help in providing all weather information accurately. Some of the important weather satellites are: METSAT-1/KALPANA-1, OCEANSAT-2, INSAT -3D, SCATSAT-1

12.4 Weather Symbols

Symbols are the pictorial representation of the various elements. On a weather map, weather elements are represented using symbols. Weather codes are used in weather charts as meteorological symbols. Weather symbols are created and standardized by the World Meteorological organization and also by Natural Weather Bureaus. Knowledge of weather symbols is prime for weather map interpretation and weather forecasting. Weather symbols are listed below for precipitation, wind direction, cloud cover and sea conditions. Weather symbols depicted in weather charts help in weather forecasting.

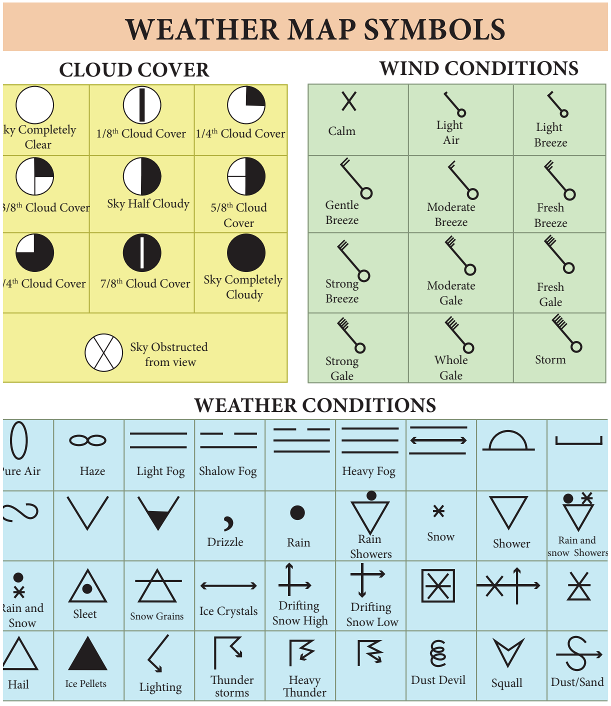


Figure 12.1 Weather Map Symbols

12.5 Station Model

The weather station is the place where all the data about the weather are being recorded, evaluated and documented. Station model is the symbolic drawing of the current weather condition, based on the collected data of weather elements in the particular station. The weather elements observed are shown in symbols in station models.

The value highlighted in the upper left corner is the temperature in degrees Celsius. The above image portrays the temperature as 12 degrees Celsius. The value highlighted in the lower left corner is the dew point temperature in degrees Celsius. According to the above example, the dew point of temperature which is 5 degrees Celsius. The image at the centre refers to cloud cover which is 7/8 cloudy. The value highlighted in the upper right corner represents the last three digits of the sea level pressure or in other words,

Sea Condition

Sl.No.	Weather Elements Sea Condition	Representation of Symbol
1.	Calm	Cm
2.	Smooth	Sm
3.	Slight	Sl
4.	Moderate	Mod
5.	Rough	Ro
6.	Very Rough	V.Ro
7.	High	Hi
8.	Very High	V.Hi
9.	Phenomenal	Ph

Barometric pressure reduced to sea level. The above image indicates the sea level pressure as 105 millibars. The symbol extending from cloud cover is the wind barb, that shows wind direction and wind speed (velocity). According to the image, the wind blows from the North East direction to the South West direction at a speed of 15 knots.

12.6 Reading Weather Map

Based on the above flow chart basic weather elements are represented. The following points are to be described while reading the weather map.

Pressure

1. Location of high pressure shown as ‘H’ in the weather map. The number and location must be specified
2. Location of low pressure, represents as ‘L’ the number of occurrence, location and nearby isobar value to be noted.
3. Trend of Isobars-The general path of isobars are to be observed.

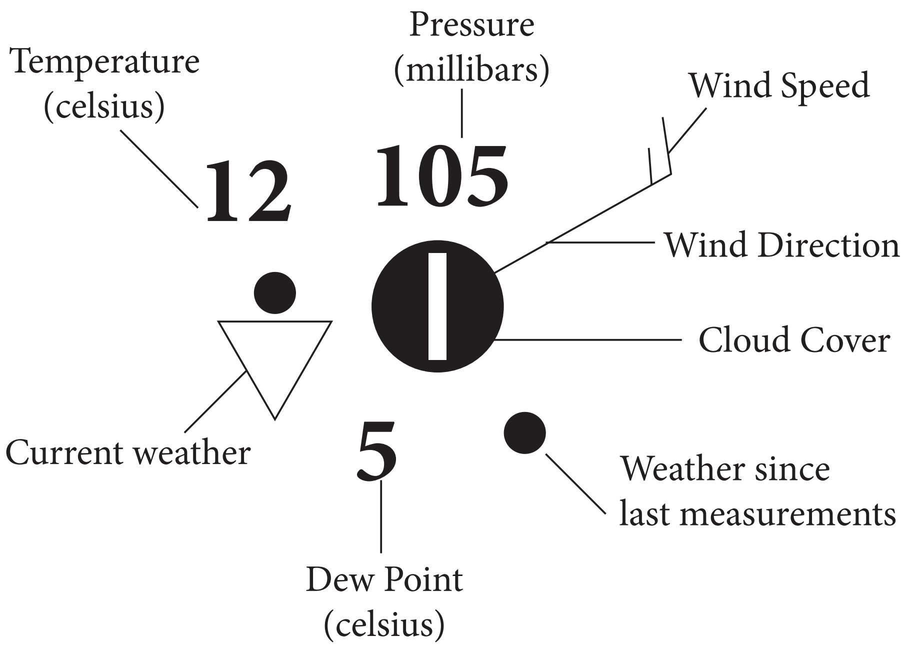


Figure 12.2 Station model using symbols

4. Pressure gradient denotes gentle or steepness based on the spacing of isobars. When the isobars are closely spaced the pressure gradient is steep and gentle if the isobars are widely spaced.

Wind

1. In weather Map interpretation, wind barbs indicate wind direction and wind speed. The staff part shows wind direction. The staff is a line above the circle that indicates wind direction. The number and size of the feather and pennants included to the wind barb show the wind velocity.
2. Sky condition is represented using circle, shaded according to the cloud cover
3. Sea condition is shown as codes, for example, Ro- Rough.
4. Precipitation and temperature and the other weather data are generally tabulated and attached to the Indian daily weather map.

12.7 Weather Map Interpretation

The weather map is a symbolic representation of the atmospheric conditions of an area at a given time. On a weather map, you will find isobars and symbols related to pressure, direction and velocity of winds, clouds, precipitation and sea condition on a base map with political boundaries. These details are recorded at different weather stations at specified time.

Meteorological Departments forecast weather conditions by evaluating these weather elements shown on a weather map. This weather map is used in predicting weather conditions for a day, a week or a month in advance, which helps in taking precautions and safety measures. Weather forecasts help farmers, fishermen and crew of ships. It also helps air flights in predicting atmospheric condition a few hours ahead.

