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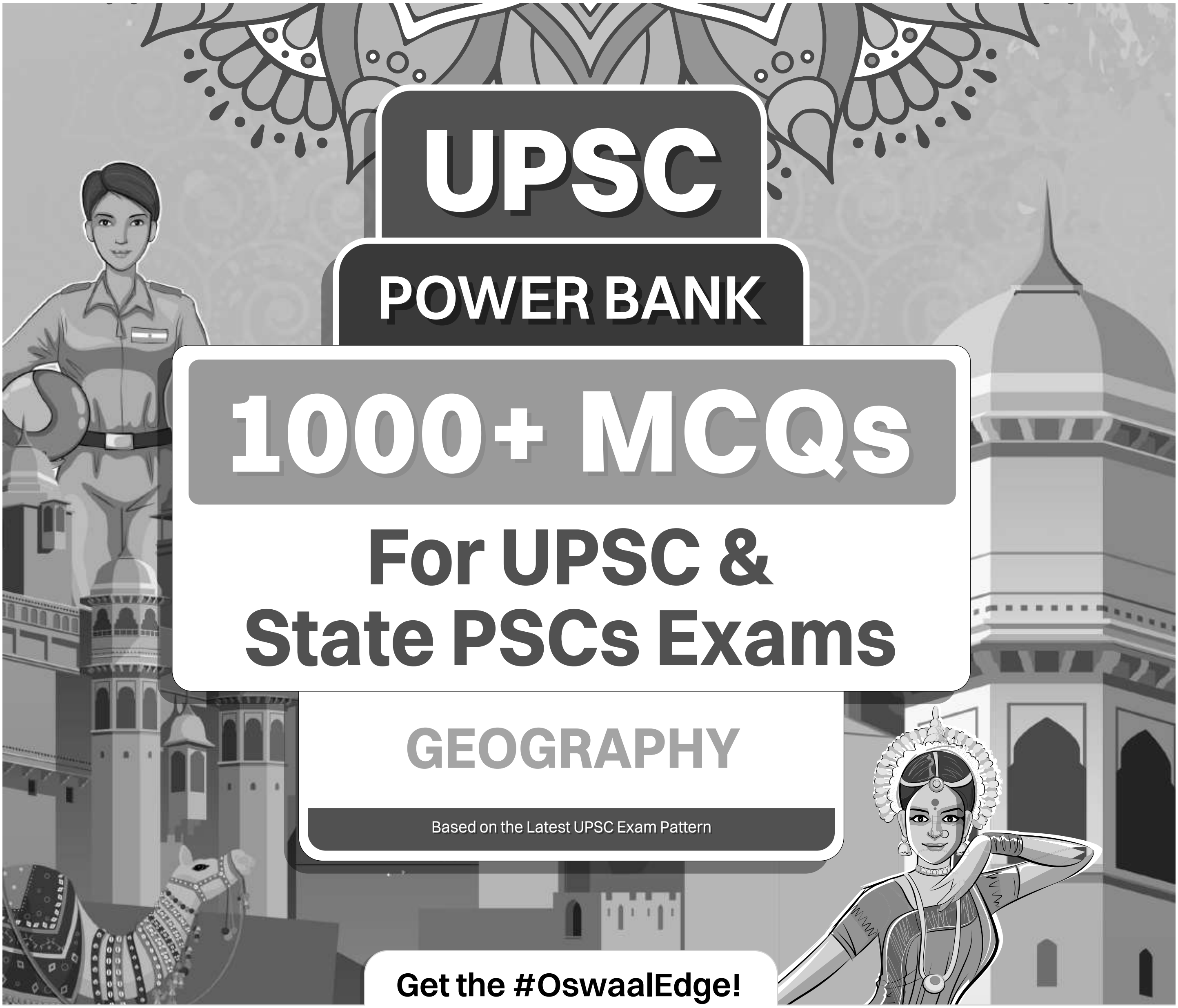

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PREFACE

TThe geography subject is an important component of the Civil Services Examination conducted by the Union Public Service Commission (UPSC). Aspirants who are preparing for this prestigious examination need to have a strong understanding of Indian Economy subject.

This book of UPSC Power Bank of Geography subject has been designed keeping in mind the needs of aspirants who are preparing for the Civil Services Examination. The book covers all the important topics of geography including Geomorphology, Climatology, Oceanography, Indian Monsoon, Drainage System of India and Vegetation.

The questions in this book are comprehensive and have been curated after extensive research to ensure that they cover all the aspects of Geography. Each question is accompanied by a detailed answer that not only explains the correct option but also provides additional information related to the question. This will help aspirants to build a strong foundation in Geography subject and understand the subject in greater depth.

The objective of this book is:

1. **Assessing Knowledge:** by testing the candidates' understanding and knowledge of these topics.
2. **Testing Critical Thinking Skills:** to apply it in new and different contexts, analyse and evaluate information, and draw conclusions.
3. **Providing Practice:** by making them familiar with the format and style of UPSC questions.
4. **Preparing for the Exam:** by covering the same types of questions and difficulty levels as the actual exam.
5. **Identifying Knowledge Gaps:** By using the question bank, candidates can identify areas where they need to improve their knowledge or skills, and focus their study efforts accordingly.
6. **Improving Time Management:** This question bank provides a variety of questions that test different aspects of knowledge and skills, so that candidates can learn to manage their time effectively during the actual exam.
7. **Encouraging Self-Assessment:** By detailed explanations and solutions to each question, candidates can assess their own performance and identify areas for improvement.

We hope that this book will prove to be a valuable resource for aspirants preparing for the UPSC Civil Services Examination and help them achieve their goals. We wish all the aspirants the very best for their preparation and future endeavours.

We also express our gratitude to **Mr. Yashovardhan Mishra & Mr. Lalit Sikarwar** who have contributed to the book, for their experience and their knowledge. Their contributions will help our readers gain valuable insights and knowledge and secure a high rank in the UPSC examination.
We wish the readers great success ahead!

All the best!
Team Oswaal

Study approach for the Geography for UPSC prelims

Geography is a fundamental subject that forms an integral part of the UPSC syllabus. Its significance stems from the fact that it encompasses various aspects of both physical and human geography, which are essential for a comprehensive understanding of the world we live in. Here are some key points which will help you in the preparation of UPSC exams.

- **Understand the Syllabus:** Begin by thoroughly understanding the UPSC syllabus for geography. The Syllabus of Geography for UPSC Prelims is divided into two parts: World Geography and Indian Geography. This will help you identify the relevant topics and chapters that need to be covered.

- **Study Material Selection:** Select reliable and comprehensive study materials for geography. NCERTs are must for geography.

- **Familiarize with the Concepts:** Start by developing a good understanding of basic concepts in geography such as latitude, longitude, maps, climatology, oceanography, geomorphology, etc. This will provide a strong foundation for further learning.

- **Focus on Important Chapters and Topics:** Astronomy, Geomorphology, Oceanography, Climatology, World Physical Features, Indian Physiography, Drainage System, Climate, Soil, Minerals.

- **Current Affairs:** Stay updated with current affairs related to geography, such as recent environmental issues, climate change agreements, government schemes related to agriculture or urban development, and most important is places in news, etc. A special focus should be given to some specific areas concerning world map such as region of black sea, Mediterranean Sea, Gulf nation, South East Asian countries.

- **Practice Previous Year Question Papers:** Solve previous year question papers and sample papers to understand the exam pattern, time management, and to assess your preparation level. It will also help you identify the areas that need more focus.

- **Revision and Consolidation:** Regularly revise the topics you have studied. Make concise notes and mind maps to aid in quick revision.

Remember, consistency and dedication are key to succeed in the UPSC prelims. Develop a study schedule that suits you, allocate sufficient time for each topic as per its relevance.

Good luck for your exam!

Aashirvad Kumar
UPSC Consultant: **Oswaal Books**
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3 UPSC Interviews

Positive Affirmations

I courageuosly move in the direction of my dreams

I realize what I cannot Control and let the good things flow

I am Supported fully by the universe

I am wrapped in the loving energy of the universe

I allow my desires to flow to me now

All of my thoughts are aligned with my desires

Affirmations for the new "YOU"

I am open to new experiences and welcome abundance into my life

I effortlessly attract my desires

" Accept yourself, love yourself, and keep moving forward. If you want to fly, you have to give up what weighs you down. "

When I let go, I create space for something better.

I have the power to shift my mindset and see the good in everything.

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Flash Facts

Unit-I: The Universe and the Earth

Origin of The Earth

Nebular Hypothesis:

- The Nebular Hypothesis was first proposed by Immanuel Kant in the 18th century, and later revised by Pierre-Simon Laplace.
- According to the hypothesis, the planets, including the Earth, formed out of a cloud of gas and dust that surrounded the young Sun.
- The Sun was surrounded by a solar nebula that contained mostly hydrogen, helium, and other dust particles.
- Over time, the particles in the solar nebula collided and stuck together, gradually forming larger and larger clumps.
- Eventually, these clumps grew into planetesimals, which in turn collided and merged to form the planets.
- The process of growth by gradual accumulation of matter is called accretion.
- The Earth formed about 4.6 billion years ago, and is thought to have undergone significant changes since its formation, including the formation of its crust, oceans, and atmosphere, as well as movements of the tectonic plates that make up its surface.
- Ongoing research and study of the Earth's interior and geologic history is helping to refine our understanding of its origins and evolution.

Origin of The Universe

- The universe began as a single, infinitely hot and dense point known as a singularity.
- The singularity rapidly expanded and cooled in a massive explosion, known as the Big Bang, approximately 13.8 billion years ago.
- As the universe continued to expand and cool, matter began to clump together, eventually forming galaxies, stars, and planets.
- The observed redshift of light from distant galaxies suggests that the universe is still expanding and getting larger.
- The cosmic microwave background radiation, which is thought to be leftover radiation from the Big Bang, provides evidence that supports the Big Bang theory.

Stages of Development of The Universe

Stage	Time	Description
Inflation	$<10^{-36}$ seconds	Universe undergoes a brief period of exponential expansion.
Particle Era	<1 second	Particles form and interact at extremely high energies.
Nucleosynthesis	3-20 minutes	Nuclei of light elements form through fusion.
Radiation Era	70,000-380,000 years	Universe is filled with hot, dense radiation.
Matter Era	380,000 years to present	Matter dominates the universe, eventually forming galaxies and larger structures.
Dark Ages	380,000 years to 150 million years	Universe becomes neutral and dark as stars and galaxies have not yet formed.
Reionization	150 million to 1 billion years	The first stars and galaxies form, releasing ionizing radiation and reionizing the universe.
Cosmic Dawn	150 million to 1 billion years	The first stars and galaxies begin to form and illuminate the universe.
Dark Energy Era	9.8 billion years to present	Dark energy becomes the dominant force driving the expansion of the universe.
Accelerated Expansion	5 billion years to present	The expansion of the universe accelerates due to the influence of dark energy.

