PERSONAL COPY
NOT FOR SALE OR CIRCULATION

VAJIRAM & RAVI

GENERAL STUDIES

INDIAN GEOGRAPHY

2019

VAJIRAM & RAVI
(INSTITUTE FOR IAS EXAMINATION)
(A unit of Vajiram & Ravi IAS Study Centre LLP)

9-B, Bada Bazar Marg, OLD RAJINDER NAGAR,
NEW DELHI-110060 • Ph.: 25820000, 25734058
Visit us at : www. vajiramandravi.com

Geography Index

GEOGRAPHY

Background : Eratosthenes, a 3rd century B.C. chief librarian at the famous Library of Alexandria, is credited as the first person to use the word "geography." While the word geography is derived from Greek and literally means "to write about the earth". Geography is an all-encompassing discipline that seeks to understand the world - its human and physical features - through an understanding of place and location. Being able to view the world geographically is a fundamental skill for everyone. Understanding the connection between the environment and people, geography ties together diverse sciences as geology, biology, and climatology with economics, history, and politics based on location. Geographers understand conflict around the world because so many factors are involved. The Greek scholar Eratosthenes, who measured the circumference of the earth and was the first to use the word "geography," is commonly called the father of geography.

Branches of Geography : 1. Physical geography : Physical geography aims to understand the physical lithosphere, hydrosphere, atmosphere, pedosphere, and global flora and fauna patterns (biosphere). 2. **Human geography :** Human geography is a branch of geography that focuses on the study of patterns and processes that shape human interaction with various environments. It encompasses human, political, cultural, social, and economic aspects. Environmental geography is the branch of geography that describes the spatial aspects of interactions between humans and the natural world. 3. **Geomatics :** Geomatics is a branch of geography that has emerged since the quantitative revolution in geography in the mid 1950s. Geomatics involves the use of traditional spatial techniques used in cartography and topography and their application to computers. Geomatics has become a widespread field with many other disciplines using techniques such as GIS and remote sensing. Geomatics has also led to a revitalization of some geography departments especially in Northern America where the subject had a declining status during the 1950s. Geomatics encompasses a large area of fields involved with spatial analysis, such as Cartography, Geographic information systems (GIS), Remote sensing, and Global positioning systems (GPS). 4. **Regional geography :** Regional geography is a branch of geography that studies the regions of all sizes across the Earth. The main aim is to understand or define the uniqueness or character of a particular region which consists of natural as well as human elements. 5. **Geographic information systems :** Geographic information systems (GIS) deal with the storage of information about the Earth for automatic retrieval by a computer, in an accurate manner appropriate to the information's purpose. In addition to all of the other subdisciplines of geography, GIS specialists must understand computer science and database systems. GIS has revolutionized the field of cartography; nearly all mapmaking is now done with the assistance of some form of GIS software. GIS also refers to the science of using GIS software and GIS techniques to represent, analyze and predict spatial relationships. In this context, GIS stands for Geographic Information

Science. 6. **Remote sensing :** Remote sensing can be defined as the art and science of obtaining information about Earth features from measurements made at a distance. Remotely sensed data comes in many forms such as satellite imagery, aerial photography and data obtained from hand-held sensors. Geographers increasingly use remotely sensed data to obtain information about the Earth's land surface, ocean and atmosphere because it: a) supplies objective information at a variety of spatial scales (local to global), b) provides a synoptic view of the area of interest, c) allows access to distant and/or inaccessible sites, d) provides spectral information outside the visible portion of the electromagnetic spectrum, and e) facilitates studies of how features/areas change over time. Remotely sensed data may be analyzed either independently of, or in conjunction with, other digital data layers (e.g., in a Geographic Information System).

PHYSICAL GEOGRAPHY

ORIGIN OF THE EARTH

The earth is believed to have been formed from a small part of the sun. Most of the theories concerned with the origin of the earth emphasise that the planet originated as a hot gaseous mass which on cooling, turned, first into a liquid and then into a solid. One of the earliest theories was put forth by Kant, which is popularly known as the **gaseous hypothesis**. A more popular theory was advanced by *Laplace* which is called the **nebular hypothesis**. This theory considers earth as having been formed through the solidification of a ring thrown away by a cooling and rotating nebula (sun). This ring was one of the nine such rings which formed various planets. A more plausible theory put forth by Jeans and Jeffreys assumed the presence of two nebulae instead of one as assumed by Laplace. The theory advanced by Jeans and Jeffreys is called the **tidal hypothesis** and it belongs to the group of the **binary star theories** (the theories explaining the origin of the earth and the other planets on the basis of the presence of two nebulae). According to this theory a large nebula wandering in the space came very close to another smaller nebula (sun) and its gravitational pull caused a huge tidal upsurge of matter on the surface of the smaller nebula. As the larger nebula moved away from the smaller one, the matter rising as a tidal wave from the surface of the smaller nebula was pulled towards it and was drawn to a distance from which it could not come back to the parent body. However, it could not follow the larger nebula also and as the larger nebula moved away, the rising tongue of matter was detached from the smaller nebula. On cooling, this matter condensed to form the planets, including the earth, and they started revolving around the sun. This hypothesis is considered to be highly probable and close to reality. The cigar-shaped arrangement of the planets going away from the sun, with the smallest planets located closest and farthest from the sun and the larger ones occupying intermediate positions, strengthens this view.

MODERN THEORIES : However, scientists in later period took up the problems of origin of universe rather than that of just the earth or the planets. The most popular argument regarding the origin of the universe is the **Big Bang Theory**. It is also called **expanding universe** hypothesis

The Big Bang Theory

The Big Bang Theory consider the following stages in the development of the Universe:

■ All matter forming the universe existed in one place in the form of a tiny ball (singular atom). ➔ At the Big Bang, the tiny ball exploded violently. This led to a huge expansion, which continues even today. Within the first three minutes from the Big Bang event, the first atom began to form. ➔ Within 300,000 years from the Big Bang the temperature dropped to 4500 K and gave rise to atomic matter. The Universe became transparent.

With greater evidence becoming available about the expanding Universe, the scientific community at present favours the expanding Universe hypothesis.

Solar System

The **Solar System** consists of the ***Sun and those celestial objects*** bound to it by gravity. These objects are the eight planets, their 166 known moons, five dwarf planets, and billions of small bodies. The small bodies include asteroids, icy Kuiper belt objects, comets, meteoroids, and interplanetary dust. The charted regions of the Solar System are the Sun, four terrestrial inner planets, the asteroid belt, four gas giant outer planets, the Kuiper belt, the scattered disc, and the hypothetical Oort cloud. As of mid-2008, five smaller objects are classified as dwarf planets. Ceres is in the asteroid belt, and four orbit the Sun beyond Neptune: Pluto (formerly classified as the ninth planet), Haumea, Makemake, and Eris.

Discovery and exploration : For many thousands of years, humanity, with a few notable exceptions, did not recognise the existence of the Solar System. They believed the Earth to be stationary at the centre of the universe and categorically different from the divine or ethereal objects that moved through the sky. Although the Indian mathematician-astronomer Aryabhata and the Greek philosopher Aristarchus of Samos had speculated on a heliocentric reordering of the cosmos, Nicolaus Copernicus was the first to develop a mathematically predictive heliocentric system.

Structure : The relative masses of the Solar planets. Jupiter at 71% of the total and Saturn at 21% dominate the system. Mercury and Mars, which together are less than 0.1%, are not visible at this scale. The principal component of the Solar System is the Sun, a main sequence G2 star that contains 99.86 percent of the system's known mass and dominates it gravitationally. Jupiter and Saturn, the Sun's two largest orbiting bodies, account for more than 90 percent of the system's remaining mass. Most large objects in orbit around the Sun lie near the plane of Earth's orbit, known as the ecliptic. The planets are very close to the ecliptic while comets and Kuiper belt objects are usually at significantly greater angles to it. All of the planets and most other objects also orbit with the Sun's rotation (counter-clockwise, as viewed from above the Sun's north pole). There are exceptions, such as Halley's Comet.

Kepler's laws of planetary motion describe the orbits of objects about the Sun. According to Kepler's laws, each object travels along an ellipse with the Sun at one focus. Objects closer to the Sun (with smaller semi-major axes) have shorter years. On an elliptical orbit, a body's distance from the Sun varies over the course of its year. A body's closest approach to the Sun is called its ***perihelion***, while its most distant point from the Sun is called its ***aphelion***. Each body moves fastest at its perihelion and slowest at its aphelion. The orbits of the planets are nearly circular, but many comets, asteroids and Kuiper belt objects follow highly elliptical orbits.

To cope with the vast distances involved, many representations of the Solar System show orbits the same distance apart. In reality, with a few exceptions, the farther a planet or belt is from the Sun, the larger the distance between it and the previous orbit. For example, Venus is approximately 0.33 astronomical units (AU) farther out than Mercury, while Saturn is 4.3 AU out from Jupiter, and Neptune lies 10.5 AU out from Uranus. Informally, the Solar System is sometimes divided into separate regions. The inner Solar System includes the four terrestrial planets and the main asteroid belt. The outer Solar System is beyond the asteroids, including the four gas giant planets. Since the discovery of the Kuiper belt, the outermost parts of the Solar System are considered a distinct region consisting of the objects beyond Neptune. A planet is any body in orbit around the Sun that has enough mass to form itself into a spherical shape and has cleared its immediate neighbourhood of all smaller objects. By this definition, the Solar System has eight known planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Pluto was demoted from planetary status, as it has not cleared its orbit of surrounding Kuiper belt objects.

A dwarf planet is a celestial body orbiting the Sun that is massive enough to be rounded by its own gravity but which has not cleared its neighbouring region of planetesimals and is not a satellite. By this definition, the Solar System has five known dwarf planets: Ceres, Pluto, Haumea, Makemake, and Eris. Other objects that may become classified as dwarf planets are Sedna, Orcus, and Quaoar. Dwarf planets that orbit in the trans-Neptunian region are called "plutoids."

Peri - fast

(R) Aph

The regions (or zones) of the Solar system: the *inner solar system*, the *asteroid belt*, the *giant planets* (Jovians) and the *Kuiper belt*.

Sun : The Sun is the Solar System's *parent star*, and far and away its chief component. Its large mass gives it an interior density high enough to sustain nuclear fusion, which releases enormous amounts of energy, mostly radiated into space as electromagnetic radiation such as visible light. The Sun is classified as a moderately large yellow dwarf, but this name is misleading as, compared to stars in our galaxy, the Sun is rather large and bright. Stars are classified by *the Hertzsprung-Russell diagram*, a graph which plots the brightness of stars against their surface temperatures. Generally, hotter stars are brighter. Stars following this pattern are said to be on the main sequence; the Sun lies right in the middle of it. However, stars brighter and hotter than the Sun are rare, while stars dimmer and cooler are common. It is believed that the Sun's position on the main sequence puts it in the "prime of life" for a star, in that it has not yet exhausted its store of hydrogen for nuclear fusion. The Sun is growing brighter; early in its history it was 75 percent as bright as it is today. The Sun is a population I star; it was born in the later stages of the universe's evolution. It contains more elements heavier than hydrogen and helium ("metals" in astronomical parlance) than older population II stars. Elements heavier than hydrogen and helium were formed in the cores of ancient and exploding stars, so the first generation of stars had to die before the universe could be enriched with these atoms. The oldest stars contain few metals, while stars born later have more. This high metallicity is thought to have been crucial to the Sun's developing a planetary system, because planets form from accretion of metals.

Inner planets : The inner planets are Mercury, Venus, Earth, and Mars. The four inner or terrestrial planets have dense, rocky compositions, few or no moons, and no ring systems. They are composed largely of minerals with high melting points, such as the silicates which form their crusts and mantles, and metals such as iron and nickel, which form their cores. Three of the four inner planets (Venus, Earth and Mars) have substantial atmospheres; all have impact craters and tectonic surface features such as rift valleys and volcanoes. *The term inner planet should not be confused with inferior planet, which designates those planets which are closer to the Sun than Earth is (i.e. Mercury and Venus).*

Mercury : Mercury (0.4 AU) is the closest planet to the Sun and the smallest planet (0.055 Earth masses). Mercury has no natural satellites, and its only known geological features besides impact craters are lobed ridges or rupes, probably produced by a period of contraction early in its history. Mercury's almost negligible atmosphere consists of atoms blasted off its surface by the solar wind. Its relatively large iron core and thin mantle have not yet been adequately explained. Hypotheses include that its outer layers were stripped off by a giant impact, and that it was prevented from fully accreting by the young Sun's energy.

Venus : Venus (0.7 AU) is close in size to Earth, (0.815 Earth masses) and like Earth, has a thick silicate mantle around an iron core, a substantial atmosphere and evidence of internal geological activity. However, it is much drier than Earth and its atmosphere is ninety times as dense. Venus has no natural satellites. It is the hottest planet, with surface temperatures over 400 °C, most likely due to the amount of greenhouse gases in the atmosphere. No definitive evidence of current geological activity has been detected on Venus, ~~but it has no magnetic field that would prevent depletion of its substantial atmosphere, which suggests that its atmosphere is regularly replenished by volcanic eruptions~~.

Earth : Earth (1 AU) is the largest and densest of the inner planets, the only one known to have current geological activity, and the only planet known to have life. Its liquid hydrosphere is unique among the terrestrial planets, and it is also the only planet where plate tectonics has been observed. Earth's atmosphere is radically different from those of the other planets, having been altered by the presence of life to contain 21% free oxygen. It has one natural satellite, the Moon (Latin: Luna), the only large satellite of a terrestrial planet in the Solar System.

Mars : Mars (1.5 AU) is smaller than Earth and Venus (0.107 Earth masses). It possesses a tenuous atmosphere of mostly carbon dioxide. Its surface, peppered with vast volcanoes such as Olympus Mons and rift valleys such as Valles Marineris, shows geological activity that may have persisted until very recently. Its red color comes from rust in its iron-rich soil. Mars has two tiny natural satellites (Deimos and Phobos) thought to be captured asteroids.