Weather maps are the collection of weather information from various meteorological stations pertaining to the

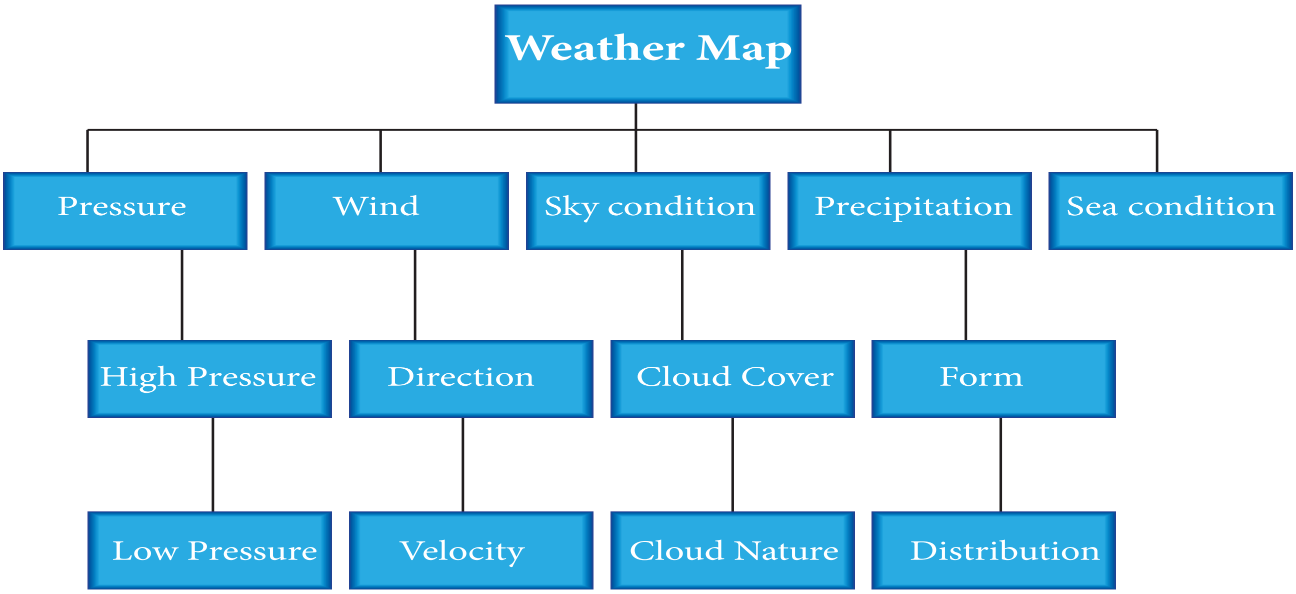


Figure 12.3 Wether Map

particular map area. The weather charts are prepared daily based on weather observations collected by the Indian Meteorological Department (IMD). The basic knowledge of weather elements is needed to interpret the weather maps. The essential weather elements to interpret the given weather maps are:

Schematic representation of weather map elements

Weather Map Interpretation

The Indian daily weather map is a political map of India, which also includes Pakistan, Afghanistan, part of China, Nepal, Bhutan, Myanmar and Sri Lanka with weather symbols indicating recorded weather data, isobars and keys for symbols.

Weather Map Interpretation – Monsoon Season (Example 1)

Weather map interpretation includes study and interpretation of all the weather parameters. The given weather map depicts the observed weather conditions on Monday 1st June 1992 at 08.30 Hrs I.S.T (0300 HRS GMT). Generally in India this observation is predicted as the southwest monsoon season that gives rain.

The key elements for weather map interpretation are:

1. **Range of Isobars:** From the given weather map it is observed that the isobars range from 1002 mb to 1010mb. The lowest value of 1002 mb is found over Bihar and West Bengal as an enclosed isobar. The 1010 mb is the highest value and is observed in the extreme south western part of the Arabian Sea.
2. **Location of Low Pressure:** In this weather map, four low pressure zones are identified. Low pressure prevails in Bihar and West Bengal, North Western Pakistan, Assam, Eastern part of India and Lakshadweep Island.
3. **Location of High Pressure:** The high pressure prevails over Afghanistan with 1008mb and the other high pressure prevails over the south western part of the Arabian Sea with 1010 mb.

INDIAN DAILY WEATHER REPORT

WEATHER MAP AT 08.30 HRS .I.S.T. (0300 HRS. G.M.T)

Monday 1 June 1992 (11 Jyaistha 1914 Saka)

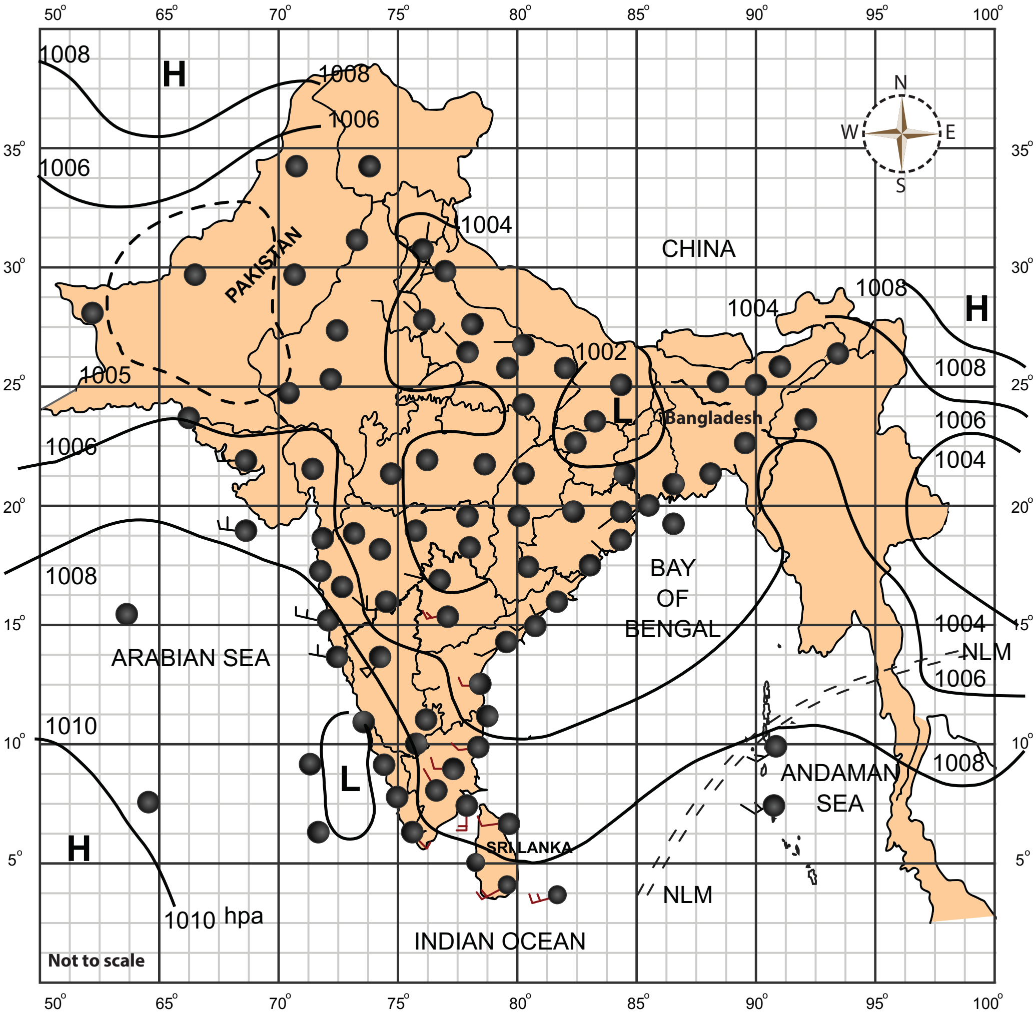


Figure 12.4 Example 1 (Monsoon Season)

4. **Gradient of Pressure:** On this map, the pressure gradient is steep along the western coast of India.
5. **Wind Direction:** The wind moves from west to east in the extreme southern part of India, The wind flows from North West to the south east in the rest of the Plateau region. The wind velocity ranges from 5 – 15 knots in most of the places on the given day. The wind is not strong in North but comparatively strong in south.
6. **Cloud Cover:** Clear sky is noticed in the North and north western part of India. Eastern coastal states are partly clouded and the southern states show extreme cloudiness and or overcast.
7. **Sea Condition:** Northern Limit of Monsoon prevails over the Andaman Sea.

8. **Precipitation:** The rainfall occurred in Assam and Meghalaya because low pressure prevails in near Assam, southern parts of Karnataka, Kerala and Lakshadweep.
9. **Departure of Maximum and Minimum temprature from Normal**

Day temperature is above normal in the west, Karnataka and eastern parts of India. Below normal in the places like northwest India and extend over the adjoining areas.