Solar System

- The solar system is composed of the Sun (a star), eight planets, more than 200 moons, millions of smaller bodies such as asteroids and comets, and a large amount of dust and gases.
- The four inner planets, Mercury, Venus, Earth, and Mars, are called terrestrial planets as they are located between the Sun and the asteroid belt. The other four planets, Jupiter, Saturn, Uranus, and Neptune, are called Jovian planets or outer planets.
- The Sun is the central and largest object in the solar system. Its atmosphere consists of the photosphere, chromosphere, and corona.
- The photosphere is the outermost layer of the Sun that emits most of the radiation. The chromosphere, located above the photosphere, is a thin layer of burning gases.
- The corona is a tenuous outermost atmosphere of plasma that surrounds the Sun and other celestial bodies. It is usually hidden by the bright light of the Sun's surface but can be observed during a total solar eclipse.
- A dark patch on the surface of the Sun is known as a sunspot.
- Solar Wind is a stream of energized charged particles, such as electrons and protons that flow outward from the Sun.

- Solar flares are powerful bursts of energy that occur on the Sun's surface, resulting in a sudden and intense brightening. They are caused by a magnetic storm on the Sun and appear as gaseous eruptions.

Planet	Distance from Sun	Day	Year	Moons	Notable Features
Mercury	Closest planet to the Sun at about 36 million miles	1 day = 59 Earth days	1 year = 88 Earth days	No moons	Smallest planet in our solar system
Venus	Second closest planet to the Sun at about 67 million miles	1 day = 243 Earth days	1 year = 225 Earth days	No moons	Brightest planet in the solar system; often called Earth's sister planet or twin
Earth	Third planet from the Sun at about 93 million miles	1 day = 24 hours	1 year = 365.25 days	1 moon	Only planet known to support life; has a magnetic field that protects the atmosphere from the solar wind
Mars	Fourth planet from the Sun at about 142 million miles	1 day = 24 hours 37 minutes	1 year = 687 Earth days	2 moons (Phobos and Deimos)	Referred to as the "Red Planet" due to the reddish iron oxide on its surface
Jupiter	Fifth planet from the Sun at about 484 million miles	1 day = 10 hours	1 year = 12 Earth years	53 named moons and 26 unnamed	Largest planet in our solar system; has a faint ring system
Saturn	Sixth planet from the Sun at about 886 million miles	1 day = 10.7 hours	1 year = 29.5 Earth years	82 moons (53 named, 29 awaiting confirmation)	Spectacular ring system with seven rings and several gaps
Uranus	Seventh planet from the Sun at about 1.8 billion miles	1 day = 17 hours	1 year = 84 Earth years	27 moons	Ice giant composed mostly of "icy" materials such as water, methane, and ammonia
Neptune	Eighth planet from the Sun at about 2.8 billion miles	1 day = 16 hours	1 year = 165 Earth years	14 moons	Ice giant composed mostly of "icy" materials such as water, methane, and ammonia; has a great ring of debris known as the Kuiper Belt

- **Celestial bodies:** Natural objects found outside of Earth's atmosphere.
- **Asteroids:** Small rocky bodies that orbit around the sun, mainly located between the orbits of Mars and Jupiter. They vary in size.
- **Dwarf planets:** Heavenly bodies that are too small to be considered planets but larger than other small bodies. They have not cleared their orbit of smaller objects and do not have enough gravity to pull themselves into a round shape.
- **Comets:** Objects made up of a nucleus of ice and dust. When they come close to the sun, they develop a "tail" made up of gas and dust particles that points away from the sun.
- **Meteors/Meteoroids:** Meteors are objects that burn and vaporize upon entering the Earth's atmosphere. They are often referred to as "shooting stars." If a meteor survives its journey through the atmosphere and lands on the surface, it is called a meteorite.

Evolution of Earth

- The earth was in a volatile state during its primordial stage.
- As the density increased, the temperature inside the earth increased, causing materials to separate based on their densities.
- Heavier materials like iron sank towards the centre of the earth, while lighter materials moved towards the surface.
- The earth cooled and solidified, leading to the development of the crust.

Evolution of Atmosphere

- **Three stages in the evolution of the present atmosphere:** loss of primordial atmosphere, contribution from the hot interior of the earth, and modification by the living world through photosynthesis.
- Early atmosphere mostly contained water vapor, nitrogen, carbon dioxide, methane, ammonia and very little free oxygen.
- Gases were outpoured from the interior through degassing and continuous volcanic eruptions.
- Photosynthesis eventually contributed oxygen to the atmosphere.

Evolution of Hydrosphere

- As the earth cooled, water vapour condensed, and carbon dioxide in the atmosphere dissolved in rainwater.
- The temperature decreased, causing more condensation and rain, which collected in depressions to give rise to oceans.
- Oceans formed within 500 million years from the formation of the earth.
- Photosynthesis eventually evolved, and life was confined to the oceans for a long time.
- Oceans began to have the contribution of oxygen through photosynthesis, which eventually saturated the oceans and flooded the atmosphere.

Structure Of Earth

Layer	Depth (km)	Composition	Characteristics
Crust	0-30/50	Oceanic: basalt, Continental: granite	Outer thin layer, thicker in continental areas, forms 5-10% of earth's volume, Mohorovicic (Moho) discontinuity between crust and outer mantle, continents composed of sial, oceans composed of sima
Mantle	30/50-2900	Solid rock and magma	Extends to a depth of 2,900 km, lithosphere includes crust and uppermost part of mantle, lower mantle beyond asthenosphere is in solid state, forms 83% of earth's volume, density varies between 2.9-3.3 g/cm3
Asthenosphere	100-400	Plastic zone in mantle	Upper portion of mantle, considered to extend up to 400 km, main source of magma, more fluidic in nature
Core	2900-6400	Nickel and iron (Nife)	Accounts for 16% of earth's volume, heaviest mineral materials of highest density, outer core is liquid while inner core is solid, Gutenberg Discontinuity between mantle and outer core.

Chemical Composition of Earth's Crust

Element	Percentage by weight
Oxygen	46.6%
Silicon	27.7%
Aluminium	8.1%
Iron	5.0%
Calcium	3.6%
Sodium	2.8%
Potassium	2.6%
Magnesium	2.1%
Other elements	1.5%

Motions of The Earth

Type of Motion	Direction	Time Taken	Effect
Rotation	West to East	Approximately 24 hours	Causes Day and Night
Revolution	Counter-clockwise around the Sun	Approximately 365.25 days	Causes Change in Seasons
Precession	Westward	Approximately 26,000 years	Causes the Position of the Celestial Pole to Shift

Seasons

Season	Date	Hemisphere Tilt	Sun's Direct Rays	Temperature	Day/Night Duration
Summer Solstice	June 21^{st}	Northern	Tropic of Cancer	Hot	Longest day, shortest night
Winter Solstice	December 22^{nd}	Southern	Tropic of Capricorn	Cold	Longest night, shortest day
Equinox	March 21^{st}	None	Equator	Mild	Equal day, equal night
Equinox	September 23^{rd}	None	Equator	Mild	Equal day, equal night

- During the Summer Solstice, the Northern Hemisphere is tilted towards the Sun, receiving more direct rays and longer days. This results in hot temperatures in the regions north of the equator.
- Conversely, during the Winter Solstice, the Southern Hemisphere is tilted towards the Sun, resulting in colder temperatures and longer nights in the regions north of the equator.
- During the Equinoxes, neither hemisphere is tilted towards the Sun, leading to mild temperatures and equal day/night durations across the entire Earth.

Latitude

- Measures a location's distance from the Equator.
- The Equator is the zero point for latitude.
- The North Pole and South Pole mark the farthest northern and southern latitudes at 90 degrees N and 90 degrees S, respectively.
- Latitude is measured in degrees, with positive values north of the Equator and negative values south of the Equator.
- Latitude helps to determine a location's climate and weather patterns, as it is closely related to the angle at which sunlight hits the earth's surface.

Longitude

- Measures a location's distance from the Prime Meridian.
- The Prime Meridian is the zero point for longitude, and is located in Greenwich, England.
- The International Date Line is the opposite of the Prime Meridian, located at 180 degrees longitude.
- Longitude is measured in degrees, with positive values east of the Prime Meridian and negative values west of the Prime Meridian.
- Longitude helps to determine a location's time zone and is used for navigation and mapping purposes.

The Prime Meridian, also known as Greenwich Meridian Time (GMT):

- The Prime Meridian is the meridian that passes through the Royal Astronomical Observatory at Greenwich, near London, UK.
- It was established in 1884 by international agreement as the zero meridian from which all other meridians are measured.

- The Prime Meridian divides the Earth into two hemispheres: the Eastern Hemisphere and the Western Hemisphere.
- It is used as a reference point for determining longitude.
- Longitude is measured in degrees eastward and westward from the Prime Meridian, up to 180 degrees in each direction.
- The Prime Meridian is important for determining local time around the world.
- The Earth completes a full rotation of 360 degrees in 24 hours, so it rotates at a speed of 15 degrees per hour, or 1 degree every 4 minutes.
- Places located to the east of the Prime Meridian experience sunrise earlier and gain time (EAST-GAIN-ADD), while places to the west of the Prime Meridian experience sunrise later and lose time (WEST-LOSE-SUBTRACT).
- GMT is often used as a standard time reference in aviation, navigation, and other industries.

International Date Line

- The International Date Line (IDL) is an imaginary line that runs roughly north-south through the Pacific Ocean, zigzagging around certain islands and landmasses.
- It serves as the 180-degree meridian of longitude, meaning that it separates the Eastern Hemisphere from the Western Hemisphere and marks the spot where the date changes by one day.
- If you cross the IDL from west to east, you add one calendar day, and if you cross it from east to west, you subtract one calendar day.
- The IDL deviates from the 180-degree line to avoid dividing certain countries, territories, and island groups in half. For example, it curves around the eastern and western sides of Fiji, Tonga, and Samoa.

Indian Standard Time

- The standard meridian of India is 82.5º east longitude which passes through Allahabad.
- This meridian is 5.5 hours ahead of the 0º meridian (Greenwich).
- India follows a single time zone of 82.5ºE.
- Many parts of North America and Europe follow Daylight Saving Time (DST).
- DST involves moving clocks forward by an hour during summer months and back during winter months.
- The purpose of DST is to utilize long-lasting sunlight in summer and save energy.
- Northeast regions of India are demanding a separate time zone due to the sun rising as early as 4 AM and setting by 4 PM in winter.

Distribution of Ocean and Continents

Continents make up about 29% of the Earth's surface, while oceans make up about 71%. The position of continents and oceans has not been constant throughout Earth's history and has changed over time. There are several scientific theories that explain the position of continents, including:

- **Continental Drift Theory:** This theory proposes that the continents were once joined together in a single landmass called Pangaea, which later broke apart and drifted to their current positions.
- **Plate Tectonics Theory:** This theory explains the movement of the Earth's lithosphere (crust and uppermost mantle) through the process of plate tectonics. The lithosphere is divided into several plates, which move and interact with each other, causing the formation of mountains, volcanoes, and ocean basins.
- **Seafloor Spreading Theory:** This theory suggests that new oceanic crust is formed at mid-ocean ridges, where magma rises up and solidifies, pushing the existing crust away from the ridge and creating new oceanic crust.
- **Mantle Convection Theory:** This theory suggests that the movement of the Earth's lithosphere is driven by the convective flow of the Earth's mantle, which carries heat from the Earth's interior to the surface. The upwelling of hot material at mid-ocean ridges and the sinking of cool material at subduction zones drive the movement of the plates.