Asteroid belt : Asteroids are mostly small Solar System bodies composed mainly of rocky and metallic non-volatile minerals. The main asteroid belt occupies the orbit between Mars and Jupiter, between 2.3 and 3.3 AU from the Sun. It is thought to be remnants from the Solar System's formation that failed to coalesce because of the gravitational interference of Jupiter. Asteroids range in size from hundreds of kilometres across to microscopic. All asteroids save the largest, Ceres, are classified as small Solar System bodies, but some asteroids such as Vesta and Hygieia may be reclassed as dwarf planets if they are shown to have achieved hydrostatic equilibrium.

A small part or portion that remains after the main part no longer

fuse or cause to grow together

The asteroid belt contains tens of thousands, possibly millions, of objects over one kilometre in diameter. Despite this, the total mass of the main belt is unlikely to be more than a thousandth of that of the Earth. The main belt is very sparsely populated; spacecraft routinely pass through without incident. Asteroids with diameters between 10 and 10^{-4} m are called ***meteoroids.***

In a Not dense manner

Ceres : Ceres (2.77 AU) is the largest body in the asteroid belt and is classified as a dwarf planet. It has a diameter of slightly under 1000 km, large enough for its own gravity to pull it into a spherical shape. Ceres was considered a planet when it was discovered in the 19th century, but was reclassified as an asteroid in the 1850s as further observation revealed additional asteroids. It was again reclassified in 2006 as a dwarf planet.

Outer Solar System : The outer region of the Solar System is home to the gas giants and their planet-sized satellites. Many short period comets, including the centaurs, also orbit in this region. The solid objects in this region are composed of a higher proportion of volatiles (such as water, ammonia, methane, often called *ices* in planetary science) than the rocky denizens of the inner Solar System.

Outer planets : The four outer planets. or gas giants (sometimes called Jovian planets), collectively make up 99 percent of the mass known to orbit the Sun. Jupiter and Saturn consist overwhelmingly of hydrogen and helium; Uranus and Neptune possess a greater proportion of ices in their makeup. Some astronomers suggest they belong in their own category, "ice giants." All four gas giants have rings, although only Saturn's ring system is easily observed from Earth. The term *outer planet* should not be confused with *superior planet*, which designates planets outside Earth's orbit (the outer planets and Mars).

Jupiter : Jupiter (5.2 AU), at 318 Earth masses, masses 2.5 times all the other planets put together. It is composed largely of hydrogen and helium. Jupiter's strong internal heat creates a number of semi-permanent features in its atmosphere, such as cloud bands and the Great Red Spot. Jupiter has sixty-three known satellites. The four largest, Ganymede, Callisto, Io, and Europa, show similarities to the terrestrial planets, such as volcanism and internal heating. Ganymede, the largest satellite in the Solar System, is larger than Mercury.

Saturn: Saturn (9.5 AU), distinguished by its extensive ring system, has similarities to Jupiter, such as its atmospheric composition. Saturn is far less massive, being only 95 Earth masses. Saturn has sixty known satellites (and three unconfirmed); two of which, Titan and Enceladus, show signs of geological activity, though they are largely made of ice. Titan is larger than Mercury and the only satellite in the Solar System with a substantial atmosphere.

Uranus : Uranus (19.6 AU), at 14 Earth masses, is the lightest of the outer planets. Uniquely among the planets, it orbits the Sun on its side; its axial tilt is over ninety degrees to the ecliptic. It has a much colder core than the other gas giants, and radiates very little heat into space. Uranus has twenty-seven known satellites, the largest ones being Titania, Oberon, Umbriel, Ariel and Miranda.

Neptune : Neptune (30 AU), though slightly smaller than Uranus, is more massive (equivalent to 17 Earths) and therefore more dense. It radiates more internal heat, but not as much as Jupiter or Saturn. Neptune has thirteen known satellites. The largest, Triton, is geologically active, with geysers of liquid nitrogen.[41] Triton is the only large satellite with a retrograde orbit. Neptune is accompanied in its orbit by a number of minor planets, termed Neptune Trojans, that are in 1:1 resonance with it.

dry carbon

Sun

eccentric orbit

Comets : Comets are small Solar System bodies, usually only a few kilometres across, composed largely of volatile ices. They have highly eccentric orbits, generally a perihelion within the orbits of the inner planets and an aphelion far beyond Pluto. When a comet enters the inner Solar System, its proximity to the Sun causes its icy surface to sublimate and ionise, creating a coma: a long tail of gas and dust often visible to the naked eye. *Short-period comets* have orbits lasting less than two hundred years. Long-period comets have orbits lasting thousands of years. Short-period comets are believed to originate in the Kuiper belt, while long-period comets, such as Hale-Bopp, are believed to originate in the Oort cloud. Many comet groups, such as the Kreutz Sungrazers, formed from the breakup of a single parent. Some comets with hyperbolic orbits may originate outside the Solar System, but determining their precise orbits is difficult. Old comets that have had most of their volatiles driven out by solar warming are often categorised as asteroids.

Meteors: When we speak of "*shooting stars*" we mean meteors. These are not stars at all. They are believed to come from two different sources. The majority of them are small fragments like those in the belt of asteroids between Mars and Jupiter. Another source appears to be the tails of comets, for each time the earth crosses the path of a comet, swarms of meteors are seen. Meteors enter the earth's atmosphere with such speed (approximately 30-60 times the speed of sound) that the heat generated from friction with the air causes them to vaporise with a brief flash of brilliantly glowing gas.

Centaurs : The centaurs are icy comet-like bodies with a semi-major axis greater than Jupiter (5.5 AU) and less than Neptune (30 AU). The largest known centaur, 10199

$\frac{1}{2}$ the major axis of ellipse

Chariklo, has a diameter of about 250 km. The first centaur discovered, 2060 Chiron, has also been classified as comet (95P) since it develops a coma just as comets do when they approach the Sun. Some astronomers classify centaurs as inward-scattered Kuiper belt objects along with the outward-scattered residents of the scattered disc.

Trans-Neptunian region : The area beyond Neptune, or the "trans-Neptunian region", is still largely unexplored. It appears to consist overwhelmingly of small worlds (the largest having a diameter only a fifth that of the Earth and a mass far smaller than that of the Moon) composed mainly of rock and ice. This region is sometimes known as the "outer Solar System", though others use that term to mean the region beyond the asteroid belt.

Trans Neptune region

Kuiper belt : The Kuiper belt, the region's first formation, is a great ring of debris similar to the asteroid belt, but composed mainly of ice. It extends between 30 and 50 AU from the Sun. It is composed mainly of small Solar System bodies, but many of the largest Kuiper belt objects, such as Quaoar, Varuna, and Orcus, may be reclassified as dwarf planets. There are estimated to be over 100,000 Kuiper belt

Pluto and Charon : Pluto (39 AU average), a dwarf planet, is one of the largest known object in the Kuiper belt. When discovered in 1930, it was considered to be the ninth planet; this changed in 2006 with the adoption of a formal definition of planet. Pluto has a relatively eccentric orbit inclined 17 degrees to the ecliptic plane and ranging from 29.7 AU from the Sun at perihelion (within the orbit of Neptune) to 49.5 AU at aphelion.

Pluto and its three known moons : It is unclear whether Charon, Pluto's largest moon, will continue to be classified as such or as a dwarf planet itself. Both Pluto and Charon orbit a barycenter of gravity above their surfaces, making Pluto-Charon a binary system. Two much smaller moons, Nix and Hydra, orbit Pluto and Charon. Pluto lies in the resonant belt and has a 3:2 resonance with Neptune, meaning that Pluto orbits twice round the Sun for every three Neptunian orbits. Kuiper belt objects whose orbits share this resonance are called plutinos.[51]

Haumea and Makemake : Haumea (43.34 AU average), and Makemake (45.79 AU average) are the largest known objects in the classical Kuiper belt. Haumea is an egg-shaped object with two moons. Makemake is the brightest object in the Kuiper belt after Pluto. Originally designated 2003 EL_{61} and 2005 FY_9 respectively, they were granted names (and the status of dwarf planet) in 2008. Their orbits are far more inclined than Pluto's (28° and 29°) and unlike Pluto are not affected by Neptune, being part of the classical KBO population.

Sedna: 90377 Sedna (525.86 AU average) is a large, reddish Pluto-like object with a gigantic, highly elliptical orbit that takes it from about 76 AU at perihelion to 928 AU at aphelion and takes 12,050 years to complete. Mike Brown, who discovered the object in 2003, asserts that it cannot be part of the scattered disc or the Kuiper belt as its perihelion is too distant to have been affected by Neptune's migration. He and other astronomers consider it to be the first in an entirely new population, which also may include the object 2000 CR_{105}, which has a perihelion of 45 AU, an aphelion of 415 AU, and an orbital period of 3420 years. Brown terms this population the "Inner Oort cloud," as it may have formed through a similar process, although it is far closer to the Sun. Sedna is very likely a dwarf planet, though its shape has yet to be determined with certainty.

The Earth

Earth is the third planet from the Sun. Earth is the largest of the terrestrial planets in the Solar System in diameter, mass and density. It is also referred to as *the World* and *Terra*. Home to millions of species, including humans, Earth is the only place in the universe where life is known to exist. Scientific evidence indicates that the planet formed 4.54 billion years ago, and life appeared on its surface within a billion years. Since then, Earth's biosphere has significantly altered the atmosphere and other abiotic conditions on the planet, enabling the proliferation of aerobic organisms as well as the formation of the ozone layer which, together with Earth's magnetic field, blocks harmful radiation, permitting life on land. The physical properties of the Earth, as well as its geological history and orbit, allowed life to persist during this period. The world is expected to continue supporting life for another 1.5 billion years, after which the rising luminosity of the Sun will eliminate the biosphere.

Earth's outer surface is divided into several rigid segments, or tectonic plates, that gradually migrate across the surface over periods of many millions of years. About 71% of the surface is covered with salt-water oceans, the remainder consisting of continents and islands; liquid water, necessary for all known life, is not known to exist on any other planet's surface. Earth's interior remains active, with a thick layer of relatively solid mantle, a liquid outer core that generates a magnetic field, and a solid iron inner core.

At present, Earth orbits the Sun once for every roughly 366.26 times it rotates about its axis. This length of time is a sidereal year, which is equal to 365.26 solar days The Earth's axis of rotation is tilted 23.4° away from the perpendicular to its orbital plane, producing seasonal variations on the planet's surface with a period of one tropical year (365.24 solar days). Earth's only known natural satellite, the Moon, which began orbiting it about 4.53 billion years ago, provides ocean tides, stabilizes the axial tilt and gradually slows the planet's rotation.

History: Scientists have been able to reconstruct detailed information about the planet's past. About 4.54 billion years ago (within an uncertainty of 1%), the Earth and the other planets in the Solar System formed out of the solar nebula—a disk-shaped mass of dust and gas left over from the formation of the Sun. This assembly of the Earth through accretion was largely completed within 10–20 million years. Initially molten, the outer layer of the planet Earth cooled to form a solid crust when water began accumulating in the atmosphere. The Moon formed soon afterward, possibly as the result of a Mars-sized object (sometimes called Theia) with about 10% of the Earth's mass impacting the Earth in a glancing blow. Some of this object's mass would have merged with the Earth and a portion would have been ejected into space, but enough material would have been sent into orbit to form the Moon. Outgassing and volcanic activity produced the primordial atmosphere. Condensing water vapor, augmented by ice and liquid water delivered by asteroids and the larger proto-planets, comets, and trans-Neptunian objects produced the oceans. The highly energetic chemistry is believed to have produced a self-replicating molecule around 4 billion years ago, and half a billion years later, the last common ancestor of all life existed. The present pattern of ice ages began about 40 mya and then intensified during the Pleistocene about 3 mya. The polar regions have since undergone repeated cycles of glaciation and thaw, repeating every 40–100,000 years. The last ice age ended 10,000 years ago.

Composition and structure : Earth is a terrestrial planet, meaning that it is a rocky body, rather than a gas giant like Jupiter. It is the largest of the four solar terrestrial planets, both in terms of size and mass. Of these four planets, Earth also has the highest density, the highest surface gravity, the strongest magnetic field, and fastest rotation. It also is the only terrestrial planet with active plate tectonics.

Shape : The Earth's shape is very close to an oblate spheroid—a rounded shape with a bulge around the equator—although the precise shape (the geoid) varies from this by up to 100 meters. The average diameter of the reference spheroid is about 12,742 km. More approximately the distance is 40,000 km/π because the meter was originally defined as 1/10,000,000 of the distance from the equator to the north pole through Paris, France. The rotation of the Earth creates the equatorial bulge so that the equatorial diameter is 43 km larger than the pole to pole diameter. The largest local deviations in the rocky surface of the Earth are Mount Everest (8,848 m above local sea level) and the Mariana Trench (10,911 m below local sea level). Hence compared to a perfect ellipsoid, the Earth has a tolerance of about one part in about 584, or 0.17%, which is less than the 0.22% tolerance allowed in billiard balls. Because of the bulge, the feature farthest from the center of the Earth is actually Mount Chimborazo in Ecuador.