Conclusion: The general prevalence of the South Westerly winds the location of low pressure over the land and high pressure over the ocean, the occurrence of rainfall over South and eastern part of India. This season is observed as the monsoon season.

INDIAN DAILY WEATHER REPORT

WEATHER MAP AT 08.30 HRS .I.S.T. (0300 HRS. G.M.T)

Tuesday 1 November 1991 (14 Jyaistha 1913 Saka)

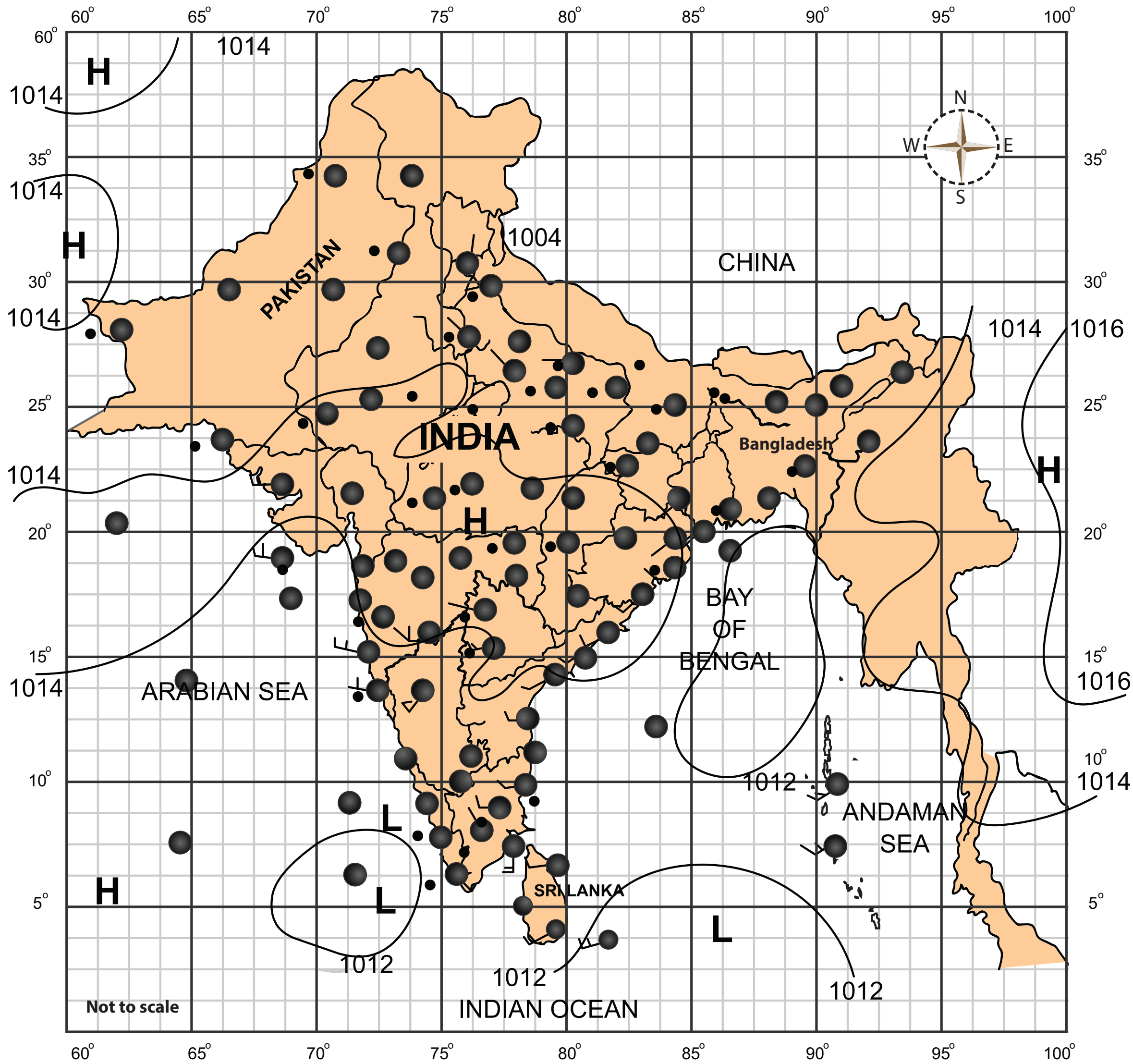


Figure 12.5 Example 2
(Monsoon Season)

Weather Map Interpretation – Monsoon Season (Example 2)

The given weather map shows the weather condition on Tuesday 5^{th} November 1991 at 08.30 Hrs IST 0300 Hrs GMT.

Distribution of Pressure Condition

1. **Low Pressure**: Low pressure areas exist over Northern and Southern Bay of Bengal and Lakshadweep (1012mb).
2. **High Pressure**: Central part of India, the plateau region is marked with High pressure. High pressure also prevails over Gujarat and Rajasthan. The other two high pressure areas are located in Afghanistan (1014mb), to the East of India. The pressure gradient is gentle throughout India.
3. **Wind Condition:** Calm weather prevails in north western coast of Orissa. Winds are northern in Tamilnadu, Southerly in Gujarat. In Central India, it is from the northeast.
4. **Sky Cover**: Sky cover is almost clear in North. In the South, it is partially cloudy. Sea condition is moderate. Haze is found near north eastern part of India.
5. **Precipitation**: Rain or thundershowers have occurred at a few places in coastal Andhra Pradesh, Tamil Nadu and South Interior Karnataka at one or two places in Telangana, Rayalasaema and Kerala.
6. **Departure of Maximum and Minimum temperature from Normal:** South west states record above normal temperature, eastern states have below normal temperature, except of the northwestern part of Rajasthan.

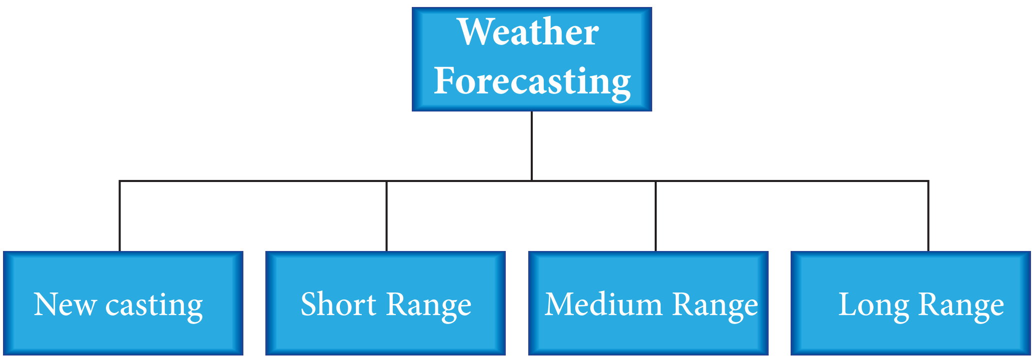
Conclusion: Low pressure prevails in sea and High pressure inland, so it indicates north east monsoon.

12.8 Weather Forecasting

Weather forecasting plays a major role in predicting the weather in the near future. It is difficult to predict the weather that could prevail in the future. A thorough understanding of meteorology is necessary for the forecast familiarity with the local weather helps to correlate the existing weather conditions and in forecast the future weather. The prediction of weather for a given place, is normaly for a period of time, for instance is for 24 to 48 hours.

The methods used for weather forecasting are conventional, synoptic, numerical weather prediction. Conventional interprets the trend of weather system. Numerical solutions, global circulation models, variation analysis for synoptic hours.

The weather forecast categories are now casting, short range, medium range long range and forecasting. Now casting gives the details of the current weather



and forecasts up to a few hours ahead using radar products.

Short range forecasts is for one to three days. Weather mainly rainfall for each successive 24 hour intervals may be predicted up to three days. It concerned about the observed latest weather charts and new systems.

Medium range forecasts are for 4 to 10 days – average weather conditions and the weather on each day may be prescribed with progressively lesser details and accuracy than that for short range forecasts dependent on NWP (Numerical Weather Prediction) products.