Theory	Description	Key Proponents	Year of Proposal	Evidence
Continental Drift Theory	Suggests that the continents were once joined together in a single landmass called Pangaea, which later broke apart and drifted to their current positions	Alfred Wegener	1912	Similar geological features and fossil records found on opposite sides of the ocean basins, such as the Appalachian Mountains and the Caledonian Mountains
Plate Tectonics Theory	Explains the movement of the Earth's lithosphere through the process of plate tectonics	John Tuzo Wilson, Jason Morgan, Dan McKenzie	1960s	Seafloor spreading, magnetic striping, earthquake patterns, and volcanic activity
Seafloor Spreading Theory	Suggests that new oceanic crust is formed at mid-ocean ridges, where magma rises up and solidifies, pushing the existing crust away from the ridge and creating new oceanic crust	Harry Hess, Robert Dietz	1960s	Magnetic striping on the seafloor, which indicates the polarity of the Earth's magnetic field at the time of formation
Mantle Convection Theory	Suggests that the movement of the Earth's lithosphere is driven by the convective flow of the Earth's mantle, which carries heat from the Earth's interior to the surface	Arthur Holmes, Jason Morgan	Early 20th century, 1970s	The upwelling of hot material at mid-ocean ridges and the sinking of cool material at subduction zones, which drive the movement of the plates

Plume Tectonics Theory	Suggests that the movement of the Earth's lithosphere is driven by the upwelling of hot mantle plumes, which cause melting and partial melting of the lithosphere, leading to the formation of volcanoes and oceanic crust	W. Jason Morgan, Edward Bullard	1970s	The formation of hotspot chains, such as the Hawaiian-Emperor seamount chain
Expansion Tectonics Theory	Suggests that the Earth is expanding, causing the continents to move away from each other	Samuel Warren Carey	1950s-1970s	Controversial and lacking widespread acceptance among the scientific community

Unit-2: Geomorphology

1. Minerals and Rocks

Rock Type	Description
Igneous	• Formed from cooled and solidified lava or magma. • May have large crystals (intrusive) or small crystals (extrusive) depending on how fast it cooled. • Examples include granite, basalt, and pumice.
Sedimentary	• Formed from the accumulation and cementation of fragments of other rocks, • Organic materials, or chemical precipitates. Often layered or contain fossils. • Examples include sandstone, shale, and limestone.
Metamorphic	• Formed from pre-existing rocks that have been subjected to heat, pressure, and/or chemical changes. • May have bands or layers due to the alignment of minerals. • Examples include marble, slate, and gneiss.
Hydrothermal	• Formed from mineral-rich solutions that are heated and then deposited as veins or other structures in pre-existing rocks. • Examples include quartz and beryl.
Volcanoclastic	• Formed from fragments of volcanic material, such as ash, pumice, and lapilli, that have been deposited by explosive volcanic activity. • Examples include tuff and ignimbrite.
Conglomerate	• A type of sedimentary rock composed of rounded fragments that are greater than 2 mm in size. • May contain pebbles, cobbles, and boulders.
Breccia	• A sedimentary or volcanic rock composed of angular fragments greater than 2 mm in size. • May contain sharp edges and corners.
Lava	• Molten rock that has erupted onto the Earth's surface and solidified. • May form basaltic or andesitic flows.
Obsidian	• A type of volcanic glass that forms when lava cools quickly without forming crystals. • Has a smooth, glassy texture and can be sharp enough to be used as a cutting tool.
Schist	• A type of metamorphic rock with a foliated texture formed from the metamorphism of shale or other fine-grained sedimentary rocks. • Often contains mica and other minerals that give it a shiny appearance.

2. Geomorphic Processes

- Geomorphology is a scientific field that investigates the physical features of the Earth's surface and their relationship with its geological structures.
- This discipline aims to understand how natural processes, such as erosion, weathering, and tectonic activity, shape the landforms we see today.
- The formation and deformation of landforms on the Earth's surface are ongoing processes that result from the continuous influence of both external and internal forces.
- These forces include natural processes like erosion, deposition, and weathering, as well as internal processes such as tectonic activity and volcanic eruptions.
- The study of geomorphic processes is crucial for understanding how landscapes evolve over time and how they respond to environmental change.

Geomorphic Agents

Geomorphic Agent	Definition	Effects on Landscape
Water	Any type of flowing water, such as rivers, streams, and ocean currents	Erosion of rock and soil, transportation and deposition of sediment, creation of landforms such as canyons, valleys, and deltas

Wind	Moving air, usually in arid regions	Erosion of rock and soil, transportation and deposition of sediment, formation of dunes and sand sheets
Glaciers	Masses of ice that move slowly over the land	Erosion of rock and soil, transportation and deposition of sediment, creation of landforms such as valleys, cirques, and moraines
Gravity	The force that pulls objects toward the center of the Earth	Mass wasting and landslides, creation of landforms such as talus slopes and rock falls
Tectonic activity	The movement and deformation of the Earth's crust	Creation of mountains, valleys, and other large-scale landforms, earthquakes and other geological hazards
Biological activity	The effects of living organisms on the landscape	Weathering of rock and soil, soil formation, regulation of water flow
Humans	The impact of human activities on the landscape	Land use changes, such as deforestation and urbanization, construction activities, pollution

Different Geomorphic Processes

Geomorphic Process	Definition	Examples
Weathering	The breakdown of rocks and minerals at or near the Earth's surface	Physical weathering (e.g. freeze-thaw, abrasion), chemical weathering (e.g. dissolution, oxidation)
Erosion	The removal of soil and rock material by wind, water, ice, or gravity	River erosion, coastal erosion, glacial erosion, wind erosion
Transportation	The movement of sediment by wind, water, ice, or gravity	River transport, beach drift, glacial transport, landslide
Deposition	The settling of sediment carried by wind, water, ice, or gravity	River delta formation, beach formation, glacial moraine formation, alluvial fan formation
Mass Wasting	The downslope movement of rock and soil material due to gravity	Rockfall, landslide, mudflow
Tectonic activity	The movement and deformation of the Earth's crust	Uplift, subsidence, faulting, folding
Fluvial processes	Processes related to the movement of water in rivers and streams	Erosion, transportation, deposition, meandering, braiding
Coastal processes	Processes related to the movement of water along coastlines	Erosion, transportation, deposition, wave-cut platforms, sea stacks
Glacial processes	Processes related to the movement of glaciers	Erosion, transportation, deposition, formation of cirques, U-shaped valleys, moraines
Karst processes	Processes related to the dissolution of soluble rocks such as limestone and dolomite	Sinkhole formation, cave formation
Aeolian processes	Processes related to the movement of wind	Erosion, transportation, deposition, formation of sand dunes, loess deposits

Volcanoes

- Volcanism refers to the process of magma rising from the Earth's mantle or crust and erupting through a volcano onto the surface of the Earth. There are several types of volcanoes, and the type of volcano depends on the type of magma that is erupted.

Type of Volcano	Description
Shield volcanoes	These are broad, gently sloping volcanoes that are typically formed from basaltic lava flows. Shield volcanoes have low viscosity lava, which means it flows easily and can travel long distances. Examples of shield volcanoes include Mauna Loa in Hawaii and Mt. Etna in Italy.
Composite volcanoes	These are tall, steep-sided volcanoes that are formed from alternating layers of lava and ash. The lava that erupts from composite volcanoes is typically andesitic or rhyolitic, which has a higher viscosity than basaltic lava. Examples of composite volcanoes include Mt. Fuji in Japan and Mt. St. Helens in the United States.
Cinder cones	These are small, steep-sided volcanoes that are formed from explosive eruptions of gas-rich magma. The eruptions produce cinders, which are small pieces of volcanic rock. Cinder cones are typically formed from basaltic lava, and they are often found on the flanks of larger volcanoes.

Fissure volcanoes	These are long, narrow volcanoes that are formed when lava erupts from a fissure, or crack, in the Earth's crust. Fissure eruptions can produce large amounts of basaltic lava, which can flow for long distances. The largest fissure volcano on Earth is the Mid-Atlantic Ridge, which stretches for over 10,000 miles along the bottom of the Atlantic Ocean.

- Lava is the molten rock that is erupted from a volcano. There are three main types of lava:
  - **Basaltic lava:** This type of lava has low viscosity, which means it flows easily and can travel long distances. Basaltic lava typically forms shield volcanoes.
  - **Andesitic lava:** This type of lava has a higher viscosity than basaltic lava, which means it doesn't flow as easily. Andesitic lava typically forms composite volcanoes.
  - **Rhyolitic lava:** This type of lava has the highest viscosity of the three types, which means it flows very slowly and forms steep-sided volcanoes. Rhyolitic lava typically forms the most explosive volcanic eruptions.
- Volcanism can create a variety of landforms, some of which are unique and breathtaking. Here are some examples:
  - **Volcanic cones:** These are formed by the accumulation of lava, ash, and other volcanic materials around the vent of a volcano. The shape of a volcanic cone can vary depending on the type of eruption that created it. Cinder cones, for example, are typically steep-sided and have a conical shape, while shield volcanoes have a broad, gently sloping shape.
  - **Calderas:** These are large, circular depressions that form when a volcano collapses into its magma chamber. Calderas can be several kilometers wide and are often filled with water. Crater Lake in Oregon, USA, is an example of a caldera that was formed by the collapse of a volcanic cone.
  - **Lava plateaus:** These are large, flat areas that are formed by the accumulation of lava flows over a wide area. The Deccan Plateau in India and the Columbia Plateau in the USA are examples of lava plateaus.
  - **Fissure vents:** These are long, narrow cracks in the Earth's crust from which lava can erupt. Fissure vents can produce large amounts of lava, which can cover vast areas. The largest fissure vent system on Earth is the Mid-Atlantic Ridge, which stretches for over 10,000 miles along the bottom of the Atlantic Ocean.
  - **Volcanic islands:** These are islands that are formed by volcanic activity. Some of the world's most famous volcanic islands include Hawaii, Iceland, and the Galapagos Islands.
  - Volcanic necks: These are steep-sided columns of solidified lava that form when magma hardens inside a volcanic vent. Shiprock in New Mexico, USA, is an example of a volcanic neck.
  - **Hot springs and geysers:** These are formed when groundwater is heated by magma or hot rocks beneath the Earth's surface. The heated water rises to the surface and can create hot springs or geysers. Yellowstone National Park in the USA is known for its many hot springs and geysers.

Distribution of Volcanoes

- The Circum-Pacific Ring of Fire, also known as the Pacific Ring of Fire, is a region around the Pacific Ocean where many active volcanoes and tectonic plate boundaries are located. It extends for over 40,000 kilometers and includes the western coast of North America, Central America, South America, Asia, and Oceania.
- Around two-thirds of the world's active volcanoes are located in the Pacific Ring of Fire. This is because the region sits on the boundary of several tectonic plates, which are constantly moving and colliding with each other. This movement can cause earthquakes, volcanic eruptions, and other geological activity.
- While the majority of the world's active volcanoes are found in the Pacific Ring of Fire, there are still some active volcanoes located along the Atlantic and Mediterranean coasts. For example, Mount Etna in Italy and the Azores in Portugal are both located on the Atlantic coast and are active volcanoes.