Chemical composition : The mass of the Earth is approximately 5.98×10^{24} kg. It is composed mostly of iron (32.1%), oxygen (30.1%), silicon (15.1%), magnesium (13.9%), sulfur (2.9%), nickel (1.8%), calcium (1.5%), and aluminum (1.4%); with the remaining 1.2% consisting of trace amounts of other elements. Due to mass segregation, the core region is believed to be primarily composed of iron (88.8%), with smaller amounts of nickel (5.8%), sulfur (4.5%), and less than 1% trace elements. The geochemist F. W. Clarke calculated that a little more than 47% of the Earth's crust consists of oxygen. The more common rock constituents of the Earth's crust are nearly all oxides; chlorine, sulfur and fluorine are the only important exceptions to this and their total amount in any rock is usually much less than 1%. The principal oxides are silica, alumina, iron oxides, lime, magnesia, potash and soda. The silica functions principally as an acid, forming silicates, and all the commonest minerals of igneous rocks are of this nature. From a computation based on 1,672 analyses of all kinds of rocks, Clarke deduced that 99.22% were composed of 11 oxides . All the other constituents occur only in very small quantities

Internal structure : The interior of the Earth, like that of the other terrestrial planets, is divided into layers by their chemical or rheological properties. The Earth has an outer silicate solid crust, a highly viscous mantle, a liquid outer core that is much less viscous than the mantle, and a solid inner core. The crust is separated from the mantle by the Mohorovičić discontinuity, and the thickness of the crust varies: averaging 6 km under the oceans and 30–50 km on the continents. The inner core may rotate at a slightly higher angular velocity than the remainder of the planet, advancing by 0.1–0.5° per year.

Geologic layers of the Earth[44]

Earth cutaway from core to exosphere. Not to scale.

Depth km	Component Layer	Density g/cm³
0–60	Lithosphere	—
0–35	... Crust[47]	2.2–2.9
35–60	... Upper mantle	3.4–4.4
35–2890	Mantle	3.4–5.6
100–700	... Asthenosphere	—
2890–5100	Outer core	9.9–12.2
5100–6378	Inner core	12.8–13.1

The internal heat of the planet is probably produced by the radioactive decay of potassium-40, uranium-238 and thorium-232 isotopes. All three have half-life decay periods of more than a billion years. At the center of the planet, the temperature may be up to 7,000 K and the pressure could reach 360 GPa. A portion of the core's thermal energy is transported toward the crust by Mantle plumes; a form of convection consisting of upwellings of higher-temperature rock. These plumes can produce hotspots and flood basalts.

Tectonic plates : According to plate tectonics theory, the outermost part of the Earth's interior is made up of two layers: the lithosphere, comprising the crust, and the solidified uppermost part of the mantle. Below the lithosphere lies the asthenosphere, which forms the inner part of the upper mantle. The asthenosphere behaves like a superheated material that is in a semi-fluidic, plastic-like state. The lithosphere essentially *floats* on the asthenosphere and is broken up into what are called tectonic plates. These plates are rigid segments that move in relation to one another at one of three types of plate boundaries: convergent, divergent and transform. The last occurs where two plates move laterally relative to each other, creating a strike-slip fault. Earthquakes, volcanic activity, mountain-building, and oceanic trench formation can occur along these plate boundaries.

Notable minor plates include the Indian Plate, the Arabian Plate, the Caribbean Plate, the Nazca Plate off the west coast of South America and the Scotia Plate in the southern Atlantic Ocean. The Australian Plate actually fused with Indian Plate between 50 and 55 million years ago. The fastest-moving plates are the oceanic plates, with the Cocos Plate advancing at a rate of 75 mm/yr and the Pacific Plate moving 52–69 mm/yr. At the other extreme, the slowest-moving plate is the Eurasian Plate, progressing at a typical rate of about 21 mm/yr.

Surface : The Earth's terrain varies greatly from place to place. About 70.8% of the surface is covered by water, with much of the continental shelf below sea level. The submerged surface has mountainous features, including a globe-spanning mid-ocean ridge system, as well as undersea volcanoes, oceanic trenches, submarine canyons, oceanic plateaus and abyssal plains. The remaining 29.2% not covered by water consists of mountains, deserts, plains, plateaus, and other geomorphologies. The planetary surface undergoes reshaping over geological time periods due to the effects of tectonics and erosion. The surface features built up or deformed through plate tectonics are subject to steady weathering from precipitation, thermal cycles, and chemical effects. Glaciation, coastal erosion, the build-up of coral reefs, and large meteorite impacts also act to reshape the landscape. As the tectonic plates migrate across the planet, the ocean floor is subducted under the leading edges. At the same time, upwellings of mantle material create a divergent boundary along mid-ocean ridges. The combination of these processes continually recycles the oceanic crustal material. Most of the ocean floor is less than 100 million years in age. The oldest oceanic crust is located in the Western Pacific, and has an estimated age of about 200 million years. By comparison, the oldest fossils found on land have an age of about 3 billion years.

The continental crust consists of lower density material such as the igneous rocks granite and andesite. Less common is basalt, a denser volcanic rock that is the primary constituent of the ocean floors. Sedimentary rock is formed from the accumulation of sediment that becomes compacted together. Nearly 75% of the continental surfaces are covered by sedimentary rocks, although they form only about 5% of the crust. The third form of rock material found on Earth is metamorphic rock, which is created from the transformation of pre-existing rock types through high pressures, high temperatures, or both. The most abundant silicate minerals on the Earth's surface include quartz, the feldspars, amphibole, mica, pyroxene and olivine. Common carbonate minerals include calcite (found in limestone), aragonite and dolomite.

The pedosphere is the outermost layer of the Earth that is composed of soil and subject to soil formation processes. It exists at the interface of the lithosphere, atmosphere, hydrosphere and biosphere. Currently the total arable land is 13.31% of the land surface, with only 4.71% supporting permanent crops. Close to 40% of the Earth's land surface is presently used for cropland and pasture, or an estimated 1.3×10^7 km² of cropland and 3.4×10^7 km² of pastureland. The elevation of the land surface of the Earth varies from the low point of −418 m at the Dead Sea, to a 2005-estimated maximum altitude of 8,848 m at the top of Mount Everest. The mean height of land above sea level is 840 m.

Continents and Oceans: A continent is a part of the earth's surface that forms some of the great land masses of the world. The main continents are Europe, Asia, Africa, Australia, North America, South America and Antarctica. Oceans and seas together form a single mass of water called the World Ocean, above which rise continents forming, as it were, separate islands. (The major oceans of the earth are the Pacific, the Atlantic, the Indian, the Arctic and the Antarctic. The Pacific Ocean is the largest and the deepest, covering one-third of the globe).

Distribution of Land and Water: Our planet, the Earth, is in fact a watery planet. The continents form only 29 per cent while the greater part, 71 per cent, is covered by the ocean. There is an antipodal arrangement of land and sea. This means that for nearly every land-mass on one side of the globe there is sea on the part of the earth which is on the opposite side.

The Motions of the Earth : The earth has two important motions: - It rotates on its axis once in 24 hours and it Revolves around the Sun once in 365¼ days.

Rotation is turning on an axis. The earth is rotating on its axis. The evidence of this is found in the rising and setting of the Sun. The direction of this rotation is from **west to east**. Rotation gives us periods of heat and light as well as darkness. The change from **day** to **night** causes variations in temperature. During the day the sun's heat raises the temperature. At night a part of this heat accumulated during the day is given off and the temperature comes down.

Earth's rotation period relative to the Sun—its mean solar day—is 86,400 seconds of mean solar time. Each of these seconds is slightly longer than an SI second because Earth's solar day is now slightly longer than it was during the 19th century due to tidal acceleration. Earth's rotation period relative to the fixed stars, called its *stellar day* by the International Earth Rotation and Reference Systems Service (IERS), is 86164.098903691 seconds of mean solar time (UT1), or $23^h\ 56^m\ 4.098903691^s$. Earth's rotation period relative to the precessing or moving mean vernal equinox, misnamed its *sidereal day*, is 86164.09053083288 seconds of mean solar time (UT1) ($23^h\ 56^m\ 4.09053083288^s$). Thus the sidereal day is shorter than the stellar day by about 8.4 ms. The length of the mean solar day in SI seconds is available from the IERS for the periods 1623–2005 and 1962–2005. Apart from meteors within the atmosphere and low-orbiting satellites, the main apparent motion of celestial bodies in the Earth's sky is to the west at a rate of 15°/h = 15'/min. This is equivalent to an apparent diameter of the Sun or Moon every two minutes; the apparent sizes of the Sun and the Moon are approximately the same.

Revolution: The next important motion of the earth is its Revolution round the Sun in the course of its yearly journey. It takes approximately 365 ¼ days to complete a revolution. The revolution of the Earth causes four seasons : namely, Spring, Summer, Autumn and Winter. Earth orbits the Sun at an average distance of about 150 million kilometers every 365.2564 mean solar days, or one sidereal year. From Earth, this gives an apparent movement of the Sun eastward with respect to the stars at a rate of about 1°/day, or a Sun or Moon diameter every 12 hours. Because of this motion, on average it takes 24 hours—a solar day—for Earth to complete a full rotation about its axis so that the Sun returns to the meridian. The orbital speed of the Earth averages about 30 km/s (108,000 km/h), which is fast enough to cover the planet's diameter (about 12,600 km) in seven minutes, and the distance to the Moon (384,000 km) in four hours.

The Moon revolves with the Earth around a common barycenter every 27.32 days relative to the background stars. When combined with the Earth–Moon system's common revolution around the Sun, the period of the synodic month, from new moon to new moon, is 29.53 days. Viewed from the celestial north pole, the motion of Earth, the Moon and their axial rotations are all counter-clockwise. Viewed from a vantage point above the north poles of both the Sun and the Earth, the Earth appears to revolve in a counterclockwise direction about the Sun. The orbital and axial planes are not precisely aligned: Earth's axis is tilted some 23.5 degrees from the perpendicular to the Earth–Sun plane, and the Earth–Moon plane is tilted about 5 degrees against the Earth-Sun plane. Without this tilt, there would be an eclipse every two weeks, alternating between lunar eclipses and solar eclipses.

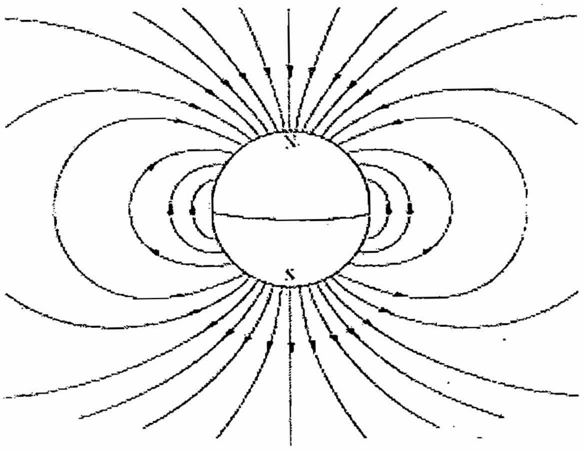
The Hill sphere, or gravitational sphere of influence, of the Earth is about 1.5 Gm (or 1,500,000 kilometers) in radius. This is maximum distance at which the Earth's gravitational influence is stronger than the more distant Sun and planets. Objects must orbit the Earth within this radius, or they can become unbound by the gravitational perturbation of the Sun.

Earth, along with the Solar System, is situated in the Milky Way galaxy, orbiting about 28,000 light years from the center of the galaxy, and about 20 light years above the galaxy's equatorial plane in the Orion spiral arm

Solstices and Equinoxes: At any one time only half the earth's surface receives light from the Sun and the imaginary line that separates the lighted from the darkened half of the earth is known as the **circle of Illumination.** In the Northern Hemisphere the sun shines vertically over the Tropic of Cancer on June 21st, this is the **Summer Solstice** in the Northern Hemisphere. As a result the Northern Hemisphere becomes hot and the season is called as the summer season. At the same time, the southern hemisphere the conditions are opposite to that of the northern hemisphere and it is the winter season there. On December 22nd, the Sun shines vertically over the tropic of Capricorn. This is the winter solstices and leads to winter in the northern hemisphere and summer in the southern hemisphere. On March 21st and September 23rd the days are nearly equal to the nights all over the world and these are called as **Equinoxes**.

Location of Places on the Earth : A grid is a series of crossing lines used for locating places on a map or a globe. On a true sphere it would not be possible to indicate the exact point where we could begin marking the lines of the grid because there are no corners, no sides, no beginning or end. But on a rotating earth it is easy as it is spinning round its axis. Each end of the axis is known as **"Pole"** and midway between these poles lies the **"Equator"**. So we draw one series of lines from the north pole to the south pole and another series of lines parallel to the equator. This complete network of meridians and parallels, called the Earth Grid, enables us to determine the location of any point on the earth.

Magnetic field of the Earth



The Earth's magnetic field approximates a dipole. The Earth's magnetic field is shaped roughly as a magnetic dipole, with the poles currently located proximate to the planet's geographic poles. According to dynamo theory, the field is generated within the molten outer core region where heat creates convection motions of conducting materials, generating electric currents. These in turn produce the Earth's magnetic field. The convection movements in the core are chaotic in nature, and periodically change alignment. This results in field reversals at irregular intervals averaging a few times every million years. The most recent reversal occurred approximately 700,000 years ago.

The field forms the magnetosphere, which deflects particles in the solar wind. The sunward edge of the bow shock is located at about 13 times the radius of the Earth. The collision between the magnetic field and the solar wind forms the Van Allen radiation belts, a pair of concentric, torus-shaped regions of energetic charged particles. When the plasma enters the Earth's atmosphere at the magnetic poles, it forms the aurora.

Axial tilt and seasons : Because of the axial tilt of the Earth, the amount of sunlight reaching the surface varies over the course of the year. This results in seasonal change in climate, with summer in the northern hemisphere occuring when the north pole is pointing toward the Sun, and winter taking place when the pole is pointed away. During the summer, the day lasts longer and the Sun climbs higher in the sky. In winter, the climate becomes generally cooler and the days shorter. Above the arctic circle, an extreme case is reached where there is no daylight at all for part of the year—a polar night. In the southern hemisphere the situation is exactly reversed, with the south pole oriented opposite the direction of the north pole. By astronomical convention, the four seasons are determined by the solstices—the point in the orbit of maximum axial tilt toward or away from the Sun—and the equinoxes, when the direction of the tilt and the direction to the Sun are perpendicular. Winter solstice occurs on about December 21, summer solstice is near June 21, spring equinox is around March 20 and autumnal equinox is about September 23.