Long range forecast is an extended range forecast for more than 10 days in a season. It may range from a monthly to a seasonal forecast. Local forecast is a location specific forecast valid for a radius of 50 km around the weather stations.

A persistence forecast predicts that future weather will be the same as present weather. Analogue forecast will be like the weather that historically occurred when similar conditions were present. Statistical forecast is made routinely of weather elements based on the past performance of computer models. Trend forecast: surface weather systems tend to move in the same direction and at approximately the same speed as they have moved.

Current Scenario of Weather Forecasting

The weather satellites monitor the weather conditions and provide accurate information of weather. Satellite imageries are pictorial representations of radiation reaching the sensors from the earth from the different spectral bands that imprints the accurate weather elements such as winds, rainfall, and sea surface temperature.

Weather forecasting is based on the weather observation of surface data based on radars. Numerical weather prediction (NWP) using current and past observations to predict weather in near future AWIPS- Advanced weather interactive processing systems used by forecasters and process satellite, radar, surface observations, and weather forecasting models.

Occultation method is one of the most recent and capable atmospheric remote sensing technique applied to GPS measurements.

The meteogram is a chart that shows how one or more weather variables has changed at a station over a given period of time. Auxiliary charts- satellite imageries, satellite bulletins, satellite observations and current weather observations. These predictions are significant for warning of natural hazards.

12.9 Tracking of Cyclones

Tropical cyclone forecasting involves the prediction of several interrelated features, including the track of the cyclone, its intensity, resulting rainfall and storm surge and the areas threatened. Cyclone tracking is a constantly evolving science.

Different methods are used, including using satellites, radars, etc. A skilled meteorologist has often developed an ability to detect overall patterns in climatological conditions and can assess how these may affect cyclone development. Manual forecasts made by skilled

Figure 12.6 Very Severe Cyclonic Storm

meteorologist may be a good complement to other forecasting techniques.

At present, the cyclones are tracked with the help of satellite images. The satellite images are collected and put into motion for several hours, and with the gathered information, the development of a tropical cyclone is tracked. Doppler radars detect rain associated with cyclones, which locate and estimate the amount of rainfall and depicts a hurricane's rainfall.

In the satellite based techniques, track and intensity of cyclone are forecast based on the cloud pattern associated with the cyclone. Generally the outer cloud bands of cumulonimbus clouds indicate the future direction, and the cloud pattern surrounding eye of the cyclone indicates the future intensity of the cyclone. Below is an example of tracking Vardah Cyclone by using satellite images.

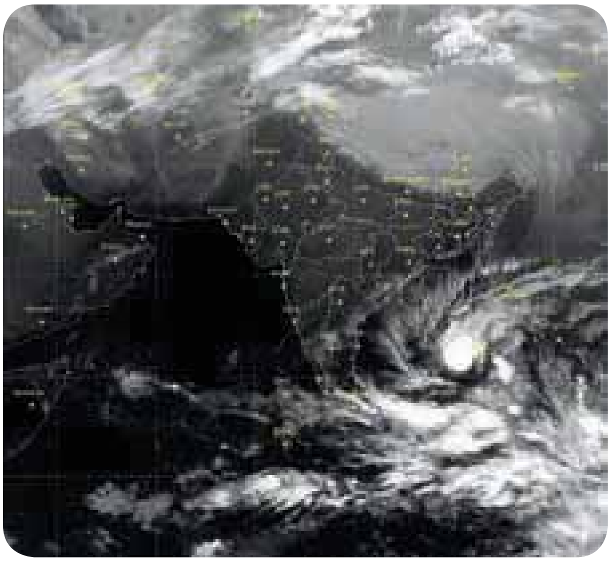
Cyclone Tracking based on Satellite Images – Vardah (Example)

Vardah at peak strength on 11 December

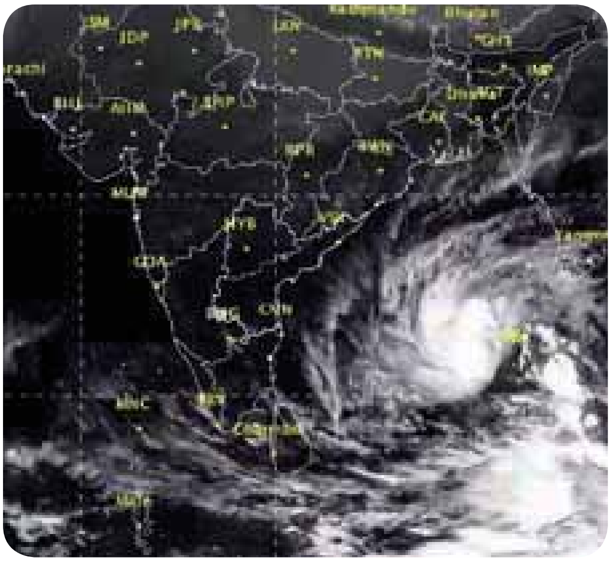
Formed	December 6, 2016
Dissipated	December 18, 2016
Highest Winds	3- minute sustained : 130 km/h 1-minute sustained : 155km/h
Lowest pressure	975 mb
Fatalities	38
Damage	$5.1 billion
Areas affected	Thailand, Sumatra, Malaysia, Andaman and Nicobar Islands, Sri Lanka, South India, Somalia

Very Severe Cyclonic Storm, Vardah, was the fourth cyclonic storm, as well as the most intense tropical cyclone of the 2016 North Indian Ocean. The system struck the Andaman and Nicobar Islands, as well as South India. Originating as a low pressure area near the Malay Peninsula on December 3, the storm was designated as a depression on December 6. It gradually intensified into a Deep Depression on the following day, skirting off the Andaman and Nicobar Islands, and intensified into a Cyclonic Storm on December 8. Maintaining a generally westward track thereafter, Vardah consolidated into a Severe Cyclonic Storm on December 9, before peaking as a Very Severe Cyclonic Storm, with winds of 130 km/h, and a minimum central pressure of 982 mb on December 11. Weakening into a Severe Cyclonic Storm, Vardah, made landfall close to Chennai on the following day, and degenerated into a remnant low on