Earthquakes

- An earthquake is the shaking or trembling of the earth's surface caused by the sudden movement of a part of the earth's crust resulting in the release of energy that creates seismic waves.
- It occurs when the surplus accumulated stress in rocks in the earth's interior is relieved through the weak zones over the earth's surface in the form of kinetic energy of wave motion causing vibrations.
- Focus is the place of origin of an earthquake inside the earth, while the epicentre is the point on the earth's surface vertically above the focus. Maximum damage is caused at the epicentre.
- Earthquake magnitude is measured by the Richter scale, intensity is measured by Mercalli.
- Causes of earthquakes include compressional or tensional stresses built up at the margins of the huge moving lithospheric plates, sudden release of stress along a fault or fracture in the earth's crust, constant change in volume and density of rocks due to intense temperature and pressure in the earth's interior, and human-induced earthquakes.
- Seismic waves are produced when some form of energy stored in the Earth's crust is suddenly released due to slipping of land, these waves will travel in all directions.
- Earthquake waves are of two types — Body waves and Surface waves.
- Body waves are generated due to the release of energy at the focus and move in all directions travelling through the body of the earth.
- Body waves interact with the surface rocks and generate new sets of waves called surface waves, which move along the surface and are also more destructive (Rayleigh) than body waves.

- Body waves are of two types: Primary waves or P waves (longitudinal) and Secondary waves or S waves (transverse) (least destructive).
- **Surface Waves are of two types:** L waves (confined to the surface of the crust, Love waves produce entirely horizontal motion, they are much slower than body waves but are faster than Rayleigh) and Rayleigh waves (these waves follow an elliptical motion).
- Earthquakes are a consequence of inter-plate interaction along the convergent boundary, where compressive forces crush and cause earthquakes, while along divergent boundary tensile forces stretch and snap the earth creating earthquakes.
- Earthquakes can also be due to plate motions and the friction of lithospheric plates while they drift along the asthenosphere.
- Propagation of Earthquake Waves in Earth's Interiors: P-waves vibrate parallel to the direction of the wave, while the direction of vibrations of S-waves is perpendicular to the wave direction in the vertical plane.
- The seismic shadows are the effect of seismic waves striking the core-mantle boundary.

3. Major Landforms and their Evolution

Landforms Created by Running Water

Landform	Description
River	A large natural stream of water that flows in a channel towards an ocean, sea, lake, or another river
Valley	A low area of land between hills or mountains, often created by the erosion of a river or stream
Canyon	A deep and narrow valley with steep sides, often created by the erosion of a river or stream
Waterfall	A steep drop in a river or stream, where the water falls freely over a cliff or rock ledge
Delta	A landform created by sediment deposition at the mouth of a river, where the river flows into a larger body of water
Meander	A winding curve or loop in the course of a river or stream
Oxbow lake	A crescent-shaped body of water formed when a meander of a river or stream is cut off from the main channel
Alluvial fan	A fan-shaped deposit of sediment that forms at the base of a mountain or hill, often created by a fast-moving stream or river
Floodplain	A flat or gently sloping plain adjacent to a river or stream, which is subject to periodic flooding and is often fertile land
Gorge	A narrow and steep-sided valley or ravine, often created by the erosion of a river or stream

Types of Coastal Landforms

Landform	Description
Bay	A body of water partially enclosed by land, usually with a wide opening to the sea
Beach	A narrow strip of land along the coast composed of sand, gravel, or pebbles
Cape	A pointed piece of land extending into a sea or ocean
Cliff	A steep rock face or slope, often found along a coastline
Estuary	A partially enclosed coastal body of water where freshwater from rivers and streams mixes with saltwater from the ocean
Headland	A high and often steep point of land that extends out into a body of water, usually the sea
Inlet	A narrow strip of water extending inland from a larger body of water, often with a narrow entrance
Lagoon	A shallow body of water separated from a larger body of water by sandbars, coral reefs, or other landforms
Sea arch	A natural arch or bridge formed by erosion of a sea cliff
Spit	A narrow strip of land extending into a body of water, usually formed by longshore drift
Wave-cut platform	A flat, rocky area along the base of a sea cliff that is exposed at low tide
Sea stack	A column of rock isolated from the mainland by erosion, often found near a cliff or headland
Tombolo	A sandy or rocky bar that connects an island to the mainland or another island.

Common Landforms found in Karst Regions

Landform	Description
Sinkhole	A depression or hole in the ground caused by the collapse of a surface layer, often due to the dissolution of limestone or other soluble rocks
Cenote	A deep, natural sinkhole or water-filled pit, often found in limestone regions, especially in the Yucatan Peninsula
Karst window	An opening in the surface of the ground that exposes an underground cave or channel
Polje	A large, flat plain or valley in karst terrain, often with sinkholes and underground rivers
Tower karst	A type of karst topography characterized by steep, cone-shaped hills or towers, often found in Southeast Asia
Doline	A bowl-shaped depression in karst terrain, formed by the dissolution of limestone or other soluble rocks
Karst spring	A natural source of water that emerges from an underground karst system

Lapies	A type of karst landform characterized by fissures or grooves in the surface of limestone rock, often due to the dissolution of the rock by acidic water
Karst cave	A type of cave formed by the dissolution of limestone or other soluble rocks by acidic water
Polypoid karst	A type of karst topography characterized by small, rounded hills or mounds, often found in the Dinaric Alps
Uvala	A large, closed depression or sinkhole in karst terrain, formed by the merging of several smaller dolines or sinkholes
Karren	A type of karst landform characterized by shallow grooves or furrows in the surface of limestone rock, often due to the dissolution of the rock by acidic water

Common Landforms Formed by Glaciation

Landform	Description
Cirque	A bowl-shaped depression at the head of a glacial valley, often containing a small lake or pond
Arete	A narrow, sharp ridge of rock that separates two glacial valleys
Horn	A pointed peak formed by the erosion of multiple glacial cirques on a single mountain
Moraine	A ridge or mound of sediment that has been deposited by a glacier
Esker	A long, winding ridge of sediment deposited by a stream that flowed beneath a glacier
Drumlin	A long, teardrop-shaped hill of glacial sediment that points in the direction the glacier was moving
Kame	A small, steep-sided hill of glacial sediment that forms when a block of ice becomes partially buried and then melts
Glacial valley	A U-shaped valley that has been carved by a glacier
Fjord	A long, narrow, deep inlet of the sea that is bordered by steep cliffs, often formed when a glacier carved a U-shaped valley that was later flooded by the sea
Paternoster lakes	A series of small, interconnected lakes or ponds that are aligned in a glacial valley
Hanging valley	A smaller, tributary valley that joins a larger glacial valley, often with a waterfall or steep drop-off
Tarn	A small, mountain lake that has been formed by a glacier
Roche moutonnée	A rock that has been sculpted and smoothed by glacial erosion, with a smooth, gently sloping upstream face and a steep downstream face

Common Landforms Found in Deserts

Landform	Description
Mesa	A flat-topped mountain or hill with steep sides
Butte	A tall, narrow hill with a flat top and steep sides, often capped by hard rock
Plateau	A large, flat area of land that is elevated above the surrounding terrain
Inselberg	A prominent, isolated rock hill or mountain that rises abruptly from a desert plain
Canyon	A deep, narrow valley with steep sides, often formed by the erosion of flowing water
Arroyo	A steep-sided, narrow channel or gully formed by the erosion of flowing water
Badlands	An area of heavily eroded terrain with sharp, steep-sided hills and deep gullies
Sand dune	A hill of sand built up by wind or water flow
Playa	A flat, dry lakebed or salt pan, often formed by the accumulation of windblown sediment
Alluvial fan	A fan-shaped deposit of sediment that forms at the base of a mountain or hill, often due to flash floods
Pediment	A gently sloping desert plain that extends outward from the base of a mountain or mesa
Yardang	A long, wind-carved ridge of rock or sand, often resembling the shape of a streamlined hill
Desert pavement	A layer of closely packed gravel, rock fragments, or pebbles that covers desert surfaces

Unit-3: Climatology

- Weather refers to the current and short-term atmospheric conditions in a specific location, while climate refers to the long-term average weather patterns of a particular area, typically over a period of 30 years or more.
- In other words, weather is what you experience on a daily basis, while climate is the typical weather that can be expected in a certain region over a longer period of time.
- It is important to note that weather and climate are closely related, as climate is influenced by various factors that affect the weather patterns in a region.

Different Elements of Weather and Climate

Element	Weather	Climate
Temperature	Daily variation in temperature due to solar radiation, cloud cover, humidity, wind, and other factors	Average temperature patterns over a long period of time, influenced by latitude, altitude, ocean currents, and other factors

Precipitation	Short-term variation in rain, snow, sleet, hail, or other forms of precipitation, influenced by air masses, temperature, humidity, and other factors	Average precipitation patterns over a long period of time, influenced by location, altitude, prevailing winds, and other factors
Humidity	Daily variation in the amount of water vapor in the air, influenced by temperature and precipitation	Average humidity patterns over a long period of time, influenced by location, altitude, and other factors
Wind	Daily variation in wind speed and direction, influenced by temperature, pressure, and topography	Average wind patterns over a long period of time, influenced by latitude, topography, and pressure systems
Pressure	Daily variation in air pressure due to temperature and wind patterns, can indicate the likelihood of weather events such as storms or high-pressure systems	Average pressure patterns over a long period of time, influenced by latitude, ocean currents, and topography
Cloud cover	Daily variation in the amount and type of clouds present in the atmosphere, which can affect temperature and precipitation	Average cloud cover patterns over a long period of time, influenced by location, altitude, and prevailing winds

Cloud and its Types

Cloud Type	Description	Altitude	Characteristics
Cirrus	Thin, wispy clouds made of ice crystals	20,000 - 40,000 ft	Indicate fair weather or approaching storms; can be blown into shapes by high-altitude winds
Cirrostratus	Thin, transparent clouds that cover the entire sky, often creating a halo around the sun or moon	20,000 - 40,000 ft	Indicate an approaching storm
Cirrocumulus	Small, rounded white or gray clouds that appear in rows or patches	20,000 - 40,000 ft	Indicate fair weather or an approaching storm
Altocumulus	White or gray mid-level clouds that appear in a wavelike pattern, sometimes called "sheep backs"	6,500 - 20,000 ft	Indicate a potential for thunderstorms or light precipitation
Altostratus	Gray or blue-gray clouds that often cover the entire sky, sometimes with the sun or moon visible as a dull disc	6,500 - 20,000 ft	Indicate a potential for rain or snow
Stratus	Low, flat clouds that cover the entire sky, often associated with drizzle or light rain	Up to 6,500 ft	Indicate overcast or rainy weather
Stratocumulus	Low, rounded clouds with distinct edges and usually formed in groups	Up to 6,500 ft	Indicate fair weather or light precipitation
Cumulus	Large, puffy clouds with flat bottoms and rounded tops	Up to 6,000 ft	Indicate fair weather but can develop into thunderstorms
Cumulonimbus	Large, dense clouds that can produce thunderstorms, lightning, heavy rain, and even tornadoes	Up to 50,000 ft	Indicate severe weather; can produce strong updrafts and downdrafts
Nimbostratus	Dark, low clouds that produce steady rain or snow	Up to 6,500 ft	Indicate continuous precipitation

Atmosphere

- The atmosphere is a mixture of gases, along with water vapor and suspended particulate matter.