The angle of the Earth's tilt is relatively stable over long periods of time. However, the tilt does undergo nutation; a slight, irregular motion with a main period of 18.6 years. The orientation (rather than the angle) of the Earth's axis also changes over time, precessing around in a complete circle over each 25,800 year cycle; this precession is the reason for the difference between a sidereal year and a tropical year. Both of these motions are caused by the varying attraction of the Sun and Moon on the Earth's equatorial bulge. From the perspective of the Earth, the poles also migrate a few meters across the surface. This polar motion has multiple, cyclical components, which collectively are termed quasiperiodic motion. In addition to an annual component to this motion, there is a 14-month cycle called the Chandler wobble. The rotational velocity of the Earth also varies in a phenomenon known as length of day variation.

In modern times, Earth's perihelion occurs around January 3, and the aphelion around July 4. However, these dates change over time due to precession and other orbital factors, which follow cyclical patterns known as Milankovitch cycles. The changing Earth-Sun distance results in an increase of about 6.9% in solar energy reaching the Earth at perihelion relative to aphelion. Since the southern hemisphere is tilted toward the Sun at about the same time that the Earth reaches the closest approach to the Sun, the southern hemisphere receives slightly more energy from the Sun than does the northern over the course of a year. However, this effect is much less significant than the total energy change due to the axial tilt, and most of the excess energy is absorbed by the higher proportion of water in the southern hemisphere.

Moon

Name	Diameter	Mass	Semi-major axis	Orbital period
Moon	3,474.8 km 2,159.2 mi	7.349×10^{22} kg 8.1×10^{19} (short) tons	384,400 km 238,700 mi	27 days, 7 hours, 43.7 minutes

The Moon is a relatively large, terrestrial, planet-like satellite, with a diameter about one-quarter of the Earth's. It is the largest moon in the solar system relative to the size of its planet. (Charon is larger relative to the dwarf planet Pluto.) The natural satellites orbiting other planets are called "moons" after Earth's Moon. The gravitational attraction between the Earth and Moon causes tides on Earth. The same effect on the Moon has led to its tidal locking: its rotation period is the same as the time it takes to orbit the Earth. As a result, it always presents the same face to the planet. As the Moon orbits Earth, different parts of its face are illuminated by the Sun, leading to the lunar phases; the dark part of the face is separated from the light part by the solar terminator.

Because of their tidal interaction, the Moon recedes from Earth at the rate of approximately 38 mm a year. Over millions of years, these tiny modifications—and the lengthening of Earth's day by about 23 µs a year—add up to significant changes. During the Devonian period, for example, (approximately 410 million years ago) there were 400 days in a year, with each day lasting 21.8 hours.

The Moon may have dramatically affected the development of life by moderating the planet's climate. Paleontological evidence and computer simulations show that Earth's axial tilt is stabilized by tidal interactions with the Moon. Some theorists believe that without this stabilization against the torques applied by the Sun and planets to the Earth's equatorial bulge, the rotational axis might be chaotically unstable, exhibiting chaotic changes over millions of years, as appears to be the case for Mars. If Earth's axis of rotation were to approach the plane of the ecliptic, extremely severe weather could result from the resulting extreme seasonal differences. One pole would be pointed directly toward the Sun during *summer* and directly away during *winter*. Planetary scientists who have studied the effect claim that this might kill all large animal and higher plant life. However, this is a controversial subject, and further studies of Mars—which has a similar rotation period and axial tilt as Earth, but not its large Moon or liquid core—may settle the matter.

Viewed from Earth, the Moon is just far enough away to have very nearly the same apparent-sized disk as the Sun. The angular size (or solid angle) of these two bodies match because, although the Sun's diameter is about 400 times as large as the Moon's, it is also 400 times more distant.[95] This allows total and annular eclipses to occur on Earth. The most widely accepted theory of the Moon's origin, the giant impact theory, states that it formed from the collision of a Mars-size protoplanet called Theia with the early Earth. This hypothesis explains (among other things) the Moon's relative lack of iron and volatile elements, and the fact that its composition is nearly identical to that of the Earth's crust. Earth has at least two co-orbital asteroids, 3753 Cruithne and 2002 AA_{29}.

Habitability : A planet that can sustain life is termed habitable, even if life did not originate there. The Earth provides the (currently understood) requisite conditions of liquid water, an environment where complex organic molecules can assemble, and sufficient energy to sustain metabolism. The distance of the Earth from the Sun, as well as its orbital eccentricity, rate of rotation, axial tilt, geological history, sustaining atmosphere and protective magnetic field all contribute to the conditions necessary to originate and sustain life on this planet.

Biosphere : The planet's life forms are sometimes said to form a "biosphere". This biosphere is generally believed to have begun evolving about 3.5 billion years ago. Earth is the only place in the universe where life is known to exist. Some scientists believe that Earth-like biospheres might be rare. The biosphere is divided into a number of biomes, inhabited by broadly similar plants and animals. On land primarily latitude and height above the sea level separates biomes. Terrestrial biomes lying within the Arctic, Antarctic Circle or in high altitudes are relatively barren of plant and animal life, while the greatest latitudinal diversity of species is found at the Equator.

Natural resources and land use : The Earth provides resources that are exploitable by humans for useful purposes. Some of these are non-renewable resources, such as mineral fuels, that are difficult to replenish on a short time scale.

Large deposits of fossil fuels are obtained from the Earth's crust, consisting of coal, petroleum, natural gas and methane clathrate. These deposits are used by humans both for energy production and as feedstock for chemical production. Mineral ore bodies have also been formed in Earth's crust through a process of Ore genesis, resulting from actions of erosion and plate tectonics. These bodies form concentrated sources for many metals and other useful elements.

The Earth's biosphere produces many useful biological products for humans, including (but far from limited to) food, wood, pharmaceuticals, oxygen, and the recycling of many organic wastes. The land-based ecosystem depends upon topsoil and fresh water, and the oceanic ecosystem depends upon dissolved nutrients washed down from the land.[115] Humans also live on the land by using building materials to construct shelters. In 1993, human use of land is approximately:

Land use	**Percentage**
Arable land:	13.13%
Permanent crops:	4.71%
Permanent pastures:	26%
Forests and woodland:	32%

Urban areas:	1.5%
Other:	30%

EARTHQUAKES

Any sudden movement of a portion of the earth's crust due to a natural cause, which produces a shaking or trembling is known as an **earthquake**. The chief cause of earthquakes is the sudden **slipping** of the portion of the earth's crust past each other along fractures or faults. The movement of the molten rocks underneath the surface produces strains which break the rocks apart. Another cause of earthquake is **volcanic activity**. A violent or explosive eruption often causes the earth in its vicinity to quake. Earthquakes are often common in most volcanic areas. Minor causes of earthquake are sudden landslides, submarine slides and collapse of cavern roofs. An underground stream can, by erosion, dig out large caverns in the body of the earth. This can later cause the roofs of these averns to collapse.

The place of origin of an earthquake inside the earth is called its **focus.** The point on the earth's surface vertically above the *focus* is called the ***epicentre***. Observations have shown that most of the earthquakes originate at a depth from 50 to 100 km and only single earthquake occurs at still greater depths. The shock waves travel in all directions from the focus. On the earth's surface, the shaking is the strongest near the epicentre. That is why the greatest amount of destruction is caused near the epicentre. The earthquakes are studies by a special branch of geology known as **Seismology.** The instrument recording the shock waves is called the **Seismograph.**

Effects of Earthquakes: Sudden movements under the earth cause violent earthquakes which are often very destructive. At times, they cause landslides and damming the rivers. Sometimes, they cause depressions forming lakes. Formation of cracks or fissures in the region of epicentre are commonly noticed in the crust. These deep fissures are sometimes many kilometres long and the buildings, people and animals fall into them. Sometimes water, mud and gases are ejected from beneath the fissure. The gases may ignite the air and water, and mud may flood the surrounding area. Larger areas also subside or sink during very severe earthquakes. Landslides occur during earthquakes in highlands. An earthquake may also lead to change in surface drainage and underground circulation of water. Crystal displacements may close up the crevices along which water was coming out or they open up new ones. That is why we notice a disappearance of springs in some places and their appearance in others as a result of strong shocks.

Faults, thrusts and folds are associated with earthquakes. Perhaps more devastating are firs and a seismic sea waves (called **Tsunamis** in Japanese) which are originated by earthquakes. Instances are not lacking to show that hundreds of thousand of people have fallen victims not directly to earthquakes, but to the fire, flood and sea waves which follow them.

Distribution: About 68 per cent of all earthquakes are observed in the vast region of the Pacific ocean as a 'ring of fire' and is closely linked with the region of crystal dislocations and volcanic phenomenon. Chile, California, Alaska, Japan, Philippines, New Zealand and the Mid ocean areas have had many minor and major earthquakes in this belt. Mountains here run along the border of continents and nearly parallel to the depressions in oceans. It causes sharpest break in relief which becomes a cause for the earthquakes. Around 21 per cent of them occur in the Mid-world mountain belt extending parallel to the equator from Mexico across Atlantic ocean, the Mediterranean sea from Alpine - Caucasus ranges to the Caspian, Himalayan mountains and the adjoining lands. This zone has folded mountains, large depressions and active volcanoes. The earthquakes in India are at present mainly confined to the Himalayan region and its foothills. They are also felt in the Ganga Valley. But the earthquakes in Koyna Dam region in 1968 and Latur in 1993 in the Deccan Table came as a surprise. This region was otherwise considered to be free from earthquakes. Scientists believe that while in the former case, the reservoir caused cracks in the rocks, in the latter case the movement of the Indian plate might have been the cause.

VOLCANOES

A Volcano is a vent or an opening in the earth's crust through which hot materials come forth from deep below the surface. The opening is usually circular in form. Sometimes a volcano has only one opening at the summit, often there are other openings in the sides of the mound. Volcanic eruptions may also take place through a long crack or fissure through which steam and other materials escape. Volcanoes are grouped according to their stages, either as **active**, **dormant** or **extinct**. These names refer to the state of activity rather than the types of volcanoes. While active volcanoes erupt periodically, dormant volcanoes show no sign of activity for many years but may become active any time, extinct volcanoes are no longer active.

PRINCIPAL ACTIVE VOLCANOES

Name	Height (Metres)	Location	Country	Date of last notified

				eruption
Ojos del Saldao	6885	Andes	Argentina-Chile	1981
Guallatiri	6060	Andes	Chile	1960
Cotopaxi	5897	Andes	Equador	1975
Tupungatito	5640	Andes	Chile	1964
Lascar	5641	Andes	Chile	1968
Popocatepeti	5451	Altiplano de Maxico	Mexico	1920
Nevado del Ruiz	5400	Andes	Colombia	1985
Sangay	5230	Andes	Ecuador	1976
Klyuchevskaya	4850	Sredinnyy Khrebet (Kanchatika Peninsul)	Erstwhile USSR (now CIS)	1974

Geyser : A geyser is a hot spring characterized by intermittent discharge of water ejected turbulently and accompanied by a vapour phase (steam).

The formation of geysers is due to particular hydrogeological conditions, which exist in only a few places on Earth, and so they are a fairly rare phenomenon. Generally all geyser field sites are located near active volcanic areas, and the geyser effect is due to the proximity of magma. Generally, surface water works its way down to an average depth of around 2,134 metres (7,000 ft) where it meets up with hot rocks. The resultant boiling of the pressurized water results in the geyser effect of hot water and steam spraying out of the geyser's surface vent.

About a thousand geysers exist worldwide, roughly half of which are in Yellowstone National Park, United States. A geyser's eruptive activity may change or cease due to ongoing mineral deposition within the geyser plumbing, exchange of functions with nearby hot springs, earthquake influences, and human intervention.

Erupting fountains of liquefied nitrogen have been observed on Neptune's moon Triton, as have possible signs of carbon dioxide eruptions from Mars' south polar ice cap. These phenomena are also often referred to as *geysers*. Instead of being driven by geothermal energy, they seem to rely on solar heating aided by a kind of solid-state greenhouse effect. On Triton, the nitrogen may erupt to heights of 8 kilometres (5 mi).

LANDFORMS AND THEIR SIGNIFICANCE :

A **study** of landforms is important for understanding their influence upon man's life. It includes the description of the characteristics of various forms of land surface. There are three major landforms - **mountains, plateaus and plains:**

Mountains: An uplifted portion of the earth's surface is called a hill or a mountain. In our country, a mountain is differentiated from a hill, when its summit or top rises to more than 900 metres above the base. Those with less than this elevation are called hills. Conventionally mountains are divided into four categories namely: **folded mountains, block mountains, volcanic mountains** and **residual mountains.**

PRINCIPAL MOUNTAIN PEAKS		
Name	**Country**	**Height (in Metres)**
Mt. Everest	Nepal-Tibet	8850
Mt. Godwin Austin (K2)	India (POK)	8611
Kanchanjunga	Nepal	8126
Lhotse	Nepal	8501
Nanga Parbat	India	8126
Annapurna	Nepal	8078
Nanda Devi	India	7817
Mt. Kamet	India	7756
Saltoro Kangri	India	7742
Gurla Mandhata	Tibet	7728

Tirich Mir	Pakistan	7700
Minya Konta	China	7590
Mt. Communism	Tajikstan	7495
Muztagh Ata	China	7434
Chomo Lhari	India-Tibet	7100
Aconcagua	Argentina	6960
Ojos del Salado	Argentina-Chile	6868

Plateaus: A plateau is an elevated area generally in contrast to the nearby areas. It has a large area on its top unlike a mountain and has an extensively even or undulating surface. A steep cliff is usually marked along the side of a plateau away from the mountains except in the case of one surrounded by high mountains. It is along this slope that uplift takes place. The rocks of the plateau are layered with sandstones, shales and limestones. It is this arrangement of the strata which gives it a large even surface.