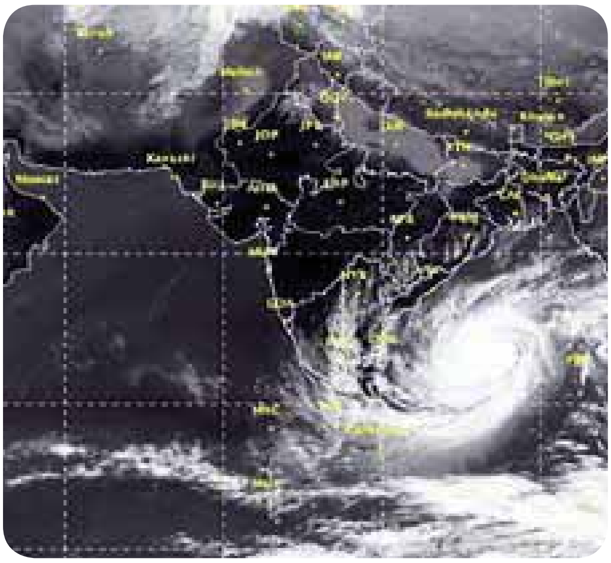
Satellite Images



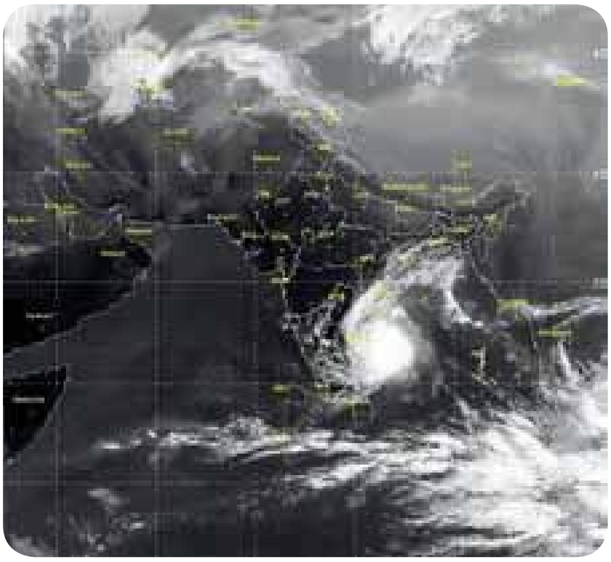
8th December 2016



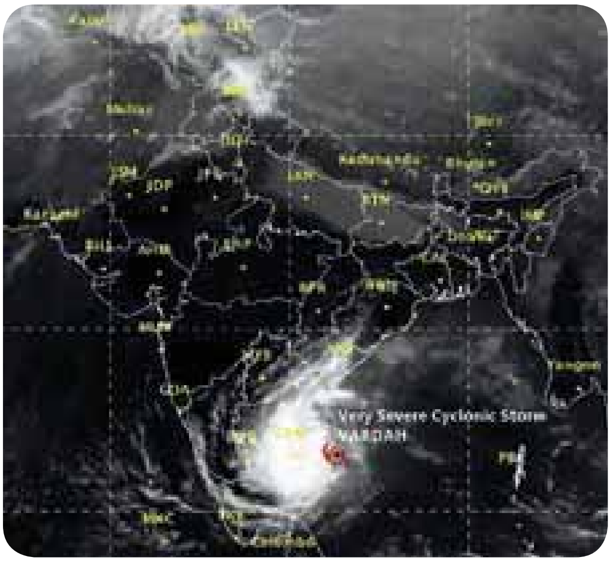
9th December 2016



10th December 2016



11th December 2017



12th December 2017

December 13.The name *Vardah*, suggested by Pakistan, refers to the red rose.

Cyclone Tracking - Vardah

Under the influence of a persistent area of convection, a low pressure area was formed in the Malay Peninsula and adjoining north Sumatra, in early December 2016. The low pressure area emerged as a tropical disturbance over the next several days, as it slowly moved towards the southeast Bay of Bengal. On December 6, The IMD classified the system as a Depression in the

BOB 06, as it had sufficiently organized itself, with winds of 45 km/h. Owing to low wind shear and favourable sea surface temperatures, the depression gradually intensified into a Deep Depression on the following day. Skirting off the Andaman and Nicobar Islands as a Deep Depression, the BOB 06 was upgraded to a Cyclonic Storm by the IMD and JTWC, in the early hours of December 8, and was assigned the name *Vardah*. The name of severe cyclonic storm 'Vardah', which has made landfall, hitting the coast 60 km from Chennai, has been given by Pakistan.

'Vardah' means 'red rose'. The name of cyclones in the Indian Ocean Region is decided by member countries -- India, Sri Lanka, Bangladesh, Thailand, Myanmar, Maldives and Oman.

With conditions favourable for further development, Vardah intensified into a Severe Cyclonic Storm on December 9. Although predicted to maintain its intensity, Vardah strengthened further, as it followed a general west-northwestwards track, prompting the IMD to upgrade its intensity to a Very Severe Cyclonic Storm status, on December 10. Gradually intensifying as it moved westwards, Vardah reached its peak intensity on December 11, with maximum sustained winds of 130 km/h, the wind gusts reached to 193 km/h, according to IMD with a minimum central pressure of 982 mb.

On December 12, Vardah weakened into a Severe Cyclonic Storm, before making landfall over the eastern coast of India, close to Chennai, with winds of 105 km/h. Afterward, it rapidly weakened into a depression, due to land interaction, on 13 December. The depression caused overnight rainfall in southern Karnataka on December 13. Due to frictional forces, the system degenerated into a well-marked low pressure area around midday on December 13, and moved out of Karnataka and into the Arabian Sea, as a low pressure area in the evening.

Reporting Cyclone Vardah based on a cyclone tracking map of December 12, 2016

Very Severe Cyclone Vardah made landfall near the Indian city of Chennai, the capital of Tamil Nadu state, on Monday, December 12, 2016, between 15:00 and 17:00 IST (9:30-11:30 UTC). With wind speeds as high as 100-110 km/h (62-68 mph) reported, and drenching rain, Vardah has caused wind damage to lightly built structures and some localized flooding as it moved across the northern part of Tamil Nadu. The National Disaster Management Authority reported four deaths from the cyclone.

Cyclone Vardah—which originated as a tropical disturbance on December 6—is the only storm to have attained very severe cyclonic storm status in the Bay of Bengal this year. While still a depression over the Bay of Bengal, Vardah brought heavy rainfall to the Andaman Islands, from which 2,300 tourists were evacuated.

Damage and Disruption

The India Meteorological Department (IMD) issued a heavy rainfall warning and a wind warning prior to landfall, and reportedly tens of thousands of people were evacuated, including many from low-lying areas. The IMD projected wind speeds of 70-80 km/h (43-50 mph), with gusts to 90 km/h (56 mph) for the first few

Figure 12.7 Cyclone Vardah track map as of 20:30 IST (15:00 UTC) on December 12, 2016. (Source: IMD)

hours after landfall, with some damage to power and communications lines due to uprooted trees and broken branches, and roof damage to thatched huts. Heavy rainfall was expected throughout the region, with heavy to very heavy precipitation in southern coastal Andhra Pradesh, Rayalaseema, northern Tamil Nadu, and Puducherry, according to the IMD. Fishermen were advised not to go to sea while the sea remained high, although conditions should moderate by Tuesday morning.

Forecast Track and Intensity

The IMD forecast Cyclone Vardah to move nearly westward across Tamil Nadu, weakening by Tuesday, December 13, to a depression, with maximum sustained surface wind speeds of 35-45 km/h (22-28 mph) and gusts to 55 km/h (34).

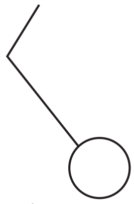
At present, the automated weather stations are connected through the VSAT and connected to NRSC server. Weather forecasting is now undertaken with the help of satellite data. The satellites provide information about the present weather condition and continuously update weather parameters from time to time.

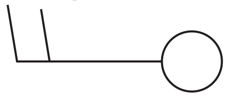
Exercises

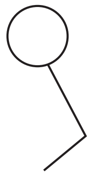
I. Answer the following

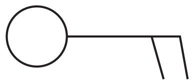
1. Which are the instruments used to measure weather elements?
2. In what way are weather satellites significant in weather forecasting?
3. Give the weather symbols for the following.
   a. Hail
   b. Gentle breeze
   c. Rain
   d. Calm
   e. Obscured
4. What is weather nowcasting?

5. Find the wind direction and velocity from the following wind barbs.

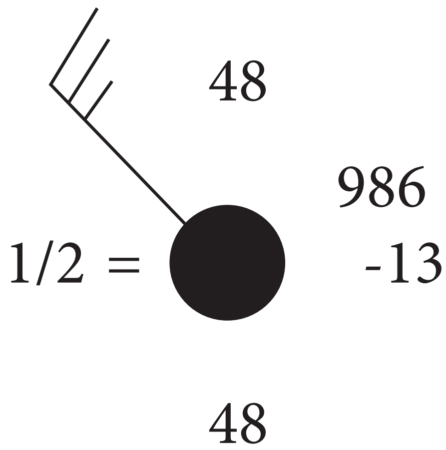
a. 

b. 

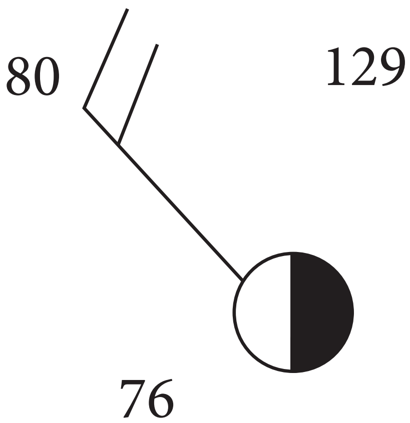
c. 

d. 