Major Components of the Earth's Atmosphere

Component	Chemical Formula	Percentage
Nitrogen	N_2	78.08%
Oxygen	O_2	20.95%
Argon	Ar	0.93%
Carbon Dioxide	CO_2	0.041%
Neon	Ne	0.0018%
Helium	He	0.0005%
Methane	CH_4	0.0002%
Krypton	Kr	0.0001%
Hydrogen	H_2	trace amounts
Water Vapor	H_2O	variable, typically between 0.1% and 3%

Structure of Atmosphere

Layer	Altitude Range	Temperature Range	Characteristics
Troposphere	0-12 km (0-7.5 mi)	-60°C (-76°F) to 20°C (68°F)	Contains most of the Earth's weather systems and is where we live and breathe; temperature decreases with altitude
Stratosphere	12-50 km (7.5-31 mi)	-60°C (-76°F) to 0°C (32°F)	Contains the ozone layer which absorbs harmful UV radiation; temperature increases with altitude due to absorption of UV radiation
Mesosphere	50-85 km (31-53 mi)	0°C (32°F) to -90°C (-130°F)	Where meteors burn up upon entry into Earth's atmosphere; temperature decreases with altitude
Thermosphere	85-600 km (53-372 mi)	-90°C (-130°F) to 1,500°C (2,732°F)	Contains the ionosphere, where charged particles are present and radio waves are reflected back to Earth; temperature increases with altitude due to absorption of solar radiation
Exosphere	600 km and up (372 mi)	Can reach up to 2,000°C (3,632°F)	Where the Earth's atmosphere gradually fades into space; contains very few gas molecules

Insolation

- Insolation refers to the amount of solar radiation reaching a particular area over a given period. It is an important factor in determining the temperature and climate of a particular region.

Apehelion and Perihelion

- Aphelion is a term used in astronomy to refer to the point in a planet's orbit around the sun where it is farthest away from the sun. This is in contrast to perihelion, which is the point in a planet's orbit where it is closest to the sun.
- For Earth, the aphelion occurs around July 4th of each year and is approximately 152 million kilometers (94.5 million miles) from the sun. The distance between the Earth and the Sun varies during the year because of the elliptical shape of Earth's orbit. The Earth is closest to the sun at perihelion, which occurs around January 3rd each year, and farthest from the sun at aphelion.
- The difference in distance between the Earth and the Sun at aphelion and perihelion does not significantly affect Earth's climate. However, it does affect the length of the seasons, with the summer season being slightly longer in the Northern Hemisphere when Earth is at aphelion and slightly shorter when Earth is at perihelion.

The atmosphere is heated and cooled through a variety of processes, including:

- **Convection:** This is the transfer of heat through the movement of fluids such as air or water. Warm air rises and cooler air sinks, creating convection currents that transfer heat throughout the atmosphere.
- **Radiation:** This is the transfer of heat through electromagnetic waves, such as the heat we feel from the sun. Radiation can both heat and cool the atmosphere, depending on the wavelength of the radiation and the properties of the gases in the atmosphere.
- **Conduction:** This is the transfer of heat through direct contact between two objects. The atmosphere is heated by conduction when warm air comes into contact with the Earth's surface, and cooled by conduction when cold air comes into contact with the Earth's surface.
- **Advection:** This is the transfer of heat through the movement of air or water from one region to another. Advection can both heat and cool the atmosphere, depending on the temperature of the air or water being transported.
- **Evaporation and Condensation:** These processes involve the transfer of heat through changes in the state of water from liquid to gas and back again. When water evaporates from the surface of the Earth, it absorbs heat from the surrounding atmosphere, cooling it. When water condenses back into liquid form, it releases heat into the atmosphere, warming it.

The Elements of Climate and the Factors Affecting them

Element of Climate	Factors Affecting
Temperature	Latitude, altitude, ocean currents, cloud cover, land cover, greenhouse gases
Precipitation	Prevailing winds, ocean currents, topography, proximity to water bodies, temperature, humidity
Humidity	Temperature, proximity to water bodies, precipitation, vegetation cover, wind patterns
Air Pressure	Altitude, temperature, humidity, wind patterns
Wind	Pressure gradients, rotation of the Earth, topography, surface roughness, temperature gradients
Cloud cover	Temperature, humidity, air pressure, wind patterns, atmospheric aerosols
Solar radiation	Latitude, time of day/year, altitude, cloud cover, atmospheric aerosols

Precipitation

Precipitation refers to any form of moisture that falls from the atmosphere and reaches the Earth's surface. This can include rain, snow, sleet, hail, and other types of frozen or liquid water droplets. Precipitation is an important part of the Earth's water cycle, as it replenishes the surface water in rivers, lakes, and oceans, as well as groundwater reserves. The amount and type of precipitation that falls in a particular area is influenced by a variety of factors, including the location, topography, temperature, and atmospheric conditions.

Type of Precipitation	Description
Rain	Liquid water droplets that fall from clouds and reach the ground
Snow	Ice crystals that fall from clouds and reach the ground
Sleet	Frozen raindrops that partially melt and refreeze on their way down
Freezing rain	Raindrops that freeze upon contact with a surface that has a temperature below freezing
Hail	Large frozen balls of ice that form in thunderstorm updrafts
Orographic	Rainfall that occurs as moist air is forced up and over a mountain range, causing it to cool and release moisture on the windward side of the mountain range. This can result in a rain shadow effect on the leeward side of the range.
Cyclonic	Rainfall that occurs as a result of the convergence of moist air masses in a low-pressure system, such as a tropical cyclone or mid-latitude cyclone.
Frontal	Rainfall that occurs at the boundary between two air masses with different temperatures and humidity levels. The warmer, more humid air rises over the cooler, denser air, causing the air to cool and release moisture as rainfall.
Convectional	Rainfall that occurs as a result of the heating of the Earth's surface, which causes air to rise and cool, releasing moisture as rainfall. This type of rainfall is common in tropical regions with high temperatures and high humidity.

Types of Pressure Belts

Pressure Belt	Description
Equatorial Low	A low-pressure belt that encircles the Earth near the equator. It is caused by the heating of the Earth's surface by the Sun, which causes warm, moist air to rise, creating a region of low pressure.
Subtropical High	A high-pressure belt that occurs in the subtropics, roughly between 20° and 35° latitude in both hemispheres. It is caused by the sinking of cool, dry air from higher altitudes, creating a region of high pressure.
Polar High	A high-pressure belt that occurs near the poles, roughly between 60° and 90° latitude in both hemispheres. It is caused by the sinking of very cold, dry air from higher altitudes, creating a region of high pressure.
Subpolar Low	A low-pressure belt that occurs in the subpolar regions, roughly between 50° and 70° latitude in both hemispheres. It is caused by the convergence of cool, dry air from the poles with warm, moist air from the subtropics, creating a region of low pressure.

Planetary Winds

The winds blowing throughout the year from high pressure belts to low pressure belts in the same direction are called "planetary or prevailing winds".

Wind Type	Description
Trade winds	Steady, easterly winds that blow from the subtropical high pressure belts towards the equatorial low pressure belt. They are named "trade winds" because they were historically used by sailors for trade routes. The trade winds are important for weather patterns and ocean currents in the tropics.
Prevailing westerlies	The prevailing winds that blow from west to east in the mid-latitudes between the subtropical high pressure belts and the polar front. These winds are responsible for the movement of weather systems in the mid-latitudes and are also important for air and sea transport.
Polar easterlies	Cold easterly winds that blow from the polar high pressure belts towards the subpolar low pressure belts. These winds are important for shaping weather patterns and moving cold air from the poles towards the mid-latitudes.
Monsoons	Seasonal winds that bring heavy rainfall to certain regions during a particular season. These winds are caused by the difference in temperature between land and sea during different times of the year. The summer monsoon, for example, brings heavy rainfall to South Asia during the summer months.
Sea and land breezes	Local winds that occur near coastlines. During the day, the land heats up more quickly than the sea, creating a region of low pressure over the land and high pressure over the sea. This causes a cool breeze to blow from the sea towards the land. At night, the land cools down more quickly than the sea, reversing the pressure gradient and causing a warm breeze to blow from the land towards the sea.

Local Winds

Local winds are small-scale winds that are influenced by the topography, temperature, and other factors of a specific region. These winds can occur on both land and sea, and they typically have a distinct pattern of circulation that is unique to their location.

Type of Local Wind	Description
Sea Breeze	A cooling wind that blows from the sea towards the land during the day
Land Breeze	A cooling wind that blows from the land towards the sea during the night
Mountain Breeze	A cooling wind that flows downhill from mountains during the night
Valley Breeze	A warming wind that flows uphill from valleys during the day
Katabatic Wind	A cold, dry wind that flows down a slope or glacier
Chinook Wind	A warm, dry wind that blows down the eastern side of the Rocky Mountains
Santa Ana Wind	A warm, dry wind that blows from the deserts of southern California towards the coast
Mistral Wind	A strong, cold wind that blows down the Rhône Valley in France
Sirocco Wind	A warm, dry wind that blows from North Africa towards the Mediterranean Sea
Föhn Wind	A warm, dry wind that blows down the leeward side of mountains in Europe

Air Mass

An air mass is a large body of air with uniform temperature, humidity, and pressure characteristics throughout its horizontal extent. The type of air mass is determined by the region it originates from and the characteristics of the surface over which it moves. Here are the five types of air masses:

- **Maritime Tropical (mT):** Warm and humid air masses that originate over tropical or subtropical oceans. When they move over land, they can cause thunderstorms, heavy rain, and flooding.
- **Maritime Polar (mP):** Cool and humid air masses that originate over the cold oceans of high latitudes. When they move over land, they can cause cool and damp weather.
- **Continental Tropical (cT):** Hot and dry air masses that originate over deserts or dry regions. When they move over land, they can cause hot and dry weather and sometimes thunderstorms.
- **Continental Polar (cP):** Cold and dry air masses that originate over high-latitude land areas. When they move over land, they can cause cold and dry weather, snow, and freezing temperatures.
- **Arctic/Antarctic (A):** Extremely cold and dry air masses that originate over the polar regions. They bring extremely cold temperatures and dry weather, and are often associated with the polar vortex.
- These air masses can interact with each other and with other weather systems to create different weather patterns. For example, when a cold front (a boundary between a cold air mass and a warm air mass) moves through an area, it can bring cooler temperatures, precipitation, and sometimes severe weather.

Fronts

A front is a boundary between two air masses with different temperature, humidity, and pressure characteristics. Fronts can be classified into four types: cold fronts, warm fronts, stationary fronts, and occluded fronts. When a front passes over a region, it can cause changes in the weather, such as temperature fluctuations, precipitation, and wind shifts.