Plains : A plain is a comparatively level surface of land at a low elevation from the sea. Plains are the simplest of land forms and also widespread. The interiors of most of the continents are occupied by plains. While some plains may rise gently inland, others are nearly flat and some others have rolling or even rough surfaces. These differences are generally caused by the different ways in which they were formed. Plains may be formed by internal earth forces and by processes of denudation and deposition. More than one cause may have contributed to the formation of plains.

SOME MINOR LANDFORMS

LAKES

Any hollows in the earth's surface filled permanently with water are known as lakes. The lakes occupy about 1.8 per cent of the Earth's surface. The water of lakes may be fresh, brackish or salt but the number of fresh water lakes in the world is the largest. The highest large lake known is Titicaca in South America at a height of 3,920 m. The largest in surface area is the Caspian Sea which is really a salt lake, in Asia. The deepest lake is Baikal in Siberia. The Dead Sea is the lowest lake in the world. The Great Lakes of the U.S. and Canada constitute the world's greatest array of large lakes.

LARGE LAKES OF THE WORLD

Name and location	Area in sq. km	Length in sq. km	Maximum depth in metres
Caspian Sea, CIS-Iran	3,94,299	1,199	946
Superior, USA-Canada	82,414	616	406
Victoria, Tanzania-Uganda	69,485	322	82
Aral, USSR (now CIS)	66,457	428	68

Huron, USA-Canada	59,596	397	229
Michigan, USA	58,016	517	281
Tanganyika, Tanzania-Zaire	32,893	676	1,435
Baikal, CIS	31,500	636	1,741
Great Bear, Canada	31,080	373	82
Nyasa, Malawi-Mozambique, Tanzania	30,044	579	706
Great Slave, Canada	28,930	480	614
Chad, Chad-	25,760	-	7

Niger-Nigeria			
Erie-USA-Canada	25,719	388	64
Winnipeg, Canada	23,553	425	62

ISLANDS

Islands are masses of land surrounded by water. They may be either in an ocean, sea, river or lake and may be formed in several ways. Islands are broadly divided into four types namely : ■ Continental islands(e.g. British Isles, New Found Land) ■ Oceanic Islands (e.g. St. Helena) ■ Tectonic Islands (e.g. Barbados in West Indies) and ■ Coral Islands (e.g. Bahamas and Bermuda).

WORLD'S LARGEST ISLANDS		
Largest islands	**Location**	**Area in sq. kms.**
Australia	Indian Ocean	7618493
Greenland	Arctic ocean	2175000
New Guiena	West Pacific	789900
Borneo	Pacific Ocean	751000
Malagasy Republic	Indian Ocean	587041
Baffin Island	Arctic Ocean	507451
Sumatra	Indian Ocean	422200
Honshu	North-West	230092

	Pacific	
Great Britain	North Atlantic	229849
Victoria Island	Arctic Ocean	217290

DESERTS

Desert is a part of the Earth's surface i.e., too dry to support plant or animal life and is usually, sparsely and inhabited or uninhabited by man. There are four main categories of deserts namely :

- ☑ **The Hot (Tropical) Deserts :** These are the areas of high atmospheric pressure, with rainfall less than 25 cm, high summer temperatures; e.g., the Sahara, Arabian, Thar deserts.
- ☑ **The Coastal Deserts** : These are on the western margins of continents in latitudes 15-30, with cold offshore currents, and low summer temperature; e.g., Atakama, Patagonia, Namib, Kalahari, Mojave deserts.
- ☑ **The Mid-Latitude Deserts**: These are the deserts of continental interiors, with high summer and low winter temperature; e.g., Gobi, Taklamakan, Turkestan, Australian deserts.
- ☑ **The Ice and Snow deserts**: These are the deserts of Polar lands : e.g., the Greenland, the Antarctica.

THE GREAT DESERTS			
Desert		**Country**	**Area (1000 kms)**
1.	Sahara	North Africa	8400
2.	Australian	Australia	1550
3.	Arabian	Arabia	1300
4.	Gobi	Mongolia, China	1040
5.	Kalahari	Botswana	520
6.	Takla-	China	320

	Makan		
7.	Kara-Kum	Turkmenistan	272
8.	Thar	North-west India	260
9.	Sonoran	USA, Mexico	310
10.	Atacama	North Chile	180

SOIL

Soil is the loose material which forms the upper layer of the crust (i.e. the layers of loose fragments which cover most of the earth's land area). It consists mainly of very small particles. It has no definite and constant composition. It contains both decayed plants and animal substances. There are four main types of substances in varying proportion: ***Silica*** is present in soil in small crystalline grains which are the chief constituents of sand, ***Clay*** is a mixture of silicates and contains several minerals, comprising iron, potassium, calcium, sodium and aluminium. Particles of clay absorb water and swell, ***Chalk*** (calcium carbonate) provides the important element calcium, which is essential for the growth of plants, ***Humus*** is not a mineral. It is an organic matter. It is formed by the decomposition of plant remains, animal manures and dead animals, and is the most important element in the fertility of soil. A soil looks dark on account of the presence of humus.

Soil may be said to consist of two layers i.e., the **Top Soil** (the upper layer) and the **Sub-soil** (the parent material from which soil is formed). Below the sub-soil there is generally solid rock.

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

SOIL EROSION : Due to various agents of soil erosion, man being a principal contributing factor, we are losing in a few years a resource which has required hundreds of years for development. In many parts of our country vast areas have been devastated by soil erosion. The kind and degree of soil erosion depend much upon the texture and structure of the soil. It also depends on the soil erosion depend much upon the texture and structure of the soil. It also depends on the condition of climate and slope, nature of cultivation and other factors.

Causes of Soil Erosion: Running Water is the most important cause of destructive soil erosion. It takes place in two ways; (i) Gully Erosion and (ii) Sheet Erosion.
i) **Gully Erosion :** Generally occurs on steep slopes when no vegetation is left to arrest the flow of storm water, which then finds its way downhill in a series of channels. Every fresh downpour widens and deepens the channels which develop into gullies. Gullies cut up agricultural land into small fragments and make them finally unfit for cultivation. ii) **Sheet Erosion :** The removal of an even layer from the whole top soil by water is known as Sheet Erosion. It is a steady gnawing process and may not be easily seen on the ground. The primary cause of sheet erosion is the cultivation of land on slopes. Cultivation weakens the soil. Rain water that previously was absorbed by the soil then runs off the surface, carrying soil with it. The action is even stronger when there are no trees and the plains are exposed to heavy storms. Generally, when a severe drought is followed by a sudden heavy storm of rain, sheet erosion takes place more quickly. This is because during the drought the surface soil becomes baked hard and the soil is unable to absorb water so easily. This increases the run-off. Sheet erosion is the more harmful because it removes the finer and more fertile of the soil particles first.

Wind: When the wind blows over land on which there is no vegetation cover, there will be damage to the top-soil. Wind erosion has caused grave destruction of soil in regions of scanty rainfall. Originally this semi-arid land had a sufficient cover of grass and bushes, which could hold the soil in place. Due to overgrazing or cultivation the natural balance is upset, and wind erosion occurs. The wind drives away fine particles, which are the most fertile part of the soil.

Man is also responsible for soil erosion. His activities such as ploughing and the removal of natural vegetation help the wind, the running water and other agents. He is also responsible for allowing overgrazing of the land.

Glacier

A glacier is a large, slow-moving river of ice, formed from compacted layers of snow, that slowly deforms and flows in response to gravity and high pressure. The processes and landforms caused by glaciers and related to them are glacial landforms. The process of glacier growth and establishment is called glaciation. Glacier ice is the largest reservoir of fresh water on Earth, and second only to oceans as the largest reservoir of total water. Glaciers cover vast areas of polar regions but are restricted to the highest mountains in the tropics.

Many geomorphological processes are interrupted or modified significantly by glaciers. Geomorphological features created by glaciers include end, lateral, ground and medial moraines that form from glacially transported rocks and debris; U-shaped valleys and cirques at their heads, and the *glacier fringe*, which is the area where the glacier has recently melted into water. Much precipitation becomes trapped in the glaciers instead of flowing immediately back to the oceans, causing sea level drops and greatly modifying the hydrology of streams. The Earth's crust is pushed down by the weight of the ice, and meltwater commonly collects and forms lakes along the ice margins. Glacial epochs have come and gone repeatedly over the last million years. Presently, Earth is in a relatively warm period, called an interglacial, exacerbated by global warming with the resulting retreat of the glaciers. The Earth has been cyclically plunged into cold episodes, however, called glacials, in which the extent of glaciers is expanded, colloquially referred to as ice ages.

Types of glaciers

There are two main types of glaciers: *alpine glaciers*, which are found in mountain terrains, and *continental glaciers*, which can cover larger areas. A *temperate* glacier is at melting point throughout the year, from its surface to its base. The ice of *polar* glaciers is always below freezing point with most mass loss due to sublimation. *Sub-polar* glaciers have a seasonal zone of melting near the surface and have some internal drainage, but little to no basal melt.

The smallest alpine glaciers form in mountain valleys and are referred to as valley glaciers. Larger glaciers can cover an entire mountain, mountain chain or even a volcano; this type is known as an ice cap. Ice caps feed outlet glaciers, tongues of ice that extend into valleys below, far from the margins of those larger ice masses. Outlet glaciers are formed by the movement of ice from a polar ice cap, or an ice cap from mountainous regions, to the sea.

The largest glaciers are continental glaciers, enormous masses of ice that are not visibly affected by the landscape and that cover the entire surface beneath them, except possibly on the margins where they are thinnest. Antarctica and Greenland are the only places where continental ice sheets currently exist. These regions contain vast quantities of fresh water. The volume of ice is so large that if the Greenland ice sheet melted, it would cause sea levels to rise some six meters (20 ft) all around the world. If the Antarctic ice sheet melted, sea levels would rise up to 65 meters (210 ft). Plateau glaciers resemble ice sheets, but on a smaller scale. They cover some plateaus and high-altitude areas. This type of glacier appears in many places, especially in Iceland and some of the large islands in the Arctic Ocean, and throughout the northern Pacific Cordillera from southern British Columbia to western Alaska.

Formation of glacial ice : The snow which forms temperate glaciers is subject to repeated freezing and thawing, which changes it into a form of granular ice called névé. Under the pressure of the layers of ice and snow above it, this granular ice fuses into denser firn. Over a period of years, layers of firn undergo further compaction and become glacial ice. The distinctive blue tint of glacial ice is often wrongly attributed to Rayleigh scattering which is supposedly due to bubbles in the ice. The blue color is actually created for the same reason that water is blue, that is, its slight absorption of red light due to an overtone of the infrared OH stretching mode of the water molecule

The lower layers of glacial ice flow and deform plastically under the pressure, allowing the glacier as a whole to move slowly like a viscous fluid. Glaciers usually flow downslope, although they do not need a surface slope to flow, as they can be driven by the continuing accumulation of new snow at their source, creating thicker ice and a surface slope. The upper layers of glaciers are more brittle, and often form deep cracks known as crevasses or bergschrunds as they move.

Crevasses form due to internal differences in glacier velocity between two quasi-rigid parts above the deeper more plastic substrate far below. As the parts move at different speeds and directions, shear forces cause the two sections to break apart opening the crack of a crevasse all along the disconnecting faces. These crevasses make travel over glaciers hazardous. Subsequent heavy snow may form a fragile snow bridge, increasing the danger by hiding their presence at the surface. Glacial meltwaters flow throughout and underneath glaciers, carving channels in the ice (called *moulins*) similar to cave formation through rock and also helping to lubricate the glacier's movement. In the aftermath of the Little Ice Age, around 1850, the glaciers of the Earth have retreated substantially. Glacier retreat has increased since the 1980s, the coldest decade since 1900.

Occurrence : Extensive glaciers are found in Antarctica, Patagonia, Canada, Greenland and Iceland. Mountain glaciers are widespread e.g. in the Andes, the Himalaya, the Rocky Mountains, the Caucasus, and the Alps. On mainland Australia no glaciers exist today, although a small glacier on Mount Kosciuszko was present in the last glacial period, and Tasmania was widely glaciated. On New Zealand's South Island the West Coast bears the Fox and Franz Josef Glaciers. In New Guinea small glaciers are located on its highest summit massif of Puncak Jaya. Africa has glaciers on Mount Kilimanjaro in Tanzania, on Mount Kenya and in the Ruwenzori Range.

As temperature decreases with altitude, high mountains — even those near the Equator — have permanent snow cover on their upper portions, above the snow line. Examples include Mount Kilimanjaro and the Tropical Andes in South America; however, the only snow to occur exactly on the Equator is at 4,690 m (15,387 ft) on the southern slope of Volcán Cayambe in Ecuador.

Conversely, large areas of the Arctic and Antarctic are arid and receive little snowfall despite the bitter cold. Cold air, unlike warm air, is unable to transport much water vapor. In Antarctica, the snow does not melt even at sea level. In addition to the dry, unglaciated regions of the Arctic, there are some mountains and volcanoes in Bolivia, Chile and Argentina that are high (4,500 metres (14,800 ft) - 6,900 m (22,600 ft)) and cold, but the relative lack of precipitation prevents snow from accumulating into glaciers. This is because these peaks are located near or in the hyperarid Atacama desert. Further examples of these temperate unglaciated mountains is the Kunlun Mountains, Tibet and the Pamir Range to the north of the Himalayas in Central Asia. Here, just like the Andes, mountains in Central Asia can reach above 6,000 m (20,000 ft) and be barren of snow and ice due to the rain shadow effect caused by the taller Himalaya Range. During glacial periods of the Quaternary, most of Siberia, central and northern Alaska and all of Manchuria, were similarly too dry to support glaciers, though temperatures were as low as or lower than in glaciated areas of Europe and North America. This was because dry westerly winds from ice sheets in Europe and the coastal ranges in North America reduced precipitation to such an extent that glaciers could never develop except on a few high mountains like the Verkhoyansk Range (which still supports glaciers today).