6. Name the weather elements in the given Station Model.



7. Write an interpretation for the following station model.



8. Prepare a station model with the following weather parameters.
   a. Dry Bulb temperature - 22^0 C
   b. Dew point -18^0C
   c. Barometric Pressure reduced to mean sea level standard gravity is 998mb
   d. Total cloud amount -5 oktas
9. Prepare a small project of the Okchi cyclone with the help of the Satellite Images.

II. Practice

A. Make an Anemometer

Materials

- 4 small paper cups
- 4 plastic drinking straws
- Tape
- Scissors
- Straight pin
- Pencil with a new eraser
- Stapler

Procedure

1. This anemometer has four cups which catch the wind and cause the anemometer to spin. The inward curve of the cups receives most of the force of the wind. That's what makes the cups move. The more spins per minute, the greater the wind velocity.
2. Arrange four (4) plastic drinking straws to form a cross and tape them together at the centre.
3. Staple the top side of one drinking cup, such as the small paper cups designed for bathroom dispensers, at the end of each straw, so the open ends of the cups all face the same direction.

4. Push a straight pin through the centre of the straws into an eraser on the end of a pencil. This provides the axle.
5. Mark one of the cups; this will be the one they use for counting when the anemometer spins.
6. Blow on the anemometer or turn an electric fan on low to make sure that it spins easily. How many times the anemometer will spin in one minute? Can you make a statement connecting the number of spins of your anemometer and the speed of the wind? (You can use the table below to record your practice trials).

B. Use an Anemometer to measure Wind Speed

Materials

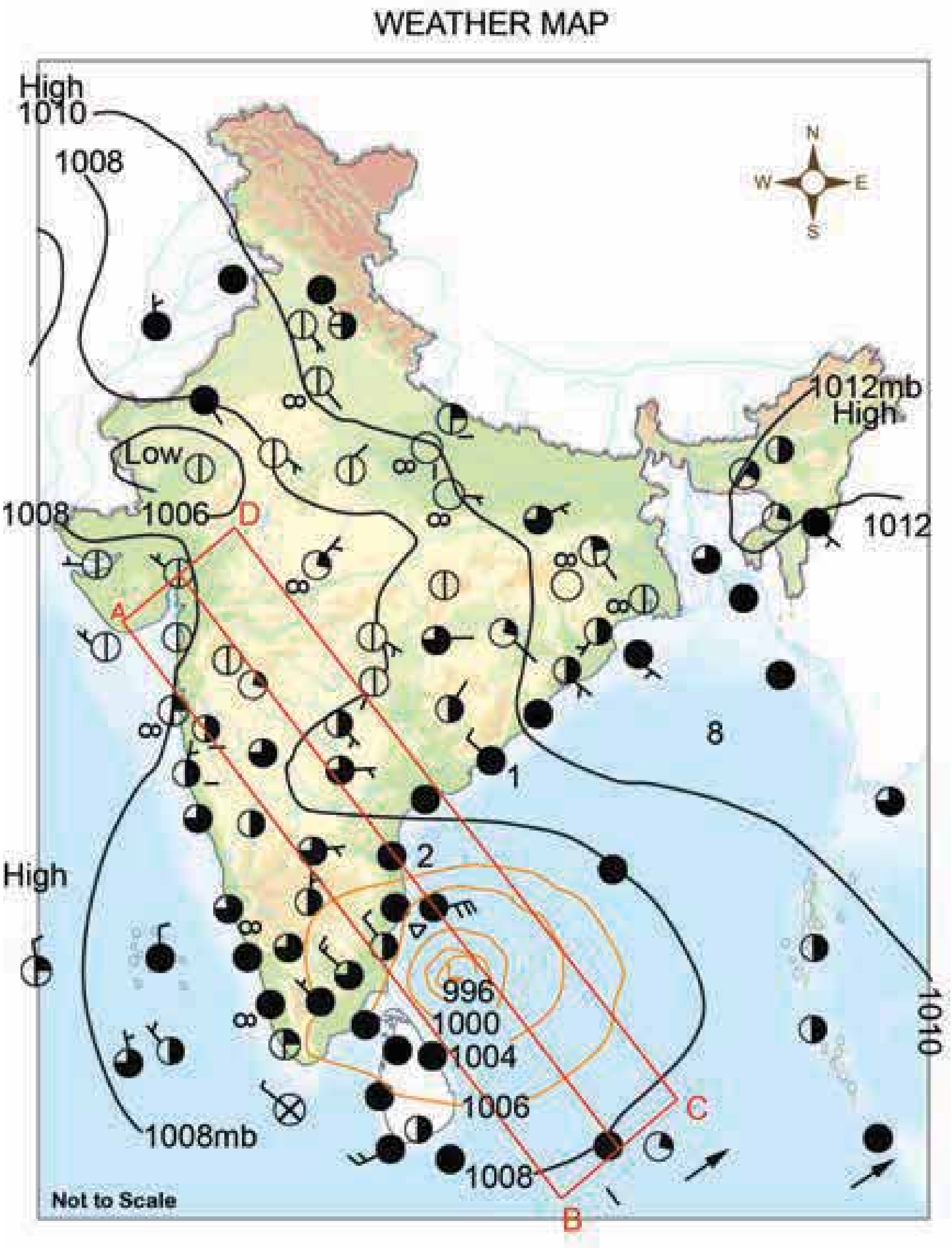
- Anemometer

1. Divide the students into small groups with the following roles (optional)
   - One time keeper who will be responsible for timing one minute for each trial.
   - One official "counter" for the day. The others may count on their own, but the counter's readings will be the ones recorded.
   - One person who will hold the anemometer while the spins are counted; the person holding should make sure that he holds the anemometer so that the wind is unobstructed.
2. Mount or hold the anemometer in a place that has full access to the wind from all directions.
3. When the timekeeper says "Go", the counter in each group will count how many times the marked cup passes them in one minute and write it down.
4. If possible, repeat the above step four (4) times and record the average number of spins

   Optional: you can multiply the average number of spins by 60 to find out how many times the anemometer would spin in an hour and come up with a statement such as: the speed of the wind today is about 1,000 spins per hour.

S. No	**Time Interval**	**Number of Spins**
1.		
2.		
3.		
4.		

Interpret the given weather map.



Unit XIII

Field Work and Report Writing

Chapter Outline

Learning Objectives:

- *Recognise the importance of field work in geography*
- *Acquire the skill of data collection.*
- *Enhance the ability for map reading and field sketching.*
- *Learn to work as a team.*
- *Develop the skill of report writing*

13.1 Introduction

The study area for geographers is so vast that for a student of geography, the knowledge of the earth is acquired through class room teaching, books, journals, maps, internet etc. Theoretical knowledge about the study area can be learned in the class room while the practical aspects could be acquired only in the field through surveys.

Field work can be defined as, the process of observing and collecting data about the natural and manmade environment. Geography is divided into two main branches: physical and human or cultural geography. Field work helps in bringing about a better understanding of the subject for a student of geography. In the case of understanding physical geography, field work becomes inevitable.

13.2 Need for field work

There are many reasons why field work is very essential for the students of geography. They are:

1. Field work facilitates direct observation of the study area (local area) and to collect original information.
2. Field observation along with class room teaching helps the students to understand the geographical concepts better.
3. Repeated field observation of the same place at regular intervals help to understand the changing patterns or trends of a phenomena. Example 1. Quality and growth of vegetation during different seasons. 2. Changes

in water level in a tank or reservoir or well before and after monsoon.

4. Field work will improve the power of observation among the students.
5. Field trips can kindle the spirit of enquiry among the students
6. The student's skill of map reading, map drawing, field sketching and use of some geographical instruments will be improved.
7. Field work is an opportunity for the student to experience and adapt to various environments.
8. It helps to enhance the students' view about the subject and to care for the environment.

Above all, it can be an enjoyable outing.