There are four main types of fronts, which are classified based on the temperature and humidity characteristics of the air masses they separate. Here are the four types of fronts:

- **Cold Front:** A cold front occurs when a mass of cold air moves into a region, replacing a mass of warm air. The cold air is denser than the warm air, so it pushes the warm air upward, causing it to cool and condense into clouds. Cold fronts often bring abrupt changes in weather, such as thunderstorms, heavy rain, and colder temperatures.
- **Warm Front:** A warm front occurs when a mass of warm air moves into a region, replacing a mass of cold air. The warm air rises over the colder air, creating a gradual slope. As the warm air rises, it cools and forms clouds, which can cause light precipitation. Warm fronts often bring milder temperatures and can create prolonged periods of precipitation.
- **Stationary Front:** A stationary front occurs when two air masses meet but neither is strong enough to push the other. This can result in a prolonged period of cloudy and wet weather. The temperature and humidity differences between the two air masses are not as significant as in cold or warm fronts.
- **Occluded Front:** An occluded front occurs when a fast-moving cold front catches up to a slow-moving warm front and lifts it off the ground, separating it from the surface. The area where the warm air is lifted is known as an "occluded" area. Occluded fronts can bring a mix of precipitation and cooler temperatures.

Types of Jet Streams

Jet streams are narrow bands of strong winds in the upper levels of the atmosphere, generally located at altitudes between 10 and 15 kilometers (6 to 9 miles). There are two main types of jet streams: the polar jet stream and the subtropical jet stream.

Type of Jet Stream	Location	Characteristics
Polar Jet Stream	Upper troposphere and lower stratosphere at latitudes between 50 and 60 degrees in both hemispheres	Strong, westerly winds that blow from west to east; strongest during winter months and weaker during summer
Subtropical Jet Stream	Lower latitudes than the polar jet stream, typically between 20 and 30 degrees in both hemispheres	Weaker and more diffuse than the polar jet stream; still has a significant impact on weather patterns in the mid-latitudes; strongest during summer months and weaker during winter

Cyclones and Anticyclones

- Cyclones and anticyclones are two types of weather systems that occur in the Earth's atmosphere.
- A cyclone is a low-pressure system in which the air rotates counter clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. Cyclones are often associated with stormy weather, including strong winds, heavy rain, thunderstorms, and sometimes tornadoes. Cyclones are also known as depressions or lows.
- Anticyclones, on the other hand, are high-pressure systems in which the air rotates clockwise in the Northern Hemisphere and counter clockwise in the Southern Hemisphere. Anticyclones are usually associated with calm and stable weather conditions, such as clear skies, light winds, and dry weather. Anticyclones are also known as highs.

Feature	Cyclone	Anticyclone
Pressure	Low	High
Wind direction	Counter-clockwise (Northern Hemisphere), clockwise (Southern Hemisphere)	Clockwise (Northern Hemisphere), counter-clockwise (Southern Hemisphere)
Air movement	Upward	Downward
Weather	Cloudy, rainy or snowy	Clear or partly cloudy
Temperature	Generally cooler	Generally warmer
Air stability	Unstable	Stable
Associated with	Stormy weather	Calm weather

Major World Climate

Climate Type	Description
Tropical Rainforest	Found near the equator with high temperatures and high precipitation throughout the year. These regions are typically covered with dense vegetation and are home to a wide variety of plant and animal species.
Tropical Savannah	Also found near the equator, but with a distinct dry season. Temperatures remain high throughout the year, but precipitation is concentrated in the wet season, with little to no rain in the dry season. Vegetation is characterized by grasslands and scattered trees.
Desert	Found in areas where the air is dry, such as the subtropics and mid-latitudes. Deserts receive very little precipitation, and temperatures can be extreme, with very hot days and very cold nights. Vegetation is sparse, and animals are adapted to the harsh conditions.
Mediterranean	Found in regions bordering the Mediterranean Sea, as well as in parts of California, South Africa, and Australia. These regions have mild, wet winters and hot, dry summers. Vegetation is characterized by shrubs and small trees, and agriculture is an important industry.
Humid Subtropical	Found in regions with hot, humid summers and mild winters, such as the southeastern United States, eastern China, and parts of Japan. Precipitation is relatively evenly distributed throughout the year, and vegetation is characterized by deciduous trees and shrubs.
Marine West Coast	Found in regions with mild, wet winters and cool, cloudy summers, such as the Pacific Northwest of the United States and Canada, as well as parts of Europe and South America. Vegetation is characterized by evergreen trees, and the fishing industry is often an important part of the local economy.
Temperate Continental	Found in regions with hot summers and cold winters, such as the Great Plains of the United States and Canada, as well as parts of Europe and Asia. Precipitation is relatively evenly distributed throughout the year, and vegetation is characterized by grasslands and deciduous trees.
Subarctic	Found in regions with very cold winters and short, cool summers, such as northern Canada and Alaska, as well as parts of Russia and Scandinavia. Vegetation is characterized by coniferous forests, and the region is important for mining and forestry.
Tundra	Found in regions with very cold winters and short summers, such as northern Canada, Alaska, and Siberia. Precipitation is low, and the ground is frozen for much of the year. Vegetation is limited to low-growing plants and shrubs, and the region is home to many species of Arctic animals.
Ice Cap	Found in Antarctica and Greenland, where the entire region is covered in ice and snow. Precipitation is extremely low, and temperatures are consistently well below freezing. The region is home to only a few species of extremophile organisms.

Unit-4: Oceanography

- The oceans cover approximately 70% of the Earth's surface, which is equivalent to about 140 million square miles.
- Oceanography is the scientific study of the oceans and their phenomena, including the physical, chemical, geological, and biological aspects of the ocean.
- It is a multidisciplinary field that combines aspects of physics, chemistry, geology, and biology to understand the complex interactions between the ocean and the Earth's atmosphere, land, and ecosystems.

Different Types of Relief Features Found in The Ocean

Relief Feature	Description
Continental Shelf	A gently sloping, shallow area of ocean floor that extends from the edge of a continent out to the continental slope
Continental Slope	A steeply sloping transition zone between the continental shelf and the deep ocean floor
Abyssal Plain	A flat, featureless area of the deep ocean floor that lies between the continental rise and mid-ocean ridges
Mid-Ocean Ridge	A long chain of underwater mountains that runs through the middle of the world's oceans, marking the boundaries between tectonic plates
Trench	A narrow, steep-sided depression in the ocean floor formed where one tectonic plate is being forced beneath another
Seamount	A large, underwater mountain rising from the ocean floor that does not reach the surface
Guyot	A seamount with a flat, submerged top that was once an island but has since sunk beneath the ocean's surface
Continental Rise	A gently sloping transition zone between the continental slope and the abyssal plain

Salinity

- Salinity refers to the degree of saltiness in water, and in seawater, NaCl (common salt) makes up about 77% of the dissolved mineral matter. Other salts such as magnesium, calcium, and potassium are also present in varying amounts.
- Despite the free movement of water in the oceans, the concentration of salts remains relatively constant throughout the world's oceans and even at great depths, although the degree of concentration can vary depending on location and other factors.
- The average salinity of seawater is around 35 parts per thousand (ppt), or 35 grams of dissolved salts per kilogram of seawater. However, salinity can vary widely in different bodies of water. For example, the Baltic Sea has a low salinity of around 7 ppt due to the influx of freshwater, while the Red Sea has a high salinity of around 39 ppt due to high levels of evaporation and few rivers draining into it.
- Other bodies of water, such as the Caspian Sea, Dead Sea, and Lake Van, have even higher salinities due to their unique geographic and climatic conditions. In fact, Lake Van has the highest salinity of any major lake in the world, with a salinity of around 330 ppt. The high density of salt in these bodies of water makes it easier to float, which is why beginner swimmers often find it easier to swim in them.

Factors Affecting the Salinity of Oceans

Factor	Description
Evaporation	As water evaporates from the ocean surface, it leaves behind dissolved salts, increasing the salinity of the remaining water
Precipitation	Rainfall and other forms of precipitation can introduce freshwater into the ocean, reducing salinity
Runoff	Rivers, streams, and other sources of freshwater can carry dissolved salts into the ocean, impacting the local salinity
Sea ice formation and melting	When sea ice forms, it leaves behind dissolved salts, increasing the salinity of the surrounding water. Conversely, when sea ice melts, it introduces freshwater into the ocean, reducing salinity
Ocean currents	Currents can transport water with different salinities to different areas of the ocean, creating regions of higher or lower salinity
Temperature	Changes in ocean temperature can impact the solubility of salts in seawater, affecting salinity
Biological processes	Activities such as photosynthesis, respiration, and decomposition by marine organisms can impact the concentration of dissolved salts in seawater
Anthropogenic activities	Human activities such as desalination, pollution, and the discharge of wastewater can introduce or remove salts from the ocean, impacting salinity

Ocean Currents

Ocean currents are continuous, directed movements of ocean water that play an important role in regulating Earth's climate and transporting heat, nutrients, and organisms around the world.

Current Type	Description
Surface Currents	Driven by winds, surface currents are the horizontal movements of water that occur in the uppermost layer of the ocean (typically the top 400 meters). They are influenced by the Coriolis effect and the distribution of continents, and can have a significant impact on climate and weather patterns. Examples include the Gulf Stream, the Kuroshio Current, and the East Australian Current.
Deep Currents	Also known as thermohaline currents, deep currents are driven by differences in water density caused by variations in temperature and salinity. They move slowly and can take centuries to complete a full circuit of the global ocean. They play a critical role in distributing heat and regulating Earth's climate. Examples include the North Atlantic Deep Water and the Antarctic Bottom Water.
Coastal Currents	Coastal currents are driven by a variety of factors, including wind, tides, and the shape of the coastline. They are typically influenced by both surface and deep currents and can have a significant impact on coastal ecosystems and the distribution of marine species. Examples include the California Current and the Benguela Current.
Equatorial Currents	Equatorial currents are surface currents that flow along the equator, driven by the trade winds. They are relatively weak and slow-moving compared to other surface currents, but they play an important role in redistributing heat and maintaining the ocean's temperature balance. Examples include the North Equatorial Current and the South Equatorial Current.

Major Ocean Currents of the World

Current Name	Location	Direction	Temperature	Description
Gulf Stream	Western Atlantic	North	Warm	This current originates in the Gulf of Mexico and flows northward along the east coast of the United States before turning eastward towards Europe. It has a significant impact on the climate of the eastern United States and western Europe.
Kuroshio Current	Western Pacific	North	Warm	This current flows northward along the east coast of Taiwan and Japan before turning eastward towards the Aleutian Islands. It is a major driver of the climate and marine ecosystems in the region.
Antarctic Circumpolar Current	Southern Ocean	East	Cold	This current circles the continent of Antarctica in a clockwise direction and is the largest ocean current in the world by volume. It helps to distribute heat and nutrients throughout the global ocean system.
North Equatorial Current	Pacific Ocean	West	Warm	This current flows westward along the equator in the Pacific Ocean and is a major driver of the climate and marine ecosystems in the region.
Benguela Current	South Atlantic	North	Cold	This current flows northward along the west coast of southern Africa and is known for its strong upwelling, which brings cold, nutrient-rich water to the surface. This makes it an important region for fishing.
Brazil Current	South Atlantic	South	Warm	This current flows southward along the east coast of South America and is known for its warm, tropical waters. It has a significant impact on the climate and marine ecosystems in the region.