Motion : Glaciers have a tendency to move, or "flow", downhill. While the bulk of a glacier flows in the direction of lower elevation, every point of the glacier can move at a different rate, and in a different direction. The general motion is due to the force of gravity, and the rate of flow at each point on the glacier is affected by many factors. Ice behaves like an easily breaking solid until its thickness exceeds about 50 meters (160 ft). The pressure on ice deeper than that depth causes plastic flow. The glacial ice is made up of layers of molecules stacked on top of each other, with relatively weak bonds between the layers. When the stress of the layer above exceeds the inter-layer binding strength, it moves faster than the layer below.

Speed : The speed of glacial displacement is partly determined by friction. Friction makes the ice at the bottom of the glacier move more slowly than the upper portion. In alpine glaciers, friction is also generated at the valley's side walls, which slows the edges relative to the center. This was confirmed by experiments in the 19th century, in which stakes were planted in a line across an alpine glacier, and as time passed, those in the center moved farther. Mean speeds vary; some have speeds so slow that trees can establish themselves among the deposited scourings. In other cases they can move as fast as meters per day, as in the case of Antarctica's Byrd Glacier, which moves 750-800 meters per year. Many glaciers have periods of very rapid advancement called surges. These glaciers exhibit normal movement until suddenly they accelerate, then return to their previous state. During these surges, the glacier may reach velocities far greater than normal speed These surges may be caused by failure of the underlying bedrock, the ponding of meltwater at the base of the glacier — perhaps delivered from a supraglacial lake — or the simple accumulation of mass beyond a critical "tipping point".

Moraines : Glacial moraines are formed by the deposition of material from a glacier and are exposed after the glacier has retreated. These features usually appear as linear mounds of till, a non-sorted mixture of rock, gravel and boulders within a matrix of a fine powdery material. Terminal or end moraines are formed at the foot or terminal end of a glacier. Lateral moraines are formed on the sides of the glacier. Medial moraines are formed when two different glaciers, flowing in the same direction, merge and the lateral moraines of each combine to form a moraine in the middle of the merged glacier. Less apparent is the ground moraine, also called *glacial drift*, which often blankets the surface underneath much of the glacier downslope from the equilibrium line. Glacial meltwaters contain rock flour, an extremely fine powder ground from the underlying rock by the glacier's movement. Other features formed by glacial deposition include long snake-like ridges formed by streambeds under glaciers, known as *eskers*, and distinctive streamlined hills, known as *drumlins*.

Stoss-and-lee erosional features are formed by glaciers and show the direction of their movement. Long linear rock scratches (that follow the glacier's direction of movement) are called *glacial striations*, and divots in the rock are called *chatter marks*. Both of these features are left on the surfaces of stationary rock that were once under a glacier and were formed when loose rocks and boulders in the ice were transported over the rock surface. Transport of fine-grained material within a glacier can smooth or polish the surface of rocks, leading to glacial polish. Glacial erratics are rounded boulders that were left by a melting glacier and are often seen perched precariously on exposed rock faces after glacial retreat. The term *moraine* is of French origin, and it was coined by peasants to describe alluvial embankments and rims found near the margins of glaciers in the French Alps. In modern geology, the term is used more broadly, and is applied to a series of formations, all of which are composed of till.

Drumlins : A drumlin field forms after a glacier has modified the landscape. The teardrop-shaped formations denote the direction of the ice flow. Drumlins are asymmetrical, canoe shaped hills with aerodynamic profiles made mainly of till. Their heights vary from 15 to 50 meters and they can reach a kilometer in length. The tilted side of the hill looks toward the direction from which the ice advanced (*stoss*), while the longer slope follows the ice's direction of movement (*lee*). Drumlins are found in groups called *drumlin fields* or *drumlin camps*.

Ogives : Ogives are alternating dark and light bands of ice occurring as ridges and valleys on glacier surfaces. They only occur below icefalls but not all icefalls have ogives below them. Once formed, they bend progressively downglacier due to the increased velocity toward the glacier's centerline. Ogives are likely linked to seasonal motion of the glacier as the width of one dark and one light band generally equals the annual movement of the glacier. The ridges and valleys are formed because ice from an icefall is severely broken up thereby increasing ablation surface area during the summertime creating a swale and creating space for snow accumulation in the winter creating a ridge.[1] Sometimes ogives are described as either wave ogives or band ogives in which they are solely undulations or varying color bands respectively.

Erosion : Rocks and sediments are added to glaciers through various processes. Glaciers erode the terrain principally through two methods: abrasion and plucking. As the glacier flows over the bedrock's fractured surface, it softens and lifts blocks of rock that are brought into the ice. This process is known as *plucking*, and it is produced when subglacial water penetrates the fractures and the subsequent freezing expansion separates them from the bedrock. When the water expands, it acts as a lever that loosens the rock by lifting it. This way, sediments of all sizes become part of the glacier's load. Abrasion occurs when the ice and the load of rock fragments slide over the bedrock and function as sandpaper that smoothes and polishes the surface situated below. This pulverized rock is called rock flour. This flour is formed by rock grains of a size between 0.002 and 0.00625 mm. Sometimes the amount of rock flour produced is so high that currents of meltwaters acquire a grayish color. Another of the visible characteristics of glacial erosion are glacial striations. These are produced when the bottom's ice contains large chunks of rock that mark trenches in the bedrock. By mapping the direction of the flutes the direction of the glacier's movement can be determined. Chatter marks are seen as lines of roughly crescent shape depressions in the rock underlying a glacier caused by the abrasion where a boulder in the ice catches and is then released repetitively as the glacier drags it over the underlying basal rock.

Material that becomes incorporated in a glacier are typically carried as far as the zone of ablation before being deposited. Glacial deposits are of two distinct types:

- Glacial till: material directly deposited from glacial ice. Till includes a mixture of undifferentiated material ranging from clay size to boulders, the usual composition of a moraine.

- Fluvial and outwash: sediments deposited by water. These deposits are stratified through various processes, such as boulders being separated from finer particles.

The larger pieces of rock which are encrusted in till or deposited on the surface are called *glacial erratics*. They may range in size from pebbles to boulders, but as they may be moved great distances they may be of drastically different type than the material upon which they are found. Patterns of glacial erratics provide clues of past glacial motions.

Glacial valleys : Before glaciation, mountain valleys have a characteristic "V" shape, produced by downward erosion by water. However, during glaciation, these valleys widen and deepen, forming a "U"-shaped glacial valley. Besides the deepening and widening of the valley, the glacier also smooths the valley due to erosion. In this way, it eliminates the spurs of earth that extend across the valley. Because of this interaction, triangular cliffs called truncated spurs are formed. Many glaciers deepen their valleys more than their smaller tributaries. Therefore, when the glaciers recede from the region, the valleys of the tributary glaciers remain above the main glacier's depression, and these are called hanging valleys. In parts of the soil that were affected by abrasion and plucking, the depressions left can be filled by lakes, called paternoster lakes.

At the 'start' of a classic valley glacier is the cirque, which has a bowl shape with escarped walls on three sides, but open on the side that descends into the valley. In the cirque, an accumulation of ice is formed. These begin as irregularities on the side of the mountain, which are later augmented in size by the coining of the ice. Once the glacier melts, these corries are usually occupied by small mountain lakes called tarns. There may be two glacial cirques 'back to back' which erode deep into their backwalls until only a narrow ridge, called an arête is left. This structure may result in a mountain pass.

Arêtes and horns (pyramid peak) : An arête is a narrow crest with a sharp edge. The meeting of three or more arêtes creates pointed pyramidal peaks and in extremely steep-sided forms these are called horns. Both features may have the same process behind their formation: the enlargement of cirques from glacial plucking and the action of the ice. Horns are formed by cirques that encircle a single mountain. Arêtes emerge in a similar manner; the only difference is that the cirques are not located in a circle, but rather on opposite sides along a divide. Arêtes can also be produced by the collision of two parallel glaciers. In this case, the glacial tongues cut the divides down to size through erosion, and polish the adjacent valleys.

Sheepback rock : Some rock formations in the path of a glacier are sculpted into small hills with a shape known as roche moutonnée or *sheepback*. An elongated, rounded, asymmetrical, bedrock knob can be produced by glacier erosion. It has a gentle slope on its up-glacier side and a steep to vertical face on the down-glacier side. The glacier abrades the smooth slope that it flows along, while rock is torn loose from the downstream side and carried away in ice, a process known as 'plucking'. Rock on this side is fractured by combinations of forces due to water, ice in rock cracks, and structural stresses.

Glacial Deposit Based Landforms : The water that rises from the ablation zone moves away from the glacier and carries with it fine eroded sediments. As the speed of the water decreases, so does its capacity to carry objects in suspension. The water then gradually deposits the sediment as it runs, creating an alluvial plain. When this phenomenon occurs in a valley, it is called a *valley train*. When the deposition is to an estuary, the sediments are known as "bay mud". Alluvial plains and valley trains are usually accompanied by basins known as kettles. Glacial depressions are also produced in till deposits. These depressions are formed when large ice blocks are stuck in the glacial alluvium and after melting, they leave holes in the sediment.

Deposits in contact with ice : When a glacier reduces in size to a critical point, its flow stops, and the ice becomes stationary. Meanwhile, meltwater flows over, within, and beneath the ice leave stratified alluvial deposits. Because of this, as the ice melts, it leaves stratified deposits in the form of columns, terraces and clusters. These types of deposits are known as *deposits in contact with ice*. When those deposits take the form of columns of tipped sides or mounds, which are called *kames*. Some *kames* form when meltwater deposits sediments through openings in the interior of the ice. In other cases, they are just the result of fans or deltas towards the exterior of the ice produced by meltwater. When the glacial ice occupies a valley it can form terraces or *kame* along the sides of the valley. A third type of deposit formed in contact with the ice is characterized by long, narrow sinuous crests composed fundamentally of sand and gravel deposited by streams of meltwater flowing within, beneath or on the glacier ice. After the ice has melted these linear ridges or eskers remain as landscape features. Some of these crests have heights exceeding 100 meters and their lengths surpass 100 km.

Loess deposits : Very fine glacial sediments or rock flour is often picked up by wind blowing over the bare surface and may be deposited great distances from the original fluvial deposition site. These eolian loess deposits may be very deep, even hundreds of meters, as in areas of China and the Midwestern United States.

Karst Topography

Karst topography is a landscape shaped by the dissolution of a layer or layers of soluble bedrock, usually carbonate rock such as limestone or dolomite. Due to subterranean drainage, there may be very limited surface water, even to the absence of all rivers and lakes. Many karst regions display distinctive surface features, with sinkholes or dolines being the most common. However, distinctive karst surface features may be completely absent where the soluble rock is mantled, such as by glacial debris, or confined by a superimposed non-soluble rock strata. Some karst regions include thousands of caves, even though evidence of caves that are big enough for human exploration is not a required characteristic of karst

Karst landforms are generally the result of mildly acidic water acting on soluble bedrock such as limestone or dolostone. The carbonic acid that causes these features is formed as rain passes through the atmosphere picking up CO_2, which dissolves in the water. Once the rain reaches the ground, it may pass through soil that may provide further CO_2 to form a weak carbonic acid solution: $H_2O + CO_2 \rightarrow H_2CO_3$. Recent studies of sulfates in karst waters suggests sulfuric and hydrosulfuric acids may also play an important role in karst formation. This mildly acidic water begins to dissolve the surface and any fractures or bedding planes in the limestone bedrock. Over time these fractures enlarge as the bedrock continues to dissolve. Openings in the rock increase in size, and an underground drainage system begins to develop, allowing more water to pass through and accelerating the formation of underground karst features.

Cavern : It is a natural underground void large enough for a human to enter. Some people suggest that the term *cave* should only apply to cavities that have some part that does not receive daylight; however, in popular usage, the term includes smaller spaces like sea caves, rock shelters, and grottos. Speleology is the science of exploration and study of all aspects of caves.

Stalactite : stalactite from the word for "drip" and meaning "that which drips") is a type of speleothem (secondary mineral) that hangs from the ceiling or wall of limestone caves. It is sometimes referred to as dripstone.

Stalagmite : stalagmite is a type of speleothem that rises from the floor of a limestone cave due to the dripping of mineralized solutions and the deposition of calcium carbonate.

ATMOSPHERE

NATURE OF THE ATMOSPHERE : The atmosphere is as much a part of the earth as land or water, although we may not feel, it, except when it moves as wind, it is not as dense as either land or water, but it has weight and exerts pressure. Held to the earth by gravitational attraction, this envelope is densest at sea level and thins rapidly upward.

Composition of Atmosphere: The atmosphere constitutes a mixture of gases, the composition and ratio of which vary somewhat with height. About 21 percent of it consists of oxygen which helps burning and breathing and without which we cannot live. The bulk of the atmosphere is made up of an inert gas, nitrogen, which dilutes the oxygen and slows down the process of oxidation. It is also necessary for the growth of plant life. There is a small amount of carbon dioxide which the plants utilise during the process of photosynthesis. This gas absorbs heat and thus allows the lower atmosphere to be warmed by heat radiation coming from the sun and from the earth's surface. It is the heaviest of the gases of the air and, therefore, the lower layers of the troposphere contain much more CO_2 than the upper layers. There are also traces of argon, ammonia and water vapour.