13. 3 Field work process

Field work for studying physical geography and human geography are quite different. Field work in physical geography involves direct observations, photography, field sketches, use of maps, satellite images etc. Human geographic studies require sample surveys, preparation of questionnaire, interviews and use of statistical techniques for data analysis and representation.

Any field work involves three stages. They are:

1. **Pre-field work**
2. **Actual field work and**
3. **Post field work**

1. Pre-Field Work

This involves proper planning, preparation and arrangements. It is undertaken by the teacher/school management/and local authorities. The tour details are to be informed to the CEO/DEO and field area police stations well in advance, along with the name and house address, contact details of the students and staff who undertake the field work.

Prior permission is to be obtained well in advance to enter restricted areas or reserved forests.

Arrangement should be made for sufficient food and safe drinking water. Students should be informed of the clothing requirements (Woolen caps, sweaters, shoes, mosquito repellents etc.).

Field work site mapping should be carried out by a small group of students with the assistance of their supervisor (teacher). The problem or the aim of the study and its objectives are to be explained in detail. The method of investigation and the equipments for survey in the field are to be discussed with the students.

Prepare a field map and discuss the method of conducting field work by different groups of the class. Each student may be supplied with a copy of maps for reference. They should be informed of the 'dos' and 'don'ts' during the field work. The following are some of the items to be carried for field work in physical geography:

1. Stationery, including scripling pads, colour pencils, wax pencils, papers, pens etc.,
2. Camera with zoom and video facility.
3. Audio/video recorders to record voices of birds, local people etc.,
4. Sufficient number of binoculars to view distant objects.
5. Minor field survey equipments like measuring tape, magnetic compass, clinometers, GNSS hand set etc.,

6. Weather instruments (for field work related to weather) like thermometer, rain gauge, barometer, wind vane etc.
7. Maps, topographic sheets (non-restricted), satellite images of the study area.

2. Actual Field Work (Method of Information Collection):

When the students reach the local study area, the actual field work begins and information is collected through

1. Observe the features and take notes. Students can record the information through photography and video-audiography.
2. Prepare field sketches by using colour pencils.
3. Instruments can be used for measurement of distances, weather elements, heights, depths etc.
4. Find the direction using magnetic compass and orient the maps and images.
5. By recollecting the map reading practices of topographic maps, satellite images and aerial photographs for recognition and mapping the features.
6. Find the important locations and routes by using GNSS and web based mapping facilities.
7. Collect unique and representative samples of rock, soil, surface water and groundwater for further analysis, class room discussion and exhibition. Do not collect plant, animal or microorganisms from the field, because this activity is banned by the government.
8. Collecting secondary data from local authorities, officers in -charge of the area etc.,

Though field work has many advantages, it also has a few limitations such as:

1. It is time consuming and expensive.
2. It needs necessary equipments, maps, satellite images etc., for proper interpretation.
3. Delay in receiving permission from Government Agencies to visit restricted areas make the trip uncertain.
4. There are certain risks in travelling, changing weather, field illness etc., during field work.

3. Post-Field Work:

The data collected from the field has to be arranged, photographs and sketches added wherever necessary, calculations carried out, results inferred, maps drawn and report of the same prepared.

13.4 Field Report

Writing a report of the work carried on in the field is a documentation of the field work. This helps in systematic reviewing of the work by students who accomplished the task and a reference for future field trips. Field reports must be short, clear and informative with supportive data, maps, sketches, photographs etc.

There are a number of steps involved in report writing. They are:

1. Title:

Identify the topic of investigation which is the purpose of field work. This is the title of the work and it has to be written in bold letters at the top of the report.

2. Introduction:

Every report should start with a brief introduction to the subject under study. It should explain what part of geography it relates to. For example if the study is about a stream, it falls under the branch of physical geography, more specifically geomorphology - an exogenetic agent of denudation. The time frame that was planned for the fieldwork can be elaborated. If the field work is extending for more than one day, then a clear timetable should be given.

3. **Need for the Study:**
   The reason why the field work is undertaken can be mentioned. This explains the need for the field work.

4. **The Study Area:**
   Details of the study area are explained here – starting with the absolute or geographical location of the study area, the choice of the study area and the physiography of the area. Other known physical and cultural details of the study area can be mentioned here. A copy of the map, satellite image etc. can be incorporated here.

5. **Methodology Used:**
   The methods used to carry out the field work have to be mentioned here. The method of information collection varies according to the type of study. It could be through observation, investigation, measurements; data collection from primary and secondary sources; field sketches, audio-video recording and photographs and GNSS surveys.

6. **Data Analysis:**
   The data collected through field work should be presented in a simple way for easy analysis. The method of representation of data should be according to the method of data collected. Example: 1. If observation method is used in data collection then the data can be represented as photographs or field sketches. 2. If data is collected through surveys, it can be represented as a plan or map. 3. Data collected from secondary sources can be presented as tables, graphs, diagrams or charts. 4. Data collected through GNSS surveys can be mapped.

   The data represented in various forms have to be neatly labeled and indexed for easy identification and understanding. The photographs, diagrams, tables, maps etc. prepared during post field work have to be arranged in a sequential order so that they can provide an answer to the purpose of study and add more meaning and value to the report of work done in the field.

7. **Conclusion:**
   The conclusion gives the gist of the field work – the aim, the results or findings and how it relates to existing knowledge and the addition of new knowledge through this field work. The conclusion has to present how the fieldwork has enhanced the theoretical knowledge gained in the class.

The table below gives a few steps in the preparation of field report for a few case studies under physical geography.

Steps involved in preparation of field report for field studies in physical geography

Sub topics	River	Hillock	Forest	Coast
Aim	To understand river as a natural resource.	To understand hillock as natural resource.	To understand forest as natural resource.	To understand coast as a natural resource.
Learning Objectives	➢ Identify the stage of river. ➢ Trace the source of the river. ➢ Assess the command area of the river. ➢ Analyse river as an ecosystem.	➢ Identify the geological history of the hillock. ➢ Determine the height of the hillock by simple measurement ➢ Draw the cross sections of it. ➢ Co-relate the vegetation with slope, supply of water and climate of the place.	➢ Identify the type of forest. ➢ List the role of forest in the life of the people. ➢ Indentify fauna and flora and their trophic level.	➢ Identify the type of coast and coastal features. ➢ List the role of coast in the life of the people. ➢ Indentify fauna and flora and their trophic level.
Study Area	Write about the river chosen, location of the village or town which is selected as study area.	Write about the hillock chosen, the village or town where the hill is located in the study area.	Write about the forest chosen, location of the village or town which is located in the study area.	Write about the coastal tract chosen and location of the village or town which is located in the tract.
Methodology	➢ With the theoretical knowledge gained to indentify the stages of a river. ➢ Trace the source of the river from published sources. ➢ Gather information about the area served by the river in terms of supplying water for irrigation, drinking purpose, industrial purpose and recreation. ➢ Observe and record the fauna and flora along the river side. ➢ Take photo/make field sketches for all your observations.	➢ Observe the agents of erosion responsible for the formation of the hillock. ➢ Using clinometer measure the height. ➢ Draw a sketch of the hillock. ➢ Collection information on cultural importance of the hillock religious / cave / paintings / resort. ➢ Study the varieties of biodiversity and correlate with the climate.	➢ Gather information about the type of trees present in the forest. ➢ Interact with local people and collect information about the resources available in terms of timber / fuel / herb / fruits and nuts / any other. ➢ Construct a trophic level diagram for the forest with the information your collected.	➢ Gather information about the area served by the coast in terms of supplying sea food, salt, power production, industrial purpose and recreation. ➢ Gather information About the type of fauna and flora along the coast and coastal water. ➢ Indentify the interaction of people with the resources available in terms of fuel/ food/fish weed /any other. ➢ Construct topic level diagram for the coastal ecosystem ➢ With your observation and gathered information, collect the historical facts about the coastal belt.
Limitation	Specify your limitations in terms of fund / time / study area selected.	Specify your limitations in terms of fund / time / study area selected.	Specify your limitations in terms of fund / time / study area selected.	Specify your limitation in terms of fund / time / study area selected.