Some More Major Ocean Currents of the World

Current Name	Location	Direction	Temperature	Description
North Atlantic Drift	North Atlantic	East	Warm	This current is an extension of the Gulf Stream and flows northeastward towards western Europe, where it helps to moderate the climate and support marine ecosystems.
South Equatorial Current	Pacific Ocean	East	Warm	This current flows eastward along the equator in the Pacific Ocean and is an important driver of the climate and marine ecosystems in the region.

Canary Current	Eastern Atlantic	South	Cold	This current flows southward along the west coast of Africa and is known for its upwelling of cold, nutrient-rich water that supports a productive fishing industry.
Agulhas Current	Indian Ocean	South	Warm	This current flows southward along the east coast of Africa and is known for its warm, tropical waters. It is an important region for marine biodiversity and supports a range of fish and other species.
California Current	Eastern Pacific	South	Cold	This current flows southward along the west coast of North America and is known for its cold, nutrient-rich waters that support a range of marine life. It also has a significant impact on the climate of the region.
Peru Current	Eastern Pacific	North	Cold	This current flows northward along the west coast of South America and is known for its upwelling of cold, nutrient-rich water that supports a productive fishing industry.

Ocean Tides

Term	Definition
Tides	The rise and fall of sea levels caused by the gravitational forces of the moon and sun
High tide	The point in the tidal cycle when sea level is at its highest
Low tide	The point in the tidal cycle when sea level is at its lowest
Spring tide	A tide with the greatest difference between high and low tide, occurring during the new and full moons when the gravitational forces of the moon and sun are aligned
Neap tide	A tide with the least difference between high and low tide, occurring during the first and third quarters of the moon when the gravitational forces of the moon and sun are perpendicular
Semi-diurnal tide	A tide with two high tides and two low tides each day, with roughly equal heights
Diurnal tide	A tide with one high tide and one low tide each day, with a large difference in height between them
Mixed tide	A tide with two high tides and two low tides each day, but with unequal heights and durations due to local geography and weather

Ocean Resources

There are many types of ocean resources that can be utilized by humans for various purposes. Here are some of the major types:

- **Fisheries:** The oceans are home to a diverse range of fish and other marine life that can be harvested for food, bait, and other purposes. Fisheries can be managed sustainably to ensure that fish populations remain healthy and productive.
- **Minerals:** The ocean floor contains a wealth of minerals such as manganese nodules, polymetallic sulfides, and cobalt-rich crusts. These minerals can be extracted using underwater mining technology.
- **Oil and gas:** The ocean floor also contains vast reserves of oil and natural gas, which can be extracted using offshore drilling platforms.
- **Renewable energy:** The ocean has the potential to provide significant amounts of renewable energy through sources such as tidal power, wave energy, and offshore wind power.
- **Desalination:** With increasing global demand for freshwater, desalination technology can be used to convert seawater into freshwater for agricultural, industrial, and domestic use.
- **Pharmaceuticals:** Many marine organisms contain compounds with potential pharmaceutical applications, such as anticancer and antibacterial agents.
- **Tourism:** The ocean provides opportunities for tourism such as beach activities, water sports, and whale watching.
- **Transportation:** The ocean is a major transportation route for goods and people, with shipping being a key component of global trade.

Unit-5: Indian Geography

India has a total geographical area of 3.3 million square kilometres, making it the seventh-largest country in the world. The country is located in South Asia and is bordered by several neighbouring countries. Here is the extent of India's borders:

- **Pakistan:** India shares a 3,323-kilometer-long border with Pakistan, which runs along the western side of the country.
- **China:** India shares a 3,488-kilometer-long border with China, which runs along the northeastern side of the country.
- **Nepal:** India shares a 1,751-kilometer-long border with Nepal, which runs along the northern side of the country.
- **Bhutan:** India shares a 699-kilometer-long border with Bhutan, which runs along the northeastern side of the country.
- **Bangladesh:** India shares a 4,096-kilometer-long border with Bangladesh, which runs along the eastern side of the country.
- **Myanmar:** India shares a 1,643-kilometer-long border with Myanmar, which runs along the northeastern side of the country.
- **Sri Lanka:** India is separated from Sri Lanka by the Palk Strait, which is about 50 kilometers wide.
- India's vast geographical extent has a significant impact on its climate, culture, and economy, and it is home to a diverse range of languages, religions, and ethnic groups.

Important Boundary Lines Between Countries

Boundary Line	Countries
Radcliffe Line	India and Pakistan
McMahon Line	India and China
Durand Line	Pakistan and Afghanistan

Geological Divisions of India as per the Physical Features

Geological Division	Physical Features
The Peninsular Block	Plateau surrounded by Eastern and Western Ghats mountain ranges, rivers like Godavari, Krishna, Cauvery, Mahanadi, and Pennar. Rich in mineral resources like iron, bauxite, manganese, and gold.
The Himalayas and other Peninsular Mountains	Youngest and highest mountain ranges in the world, including the Himalayas, Karakoram, and the Eastern and Western Ghats. Rich in mineral resources like coal, oil, and gas.
Indo-Ganga-Brahmaputra Plain	Fertile alluvial soil deposited by rivers like Ganges, Brahmaputra, and Indus. One of the most densely populated regions in the world, known for its agricultural productivity.

Physiography of India

The physiography of an area is shaped by a combination of factors such as its geological structure, tectonic processes, climatic conditions, and the stage of its development over time.

Six Physiographic Divisions of India

Physiographic Division	Description
The Northern and North-eastern Mountains	This division includes the Himalayan mountain range, the highest mountain range in the world, as well as other mountain ranges like the Karakoram and the Purvanchal range. The region is characterized by high altitude peaks, deep valleys, glaciers, and rivers like the Ganges, Brahmaputra, and Indus. It is rich in natural resources like water, forests, and minerals like coal, oil, and gas.
The Northern Plain	This division is located to the south of the Himalayan mountain range and is formed by the alluvial deposits brought down by the rivers like the Ganges, Brahmaputra, and Indus. The plain is characterized by fertile soil, flat topography, and an extensive network of rivers and canals. It is one of the most densely populated regions in the world and is known for its agricultural productivity.
The Peninsular Plateau	This division is located in the southern part of India and is characterized by a plateau that is surrounded by the Eastern and Western Ghats mountain ranges. The region has a rich mineral wealth including iron, bauxite, and manganese. It is also known for its extensive forests, rivers like Godavari, Krishna, Cauvery, Mahanadi, and Pennar, and the Deccan Plateau.
The Indian Desert	This division is located in the northwestern part of India and is characterized by the Thar Desert, which is one of the largest deserts in the world. The region is sparsely populated and has a harsh climate. It is known for its sand dunes, salt lakes, and unique flora and fauna.
The Coastal Plains	This division is located on the eastern and western coasts of India and is characterized by fertile plains that are formed by the deposition of sediments by rivers. The region is known for its biodiversity and is home to many important ports. The Eastern Coastal Plain stretches from Tamil Nadu to West Bengal, while the Western Coastal Plain runs along the Arabian Sea from Gujarat to Kerala.
The Islands	This division includes the Andaman and Nicobar Islands, which are located in the Bay of Bengal, and the Lakshadweep Islands, which are located in the Arabian Sea. The islands have a unique biodiversity and are known for their natural beauty. They are also strategically important for defense and security purposes.

Drainage System

- Drainage refers to the flow of water through well-defined channels, and the network of such channels is known as a drainage system. This system may comprise perennial streams that flow throughout the year, or ephemeral streams that only contain water during the rainy season and dry up otherwise.
- A river typically drains the water collected from a specific area, which is known as its catchment area or watershed. The catchment area may be a small region, such as a valley or a few hills, or a large area that includes multiple states or even countries.
- The entire area drained by a river and its tributaries is referred to as a drainage basin, which is also known as a river basin, catchment basin, or watershed. Drainage basins are characterized by their distinct boundaries, which are often defined by natural features such as ridges or mountains.
- The boundary line that separates one drainage basin from another is called the watershed. The catchment areas of large rivers are often referred to as river

basins, while those of smaller rivulets and rills are called watersheds.

- There are several different types of drainage patterns, including dendritic, radial, trellis, and centripetal. A dendritic pattern resembles the branches of a tree, with the main river channel and its tributaries forming a network that spreads out across the landscape. The rivers of the northern plains of India, for example, exhibit a dendritic pattern.
- In a radial pattern, the rivers originate from a hill or mountain and flow in all directions, like the spokes of a wheel. The Amarkantak range in India is an example of an area with a radial drainage pattern.
- A trellis pattern occurs when the primary tributaries of a river flow parallel to each other and are joined by secondary tributaries at right angles. This pattern is common in areas with alternating bands of hard and soft rock layers.
- In a centripetal pattern, the rivers discharge their waters from all directions into a lake or depression in the center of a circular or elliptical basin. The drainage system of the Great Lakes region of North America is an example of a centripetal pattern.

Type of Drainage Pattern	Characteristics
Dendritic	Resembles the branches of a tree, with the main river channel and its tributaries forming a network that spreads out across the landscape. Common in areas with uniform geology and topography.
Radial	Rivers originate from a hill or mountain and flow in all directions, like the spokes of a wheel. Common in areas with a central peak or dome-shaped landform.
Trellis	Primary tributaries of a river flow parallel to each other and are joined by secondary tributaries at right angles. Common in areas with alternating bands of hard and soft rock layers.
Centripetal	Rivers discharge their waters from all directions into a lake or depression in the center of a circular or elliptical basin. Common in areas with a central basin or low-lying area.
Rectangular	Characterized by a right-angled pattern formed by streams that flow in parallel lines and then join at right angles. Found in regions where the streams follow fractures or faults in the rock.
Parallel	Composed of two or more parallel main streams, with minor streams flowing at right angles into them. Found in regions where the streams are forced to flow parallel to the slope due to a resistant rock formation.
Annular	Consists of a series of concentric rings of streams that follow a circular or elliptical path around a central highland. Common in areas with a resistant core of rock surrounded by softer rock layers.

Types of Drainage Systems in India

Type of Drainage System	Description
Himalayan Drainage System	The Himalayan drainage system is also known as the perennial drainage system as it has water throughout the year due to the melting of snow and glaciers. The rivers of this system originate from the Himalayas and flow through narrow and deep valleys. The Himalayan drainage system is further classified into the Indus, Ganga, and Brahmaputra river systems. The Indus river system flows through the states of Jammu and Kashmir, Himachal Pradesh, Punjab, and Sindh. The Ganga river system flows through the states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal. The Brahmaputra river system flows through the northeastern states of Arunachal Pradesh, Assam, and Meghalaya before entering Bangladesh.
Peninsular Drainage System	The Peninsular drainage system is also known as the non-perennial drainage system as the rivers of this system are dependent on rainfall and hence are seasonal. The Peninsular drainage system is further classified into the East Coast, West Coast, and the Central Highlands river systems. The East Coast river system includes the rivers that originate in the Eastern Ghats and flow towards the Bay of Bengal. The West Coast river system includes the rivers that originate in the Western Ghats and flow towards the Arabian Sea. The Central Highlands river system includes the rivers that originate in the central part of the peninsula and flow towards the Bay of Bengal.
Coastal Drainage System	The Coastal drainage system consists of small rivers and streams that flow from the western slopes of the Western Ghats and the eastern slopes of the Eastern Ghats towards the Arabian Sea and the Bay of Bengal, respectively. These rivers are small and have limited catchment areas. The Coastal drainage system is further classified into the Konkan Coast and the Malabar Coast river systems. The Konkan Coast river system includes the rivers that flow into the Arabian Sea between the Daman and Goa rivers. The Malabar Coast river system includes the rivers that flow into the Arabian Sea south of the Goa river.