The atmosphere protects us from the millions of meteors and meteoric particles which fall toward the earth every day. It filters a great deal of the ultra-violet light coming from the Sun. It acts as a huge air-conditioner moderating the extremes of heat and cold. It is because of the atmosphere that we have winds and rain and other phenomena on which all plant and animal life depend. The main reason why the moon is uninhabitable is its lack of suitable atmosphere.

Layers of Atmosphere : The atmosphere that surrounds the earth is not of the same thickness at all levels. It is built more like a four layer cake each layer having its own characteristics. The **Troposphere** is the lower layer of the atmosphere and extends upto 8 km at the equator. About 90 % of the atmosphere's total mass is contained within this layer. The troposphere acts as a warm blanket to moderate the extremes of outer space. On the average temperature decreases everywhere with the height at the rate of 6°C per kilometre. The **Stratosphere** lies above the troposphere. Within it the temperature does not decrease with altitude as it does in the troposphere nor is there much vertical movement of the air. The stratosphere expends upto 80 km above the surface of the earth. The **Ionosphere** forms the next layer of the atmosphere from 80 km to 480 km. Radio waves used in long-distance radio communications are reflected back to earth by the ionosphere. In this way, radio messages can be transmitted round the curve of the Earth. It also benefits man by absorbing the sun's deadly x-rays. The northern lights or aurora borealis are in this zone. The outermost layer of atmosphere is known as the **Exosphere**. It lies somewhere between 480 and 960 km above the Earth.

WEATHER AND CLIMATE

Climate is one of the basic elements in the natural environment. It affects landforms, soil types and vegetation. Its influence on man is very great. The term "climate" should not be confused with "weather". Weather is the day to day condition of the atmosphere at any place as regards temperature, rainfall, winds, humidity, sunshine and cloudiness and such other elements. Climate is generally defined as the average state of weather. The elements to be considered are the same while studying the climate or the weather conditions of a place, but weather refers mainly to short periods like a day, a week, a month or a little longer while climate is concerned with average conditions determined by observations over long periods. Both weather and climate are affected by such things as directions of the sun's rays and the length of day, altitude, distribution of land and water bodies, direction of mountain ranges, air pressure, winds and ocean currents.

ELEMENTS OF CLIMATE

The main elements of climate are : Temperature, Pressure, Winds and Rainfall.

☐ **Temperature:** "Temperature" is the term used to express the intensity or degree of heat. The sun is the primary source of heat for the earth and although the earth intercepts only a fraction of this solar energy, both plant and animal life depend upon it. The amount of heat received at any place therefore depends mainly on i) **The duration of sunlight,** and ii) **The angle at which the sun's rays** strike the earth.

FACTORS AFFECTING AIR TEMPERATURE OVER THE EARTH'S SURFACE

1. **Latitude** : This midday sun is almost overhead within the tropics, while outside the tropics the sun's rays fall obliquely. Within the tropics the rays are concentrated on a smaller area and pass through less atmosphere. On the other hand, outside the tropics, the rays are spread over a larger area and pass through a longer distance and much of the heat is absorbed by clouds, water vapour and dust particles.

2. **Altitude** : The atmosphere is mainly heated by conduction, namely, by the land or water with which it is in contact. The effects of the heat are felt more in the layers of the atmosphere near the surface of the earth. Hence, places nearer to the earth's surface are warmer than those higher up.

3. **Distance from the Sea** : Due to the phenomena of land and sea breezes the temperature of the coastal margins is comparatively cooler than that of a place situated far away from the sea.

4. **Ocean Currents and Winds** : Warm and cool ocean currents raise or lower the temperatures of land surfaces along the coastal margins. This effect is felt all the more if the winds are on-shore i.e. blowing from the sea towards land.

5. **The Slope of the land** : Slopes facing south in the Northern Hemisphere are warmer than those facing north. This is because the rays of the sun strike the south-facing slopes at a steeper angle than they do the northern slopes. The severe cold of Siberia is largely due to the fact that the country slopes towards the Arctic Circle. North of the Equator, the northern slopes of the east-west valleys have a less rigorous climate than the southern, because they get the full benefit of the sun.

6. **Nature of soil** : Alluvial oil can retain water; on rocky soil the rainfall runs quickly off the surface and is lost. The more water a soil can retain, the less rapidly it heats or cools. Rocky and sandy soil is heated more rapidly and also cooled more rapidly. This increases the day temperatures and decreases the night temperatures. The

great diurnal range of temperature in the Deserts is partly due to the nature of soil. Dark coloured soils and surfaces absorb more of the sun's heat than light coloured ones.

7. **Vegetation :** Forests are like sponges which retain moisture in the soil. They also prevent the air from being heated rapidly during the day and from being cooled quickly during the night. The dense vegetation of the Equatorial forests cuts off much of the incoming insolation and in many places sunlight never reaches the ground. For this reason, it is cool in the jungle and its shade temperature is a few degrees lower than that of open spaces in similar latitudes elsewhere.

8. **Clouds and Rainfall :** Clouds check solar radiation by day and ground radiation by night. The intense heat in the Savanna regions is partly due to the lack of clouds. There are few clouds in the tropical deserts so that sunshine is abundant. This makes these regions much hotter and drier than the equatorial regions. The nature of clouds, whether cirrus, cumulus or stratus and its position in the sky also affect the sunshine hours.

WORLD DISTRIBUTION OF TEMPERATURE

Isotherms: There is a convenient method of showing the distribution of temperature over the earth or over large areas of the earth. This is done by means of maps employing isotherms. The word **"isotherm"** means **equal heat**. Isotherms are imaginary lines drawn on a map, joining places having the same average temperature for a specified period, supposing them to be at sea level. It means that the isotherms show the average temperature of that place as it would be, if the place were at sea level.

January and July Isotherms: In most of the Atlas's, the isothermal maps show January and July temperatures as they represent the extremes of heat and cold for the Northern and Southern Hemispheres. In the Northern Hemisphere temperatures are lowest in January and highest in July. Similarly in the Southern Hemisphere temperatures are highest in January and lowest in July.

MAIN FACTORS CONTROLLING THE CLIMATE OF A REGION

1. **Latitude**: Latitude or distance from the equator controls the length of the day and night at different seasons of the year. It is evident from the fact that the duration of daylight goes on increasing in summer in the Northern Hemisphere as one goes from the equator towards the pole.

2. **Altitude** : Altitude affects the climate in several ways. As we go higher up a mountain there is a decrease in temperature. This rate of decrease is not uniform. It varies with time of day, season and place. The average decrease of temperature upward in the troposphere is about $6^{o}C$ per km above sea level. This rate of fall of temperature with height is referred to as normal lapse rate.

3. **Distance from the Sea:** This factor modifies the influence of latitude to a great extent. The sea has a moderating influence on the climate of coastal area due to the

phenomena of land and sea breezes. Places which are situated far away from the influence of the sea have a large range of temperature.

4. **The Direction of Mountain Ranges:** The direction of Mountain ranges makes a great difference to the climate of country. Mountains may shield a region from the influence of a cold (or warm) wind and thus create a difference in temperature between places otherwise similarly situated.

5. **Ocean Currents:** Warm Ocean currents tend to make the climate of the neighbouring coastlands warmer than it would otherwise be. Parts of coastal Europe are very warm in January as compared with the normal for their latitudes. London on Latitude 51°N is quite warm while New York on Latitude 40°N is very cold although it is nearer the Equator. The former is kept warm by the North Atlantic Drift while the latter is affected by the cold Labrador Current. The effect of the current is more marked when the wind blows from the sea to the land. Winds blowing over warm currents pick up moisture and bring much rain. This accounts for the heavier rainfall on the West European coastlands where the prevailing westerlies blow from the sea to the land.

6. **Prevailing Winds:** When a wind blows more frequently from one direction than from any other, it is called a prevailing wind. A wind from the sea lowers the summer temperatures and raises the winter temperatures. If winds blow from the lands, they are generally dry.

ATMOSPHERIC PRESSURE

The pressure exerted by the atmosphere as a results of its weight on the surface of the Earth is referred to as atmospheric pressure.

Atmospheric Pressure

The weight of a column of air contained in a unit area from the mean sea level to the top of the atmosphere is called as atmospheric pressure. It is expressed in units of mb and pascals. The widely used unit is kilo pascal written as hPa.

FACTORS EFFECTING ATMOSPHERIC PRESSURE

Atmospheric pressure depends on three main factors: 1. **Altitude** : As you go higher up the pressure of the air decreases. Generally speaking, this decrease in pressure is at a rate of 1 cm for every 110 metres of ascent. At 5500 metres it is about half that figure and at a height of 48 km it is one-thousand the pressure at sea-level. This is because at great heights the air is thinner or less dense than the air at sea-level. Pressure, therefore, decreases as altitude increases. 2. **Temperature** : When the temperature rises, air expands, that is, it becomes less dense and exerts less pressure. When temperature falls air becomes more dense and its pressure increases. 3. **Water Vapour :** Air containing water vapour is lighter than dry air. The more water vapour there is the lighter the air. This is because water vapour in humid air displaces an equal volume of dry air. A certain volume of dry air contains more nitrogen and oxygen, but the same volume of humid air with more water vapour contains comparatively less nitrogen and oxygen. This makes the humid air lighter than dry air.

ISOBARS : The pressure of air is shown on weather maps by means of lines called "*isobars*" meaning "*equal weight*". An isobar is an imaginary line drawn on a map (or a weather chart) joining all places having equal atmospheric pressure, supposing these places to be at sea-level. When the isobars are far apart from the one another, there is little difference of atmospheric pressure and the weather is warm. When they are close to one another there is a great difference of atmospheric pressure over a small area of the earth's surface and the weather is stormy. When isobars are close together they indicate a rapid change of pressure. The daily weather map (or synoptic chart) shows isobars at a particular moment on a particular day. It is the basis of weather forecasting. The pressure map depicts the average air pressure over a long period of time. It is not useful in weather forecasting but it is invaluable for climate study.

WIND : Wind is the air in motion. It is a horizontal movement of air. When the air is at rest compared to surrounding objects, we are scarcely aware of its presence, but when it is in motion we readily recognise it. The chief cause of wind is the unequal heating of the atmosphere by the sun resulting in differences in the pressure between places. Winds always blow from areas of higher pressure toward areas of lower pressure. The greater the difference in pressure between two places, the faster the air will move. A wind is named according to the *direction from which it blows*. Thus, a wind from the south blowing towards the north is called a south wind. The Earth spins on its axis, which affects the direction of the wind. In the Northern hemisphere winds are swung to the right, and in the Southern to the left. This is called *the Coriolis Effect*. This is one of the factors affecting the wind direction.

TYPES OF WINDS : For an academic study winds can be classified into **Planetary Winds** (or the Permanent Winds of the Earth) and **Local** and other **Periodic Winds.**

Planetary Winds : The Planetary Winds are the general circulation of winds throughout the lower atmosphere of the Earth. Such a circulation of air would be set up on any planet like the Earth, which has an atmosphere envelope and rotates on its axis and which has no uniform land surface.

Some of the important Planetary winds are:

a) **The Doldrums (or the Belt of Equatorial Calms):** It is the low pressure belt round the equator, caused by the great heat making the air hot and therefore light. It s a region of calms and very light winds. Here, the North East and the South East Trade Winds coverage on and meet each other. The major movement of air in this region is upward. Although there are no regular winds, violent squalls and thunderstorms, with heavy rains occur frequently. The maximum rainfall is received at equinoxes and minimum at the solstices.

b) **The Trade Winds**: The name Trade Winds is derived from the nautical expression "to blow tread" meaning to blow along a regular "tread" or path. These winds seem to tread out a path in the seas for sailing vessels by their steadiness and regularity and so they came to be known as "trade winds". At the equator there is great heat causing the air over that region to expand and rise up in the atmosphere. This creates a low pressure area. But, as we saw earlier, there are Sub-tropical high pressure belts between 30° to 40° North and South from where winds blow towards the low pressure area around the equator. These winds are the Trade Winds. They are regular both in strength and direction. These winds blow between approximately 30° north and 30° south and their direction is north-east in the Northern Hemisphere and south-east in the Southern Hemisphere. For this reason, whatever moisture they bring is deposited on the eastern parts of the continents while the western parts have very little rain. The great hot deserts like the Mexican, Kalahari and the Atacama are, therefore, found on the western margins of the continents. There is generally fair weather in the belt of the Trade Winds except where the winds blow from the ocean to a mountainous coast. In the Indian Ocean and among the islands of the south-west Pacific, they are reversed in summer by the Monsoons.

c) **The Prevailing Westerlies (or simply "Westerlies" because they blow out of the west):** They blow outside the Tropics, in the Temperate Zone, on the poleward side of the Trade Winds, and between 30° and 60° north and south. The weather in their area is characterised by a constant procession of cyclones (or depressions) and anticyclones. These winds are also deflected due to the rotation of the earth (to the right in the Northern Hemisphere and left in the Southern Hemisphere). They are not so constant in strength and direction as the Trade Winds. However, in the Southern Hemisphere they are more constant because there are no large land masses to interrupt them. In places they become so strong between latitude 40° and 65° south, that the sailors use the word "Roaring Forties" the Furious Fifties and the Shrieking Sixties to describe them. The Westerlies bring rain. They first strike the western coasts of the continents which are therefore rainy, for example, the west coast of Europe and Southern Chile. Similarly, the Roaring Forties bring heavy rain to the western mountainous coasts of Tasmania and New Zealand.