(Continued)

Steps involved in preparation of field report for field studies in physical geography

Sub topics	River	Hillock	Forest	Coast
Data Collection	Specify the method of data collection as primary / secondary source.	Specify the method of data collection as primary / secondary.	Specify the method of data collection as primary / secondary.	Specify the method of data collection as primary / secondary source.
Data Representation	Represent the data in any cartographic form such as sketch / chart / graph / map.	Represent the data in any cartographic form such as chart / graph / map / sketch.	Represent the data in any cartographic form such as chart / graph / map / sketch.	Represent the data in any cartographic form such as sketch / chart / graph / map.
Findings	From the representation list your findings.	From the representation list your findings.	From the representation list your findings.	From the representation list your findings.
Report - Writing Narrate the full work in simple language and submit.	Narrate the full work in simple language and submit.	Narrate the full work in simple language and submit.	Narrate the full work in simple language and submit.	
References	The report should have the details of references related to the study and source of data used for the study.	The report should have the details of references related to the study and source of data used for the study.	The report should have the details of references related to the study and source of data used for the study.	The report should have the details of references related to the study and source of data used for the study.

Exercises

1. Measure your school's play ground and draw a plan of the same.
2. Arrange a field trip to a River line area study the land, direction of flow of water, trees and other plants in the area. Make a field sketch and prepare a short report.
3. Measure the daily temperature at 11.00 am and 4.00 pm and find the monthly average of maximum and minimum temperature.
4. Plan a field visit to a nearby hilly area study the slope, gradient, trees and other plants in that area. Prepare a field sketch of the same and write a short report.

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GLOSSARY

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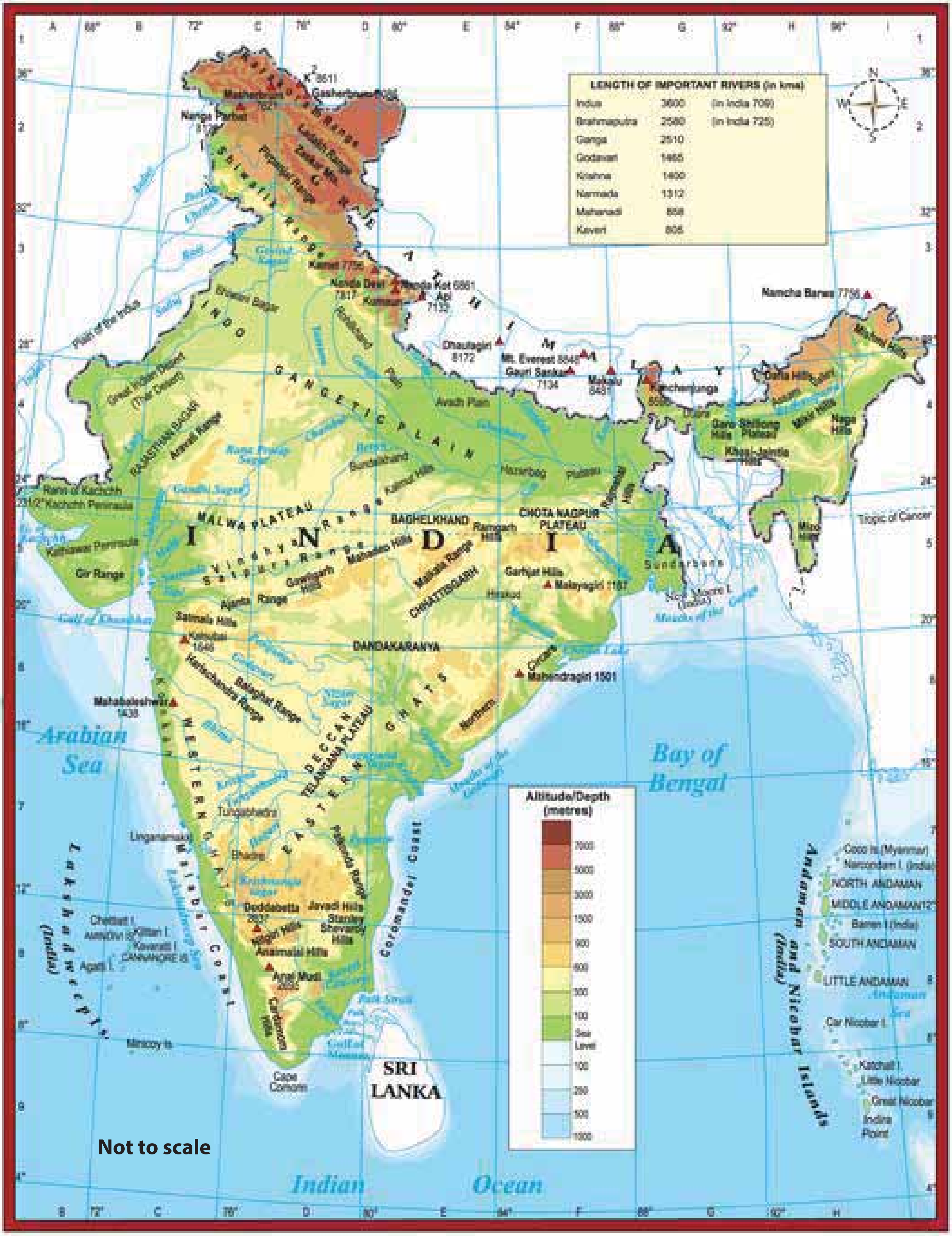
Abyssal plains	ஆழ்கடல் சமவெளி
Albedo	ஒளி திருப்பும் திறன்
Air Fronts	வளி முகம்
Boreal	வடமுனைக்குறிய
Cartography	நில வரைப்படவியல்
Cataracts	வேகமான நீர்வீழ்ச்சி
Cloud Burst	மேக வெடிப்பு
Continental rise	கண்ட உயர்வு
Coral polyps	முருகை / பவள மொட்டுக்கள்
Dark energy	இருண்ட ஆற்றல்
Endemic disease	ஆண்டு முழுவதும் தோன்றும் நோய்
Equinox	சமநாள்
Exclusive Economic Zone	தனித்த பொருளாதார மண்டலம்
Field Measurement Book	புல அளவீட்டு புத்தகம்
Galactic movement	அண்ட சுழற்சி
Global Positioning System	உலகளாவிய அமைவிடம் கண்டறியும் தொகுதி
Greenhouse effect	பசுமைக் இல்ல விளைவு
Greenwich Mean Time	கிரீன்விச் சராசரி நேரம்
Habitat	வாழிடம்
Hail	ஆலங்கட்டி மழை

Hot spot	வள மையம்
Hygrometer	ஈரப்பத அளவி
Isohaline	சம உப்பு
Isthmus	நிலச்சந்தி
Lagoon	உப்பங்கழி / காயல்
Landfall	கரையை அடைதல்
Magnetic field	காந்தப் புலம்
Map projection	நிலவரைபடக் கோட்டுச் சட்டம்
Mitigation	தணித்தல்
Natural resource	இயற்கை வளம்
Oasis	பாலைவனச் சோலை
Ozone layer	ஓசோன் அடுக்கு
permafrost	நிரந்தரப் பனிக்கட்டிகள்
Poaching	சட்டத்திற்கு புறம்பாக வேட்டையாடுதல்
Preparedness	தயார்நிலை
Prime meridian	முதன்மைத் தீர்க்ககோடு
Sedges	கோரைகள்
Sleet	கல் மழை / ஆலங்கட்டி மழை
spit	நீண்ட மணல் திட்டு
Solar flare	சூரிய பட்டொளி
Swell	வீக்கம்
Toponym	இடப்பெயர்
Trace elements	சுவடுக் கூறுகள்
Trench	அகழி

INDIA - PHYSICAL MAP



INDIA - POLITICAL MAP

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WORLD - POLITICAL MAP

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