Inland Drainage System	The Inland drainage system consists of rivers that originate in the desert regions of Rajasthan and Gujarat and flow towards salt lakes or disappear in the sand. The Luni river is the only significant river of this system, which flows towards the Rann of Kutch.

Type of Drainage System	Description
Trans-Himalayan Drainage System	The Trans-Himalayan drainage system comprises rivers that originate from the northern slopes of the Himalayas and flow towards Tibet, China. The Indus river is the major river of this system and is one of the longest rivers in Asia, flowing through India, Pakistan, and China.
Rift Valley Drainage System	The Rift Valley drainage system consists of rivers that originate in the Aravalli Range and flow towards the Great Rann of Kutch and the Gulf of Khambhat. The Sabarmati, Mahi, and Luni rivers are the major rivers of this system.
Subterranean Drainage System	The Subterranean drainage system comprises rivers that flow underground due to the presence of porous rocks, such as limestone and sandstone. The Chambal and Betwa rivers are the major rivers of this system.
Glacier Drainage System	The Glacier drainage system consists of rivers that originate from the melting of glaciers in the Himalayas and flow towards the plains. The Bhagirathi and Alaknanda rivers are the major rivers of this system and meet at Devprayag to form the Ganga river.
Estuarine Drainage System	The Estuarine drainage system consists of rivers that flow into estuaries, where the river meets the sea. The Hooghly river is the major river of this system, which flows into the Bay of Bengal.

River System	Length	Source	Drainage Area	Major Tributaries	Importance
Ganges	2,525 km	Gangotri Glacier in Uttarakhand	1,080,000 sq km	Yamuna, Ghaghara, Gandak, Kosi	Sacred river, major source of irrigation, important for transportation
Brahmaputra	2,900 km	Angsi Glacier in Tibet	651,000 sq km (in India)	Subansiri, Kameng, Manas	Important for irrigation and transportation, potential for hydroelectric power generation
Indus	3,180 km	Tibetan Plateau	1,165,000 sq km (in India)	Jhelum, Chenab, Ravi, Beas, Sutlej	Important for irrigation and hydropower generation
Godavari	1,465 km	Nasik in Maharashtra	312,812 sq km	Pranhita, Indravati, Sabari, Manjira	Major source of irrigation, potential for hydropower generation
Krishna	1,400 km	Mahabaleshwar in Maharashtra	258,948 sq km	Tungabhadra, Bhima, Musi	Major source of irrigation, potential for hydropower generation
Narmada	1,312 km	Amarkantak in Madhya Pradesh	98,796 sq km	Tawa, Betwa, Banjar, Dudhi	Potential for hydropower generation, important for irrigation
Tapi	724 km	Multai in Madhya Pradesh	65,145 sq km	Girna, Purna, Panzara	Important for irrigation and hydropower generation

Climate of India

India has a diverse climate, ranging from tropical in the south to temperate and alpine in the Himalayan north. The climate of India is primarily influenced by the Himalayas and the Thar Desert.

The climate in India is divided into four main seasons:

- **Winter (December-February):** Winter is mostly dry and cool in most parts of India, except for the Himalayas and some parts of the Northeast, which receive heavy snowfall.
- **Summer (March-June):** Summer in India is hot and humid, with temperatures ranging from 32°C to 45°C. The hottest months are May and June, and this period is known as the pre-monsoon season.
- **Monsoon (July-September):** The monsoon season brings heavy rainfall to most parts of India, which helps to nourish crops and replenish water resources.
- **Post-Monsoon (October-November):** This season is characterized by clear skies and lower humidity levels, making it an ideal time for travel and outdoor activities.
- Overall, India experiences a tropical monsoon climate, with high temperatures and abundant rainfall in most regions. The country also experiences

a significant variation in temperature and rainfall across different regions, which is influenced by factors such as elevation, proximity to the sea, and topography.

Factors Determining the Climate of India

Factor	Explanation
Latitude	India is located in the tropical and subtropical regions, which influence its climate and weather patterns. The Tropic of Cancer passes through the middle of India, dividing the country into the northern and southern hemispheres.
Altitude	The Himalayan mountain range influences the climate of India by blocking cold winds from Central Asia, resulting in a colder, alpine climate in the northern regions. Higher altitude areas generally have cooler temperatures than low-lying areas.
Distance from the sea	Coastal areas experience more moderate temperatures than inland areas due to the moderating influence of the sea. The western coast receives more rainfall than the eastern coast due to the direction of the monsoon winds.
Monsoon winds	The monsoon winds, which blow from the southwest in summer and from the northeast in winter, are a major factor influencing India's climate. They bring rainfall to most parts of the country, replenishing water resources and supporting agriculture.
Topography	The varied topography of India, including mountains, plateaus, plains, and deserts, influences the climate and weather patterns in different regions. For example, the Thar Desert in Rajasthan experiences hot and dry weather due to its low elevation and proximity to the Arabian Sea.
Ocean currents	The warm Indian Ocean current influences the monsoon season by increasing the amount of moisture in the air, leading to more rainfall in coastal areas. The cold currents from the Arctic and Antarctica also influence the temperature and weather patterns in different regions of India.

Major Climate Types in India

Climate Type	Location	Characteristics
Tropical Wet	Western Ghats, Northeast India	High temperatures throughout the year, with heavy rainfall (more than 200 cm annually) during the monsoon season; humid and tropical climate
Tropical Dry	North and Central India, Deccan Plateau	Hot and dry climate, with low rainfall (less than 100 cm annually); large temperature variation between day and night
Subtropical Humid	Northern Plains, Punjab, Haryana, Delhi	Hot summers with temperatures ranging from 35°C to 45°C; cold winters with foggy conditions; moderate rainfall during monsoon season
Subtropical Dry	Western Rajasthan, Gujarat	Hot and dry climate, with low rainfall (less than 50 cm annually); large temperature variation between day and night
Alpine	Himalayan Region	Cold, alpine climate with heavy snowfall in winters; moderate summers with occasional rainfalls
Highland	Western and Eastern Ghats, Northeast India	Moderate to high rainfall, with cooler temperatures at higher elevations; humid and tropical climate

Major Climatic Zones of India

Climatic Zone	Location	Characteristics
Himalayan Region	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh	Cold, alpine climate with heavy snowfall in winters; moderate summers with occasional rainfalls
Northern Plains	Punjab, Haryana, Delhi, Uttar Pradesh, Bihar	Hot summers with temperatures ranging from 35°C to 45°C; cold winters with foggy conditions; moderate rainfall during monsoon season
Thar Desert	Rajasthan, Gujarat	Hot and dry with low rainfall; large temperature variation between day and night
Western Ghats	Maharashtra, Karnataka, Tamil Nadu, Kerala	High rainfall; humid and tropical climate; moderate temperatures throughout the year
Eastern Ghats	Odisha, Andhra Pradesh, Tamil Nadu	Hot and humid climate with moderate rainfall; cooler temperatures at higher elevations

Coastal Plains	West Coast (Konkan, Malabar) and East Coast (Coromandel)	Tropical climate with high humidity; heavy rainfall during monsoon season; moderate temperatures throughout the year
Deccan Plateau	Central India	Semi-arid with hot summers and moderate winters; moderate rainfall during monsoon season
Northeast Region	Seven Sister States, West Bengal	Humid subtropical and alpine climate; heavy rainfall throughout the year; cooler temperatures at higher elevations

RAINFALL IN INDIA

In India, rainfall can be broadly classified into four types:

- **Southwest Monsoon rainfall:** This is the primary rainfall season in India, and it accounts for about 75% of the total rainfall. It occurs from June to September and is caused by the southwest monsoon winds.
- **Northeast Monsoon rainfall:** This occurs in the winter months, mainly from October to December. It affects the southern and southeastern parts of India and is caused by the northeast monsoon winds.
- **Pre-monsoon rainfall:** This occurs in the months of March to May, just before the onset of the southwest monsoon. It is caused by local atmospheric conditions and thunderstorms.
- **Winter rainfall:** This occurs in the northern parts of India during the winter months, mainly from December to February. It is caused by the western disturbances, which are low-pressure systems that originate over the Mediterranean Sea and move towards India.
- The amount and distribution of rainfall in India vary widely, with some regions receiving heavy rainfall and others receiving very little. The variability in rainfall patterns has a significant impact on India's agriculture, economy, and environment.

Rainfall Category	Description	Region
Heavy rainfall	Areas that receive more than 200 cm (80 in) of rainfall annually	Western Ghats, northeastern states, eastern Himalayas, and parts of the coastal regions
Moderate rainfall	Areas that receive between 100 cm (40 in) to 200 cm (80 in) of rainfall annually	Most of the Indo-Gangetic plain, central India, and parts of the Deccan Plateau
Low rainfall	Areas that receive less than 100 cm (40 in) of rainfall annually	Western and northwestern India, Rajasthan, parts of Gujarat, Punjab, Haryana, and the Deccan Plateau
Inadequate rainfall	Areas that receive very little or no rainfall annually, leading to water scarcity and droughts	Some parts of western and northwestern India, especially the arid and semi-arid regions

Major Vegetation Cover of India

Vegetation Type	Description	Region
Tropical Rainforest	Dense forests with high annual rainfall and a variety of tree species, including teak, sal, and bamboo	Western Ghats, northeastern states, Andaman and Nicobar Islands
Deciduous Forest	Forests that shed leaves seasonally, with a mix of evergreen and deciduous trees, including sal, teak, and bamboo	Central and eastern India, including parts of the Deccan Plateau
Thorny Scrub	Arid and semi-arid regions with low rainfall and thorny bushes and shrubs, including acacia and cactus	Western and northwestern India, including Rajasthan and parts of Gujarat
Alpine	High-altitude regions with low annual rainfall and sparse vegetation, including grasses, shrubs, and dwarf trees	Himalayan region, including Ladakh and parts of Sikkim
Mangrove Forests	Coastal forests that grow in brackish water with a mix of trees, shrubs, and mangrove species, including Sundari, Rhizophora, and Avicennia	Coastal regions of India, including the Sundarbans in West Bengal

According to the India State of Forest Report 2021, the total forest and tree cover of India is 24.56% of the total geographical area of the country. The report provides the following details on forest cover in India:

Type of Forest Cover	Area in square kilometers	Percentage of total geographical area
Very dense forest	96,135	2.92%
Moderately dense forest	309,982	9.42%
Open forest	214,965	6.54%
Total Forest Cover	621,082	18.88%
Tree cover outside forest	95,027	2.89%
Total Forest and Tree Cover	716,109	21.77%