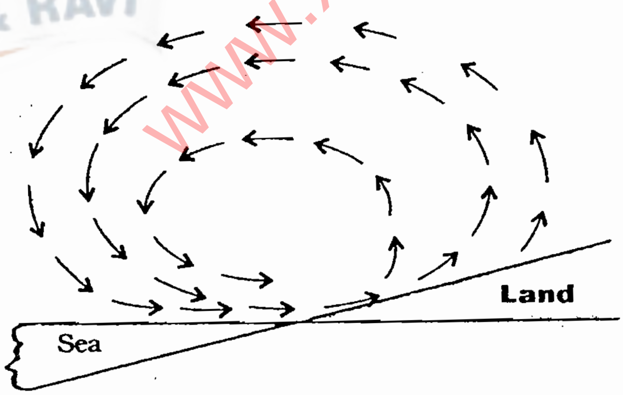
d) **The Polar Winds**: Towards the poles and over the ice-covered lands like Greenland and the Antarctica, the air that flows at higher levels is cooled and consequently sinks towards the earth. This cold air forms an area of high pressure (the Polar High) from which the air moves out. These winds are also deflected to the west in both Hemispheres to form the Polar Easterlies. The amount of deflection due to the earth's rotation is very great. The winds starting from the north pole and from the south pole toward the equator are deflected as much as 90° from their original courses until they blow eastward.

It must be noted that the pattern of the wind systems is greatly affected by certain factors, for example, the different parts of the earth's surface move at different speeds. This has effects on the speed and direction of the winds. Secondly, the earth's surface is composed both of land and sea. This results in the phenomena of land and sea breezes which affect the climate of the places near the seacoasts. For this same reason there are Monsoons developed over the large land masses of India, southern China and the countries of south-east Asia. There are also larger expanses of water in the Southern Hemisphere than in the Northern Hemisphere so that winds are more constant in the Southern Hemisphere. Finally, the position of the Sun in its yearly migration north and south of equator also affects the wind system. The whole wind system swings about 7° north or south with the Sun. It is only when the Sun is shining over the equator that there is equal distribution of heat on either side of it.

LOCAL AND REGIONAL WINDS

Land and Water differences: Land gets heated quickly during the day but also loses its heat quickly after sunset, whereas water takes much longer time to get warm, but also longer to get cold. The specific heat of water is very high compared with that of land. Two to five times as much heat is required to raise the temperature of water one degree as for an equal volume of dry earth.

Water is also a bad conductor of heat; its transparency and mobility allow the rays of the Sun to penetrate deeper into it, and the heat is spread over a greater volume, hence the same amount of heat produces a greater rise in temperature on land areas, but only moderate over water areas.



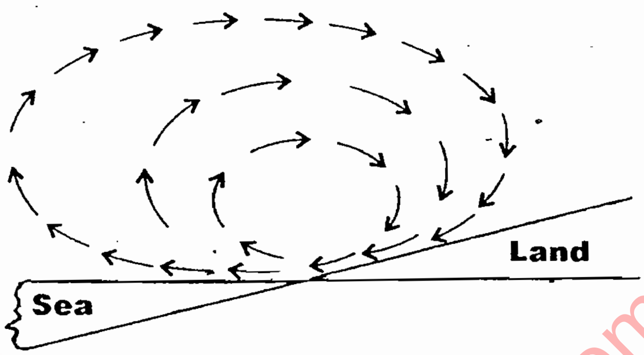
Sea Breeze

Sea Breeze: During the day, the greater heating of the land causes the air to ascend, causing a low pressure area over land and the cool heavy air from the sea moves in to take its place. This is **sea breeze**. The sea breeze is most noticeable and most regular when temperature changes are most regular, that is, when the pressure gradient is slight and the sky is clear. The strength of the sea breeze also depends on the topography of the coast and the regions. In Temperate regions it is about 15 to 20 km per hour and in the Tropics it may reach 25 to 30 km. Sea breeze is usually cool and fresh. It moderates the weather of the coastal belt on hot summer afternoons.

Land Breeze: During the night the land cools quickly so that it is colder than the sea. A low pressure area is caused over the sea and the cooler heavier air from the land begins to flow towards the sea.

The land breeze set in by midnight or a few hours later. Like the sea breeze the land breeze is also influenced by the relief of the land near the coast but it is less developed than the sea breeze.

The general effect of the contrast in heating of land and water areas is to produce cooler winters and warmer summers in the centres of continents than along coasts.



Land Breeze

Monsoon

A **monsoon** is a seasonal prevailing wind that lasts for several months. The term was first used in English in India, Bangladesh, Pakistan, and neighboring countries to refer to the big seasonal winds blowing from the Indian Ocean and Arabian Sea in the southwest bringing heavy rainfall to the region. In hydrology, monsoon rainfall is considered to be that which occurs in any region that receives the majority of its rain during a particular season. This allows other regions of the world such as North America, South America, Sub-Saharan Africa, Australia and East Asia to qualify as monsoon regions In terms of total precipitation and total area covered, the monsoons affecting the Indian subcontinent dwarf the North American monsoon. The South Asian monsoon affects a larger number of people due to the high density of population in this part of the world.

"Most summer monsoons have a dominant westerly component and a strong tendency to ascend and produce copious amounts of rain (because of the condensation of water vapor in the rising air). The intensity and duration, however, are not uniform from year to year. Winter monsoons, by contrast, have a dominant easterly component and a strong tendency to diverge, subside, and cause drought."

Process : Monsoons are caused by the larger amplitude of the seasonal cycle of land temperature compared to that of nearby oceans. This differential warming happens because heat in the ocean is mixed vertically through a "mixed layer" that may be fifty meters deep, through the action of wind and buoyancy-generated turbulence, whereas the land surface conducts heat slowly, with the seasonal signal penetrating perhaps a meter or so. Additionally, the specific heat capacity of liquid water is significantly higher than that of most materials that make up land. Together, these factors mean that the heat capacity of the layer participating in the seasonal cycle is much larger over the oceans than over land, with the consequence that the air over the land warms faster and reaches a higher temperature than the air over the ocean. The hot air over the land tends to rise, creating an area of low pressure. This creates a steady wind blowing toward the land, bringing the moist near-surface air over the oceans with it. Similar rainfall is caused by the moist ocean air being lifted upwards by mountains, surface heating, convergence at the surface, divergence aloft, or from storm-produced outflows at the surface. However the lifting occurs, the air cools due expansion in lower pressure, which in turn produces condensation.

In winter, the land cools off quickly, but the ocean keeps the heat longer. The hot air over the ocean rises, creating a low pressure area and a breeze from land to ocean while a large area of drying high pressure is formed over the land, increased by wintertime cooling. Monsoons are similar to sea and land breezes, a term usually referring to the localized, diurnal (daily) cycle of circulation near coastlines everywhere, but they are much larger in scale, stronger and seasonal.

1. **Northeast Monsoon (Southern Asia and Australasia) :** In Southern Asia, the northeastern monsoons take place from December to early March. The temperature over central Asia is less than 25°C as it is the northern hemisphere winter, therefore creating a zone of high pressure there. The jet stream in this region splits into the southern subtropical jet and the polar jet. The subtropical flow directs northeasterly winds to blow across southern Asia, creating dry air streams which produce clear skies over India. Meanwhile, a low pressure system develops over South-East Asia and Australasia and winds are directed toward Australia known as a monsoon trough.

2. **South-West Summer Monsoon :** The southwestern summer monsoons occur from June through September. The Great Indian Desert (Thar Desert) and adjoining areas of the northern and central Indian subcontinent heats up considerably during the hot summers. This causes a low pressure area over the northern and central Indian subcontinent. To fill this void, the moisture-laden winds from the Indian Ocean rush in to the subcontinent. These winds, rich in moisture, are drawn towards the Himalayas, creating winds blowing storm clouds towards the subcontinent. However the Himalayas act like a high wall and do not allow the winds to pass into Central Asia, forcing them to rise. With the gain in altitude of the clouds, the temperature drops and precipitation occurs. Some areas of the subcontinent receive up to 10,000 mm of rain.

The southwest monsoon is generally expected to begin around the start of June and dies down by the end of September. The moisture-laden winds on reaching the southernmost point of the Indian peninsula, due to its topology, become divided into two parts:

- *Arabian Sea Branch of the SW Monsoon*
- *Bay of Bengal Branch of the SW Monsoon*

The **Arabian Sea Branch of the SW Monsoon** first hits the Western Ghats of the coastal state of Kerala, India and hence Kerala is the first state in India to receive rain from the South-West Monsoon. This branch of the monsoon moves northwards along the Western Ghats giving rain to the coastal areas west of the Western Ghats. It is to be noted that the eastern parts of the Western Ghats do not receive much rain from this monsoon as the wind does not cross the Western Ghats.

The **Bay of Bengal Branch of SW Monsoon** flows over the Bay of Bengal heading towards North-Eastern India and Bengal, picking up more moisture from the Bay of Bengal. Its hits the Eastern Himalaya and provides a huge amount of rain to the regions of North-East India, Bangladesh and West Bengal. Mawsynram, situated on the southern slopes of the Eastern Himalaya in Shillong, India is one of the wettest places on Earth. After striking the Eastern Himalaya it turns towards the West, travels over the Indo-Gangetic Plain, at a rate of roughly 1-2 weeks per state pouring rain all along its way. The monsoon accounts for 80 percent of the rainfall in the country. Indian agriculture (which accounts for 25 percent of the GDP and employs 70 percent of the population) is heavily dependent on the rains, especially crops like cotton, rice, oilseeds and coarse grains. A delay of a few days in the arrival of the monsoon can, and does, badly affect the economy, as evidenced in the numerous droughts in India in the 90s.

.June 1 is regarded as the date of onset of the monsoon in India, which is the average date on which the monsoon strikes Kerala over the years for which scientific data is available with the Indian Meteoreological Department.

3. **North-East Monsoon (Retreating Monsoon) :** Around September, with the sun fast retreating south, the northern land mass of the Indian subcontinent begins to cool off rapidly. With this air pressure begins to build over northern India. The Indian Ocean and its surrounding atmosphere still holds its heat. This causes the cold wind to sweep down from the Himalayas and Indo-Gangetic Plain towards the vast spans of the Indian Ocean south of the Deccan peninsular. This is known as the North-East Monsoon or Retreating Monsoon. While traveling towards the Indian Ocean, the dry cold wind picks up some moisture from the Bay of Bengal and pours it over peninsular India. Cities like Chennai, which get less rain from the South-West Monsoon, receives rain from the Retreating Monsoon. About 50% - 60% of the rain received by the state of Tamil Nadu is from the North-East Monsoon. It is worth noting that North-East Monsoon (or the Retreating Monsoon) is not able to bring as much rain as the South-West Monsoon.

4.North American Monsoon : The North American Monsoon (NAM) occurs from late June or early July into September, originating over Mexico and spreading into the southwest United States by mid-July. It affects Mexico along the Sierra Madre Occidental as well as Arizona, New Mexico, Nevada, Utah, Colorado, West Texas, and California. It pushes as far west as the Peninsular Ranges and Transverse Ranges of southern California, but rarely reaches the coastal strip (a wall of desert thunderstorms only a half-hour's drive away is a common summer sight from the sunny skies along the coast during the monsoon). The North American monsoon is known to many as the *Summer*, *Southwest*, *Mexican* or *Arizona* monsoon. It is also sometimes called the *Desert Monsoon* as a large part of the affect

5.African Monsoon : The monsoon of western sub-Saharan Africa is the result of the seasonal shifts of the Intertropical Convergence Zone and the great seasonal temperature differences between the Sahara and the equatorial Atlantic Ocean. It migrates northward from the equatorial Atlantic in February, reaches western Africa on June 22, then moves back to the south by October.[15] The dry, northeasterly trade winds, and their more extreme form, the harmattan, are interrupted by the northern shift in the ITCZ and resultant southerly, rain-bearing winds during the summer. The semiarid Sahel and Sudan depend upon this pattern for most of their precipitationed area is desert..

6.South American Monsoon : Much of Brazil experiences seasonal wind patterns that bring a summer maximum to precipitation. Rio de Janeiro is infamous for flooding as a result of monsoon rains

OTHER LOCAL WINDS

The Sirocco is the name given to the southerly wind experienced in North Africa, Sicily and Southern Italy. It originates in the Sahara Desert and reaches the sea as a very hot dry wind. Where it descends from a mountain range, as for example, on the Algerian coast, its heat and dryness are increased. The Sirocco withers vegetation and often causes much damage to crops, especially if it blows while the vines and olives are in blossom. In Egypt this type of wind is known as the khamsin.

The Mistral is the name given to the strong, northerly or north-westerly wind experienced on the shores of the north-west Mediterranean. It is most prevalent during the winter. The wind is strong and may sometimes have a speed of over 100 km per hour. It is also very cold and harmful to plant life.

The Foehn is the name given to the hot dry wind which blows down the leeward slope of a mountain. Foehn winds often blow with great violence and cause much discomfort. In spring they cause snow to disappear very quickly and thus make pasture available for animals sooner than would otherwise be the case. Similar winds blowing eastwards across the Prairies of North America from the Rockies are known as the Chinook winds.

Loo is a hot wind which blows usually in the afternoon in the plains of northern India during May and June. Its temperature may range between 45°C and 50°C which is hot enough to cause sunstrokes. Norwesters are violent thunderstorms which occur on the passage of a strong wind that approaches from the west or north-west, hence the name "Nor'westers". They occur in the Bengal and Assam region during the hot season (April to June) before the onset of the South-West Monsoon.

How to measure Wind? The two most important things about the wind are its speed and direction in which it is blowing. We use a weather vane or a windsock (a kind of long cloth tube through which the wind is funnelled) to see wind direction. It is expressed in compass points. Wind speed is measured by the Beaufort Scale, windsocks or by special scientific instruments called anemometers. The unit of measurement is kilometres per hour (km/h) or knots.

The Beaufort Scale The Beaufort Scale was invented in 1805 by Admiral Beaufort to estimate wind speed through observations of objects. The original scale was for use at sea but it has been adapted for use on land.

The Beaufort Scale

Force	Strength	Weather Symbol	km/h	Effect
0	Calm		0-1	Smoke rises vertically
1	Light air		1-5	Smoke drifts slowly
2	Light breeze		6-11	Wind felt on face; leaves rustle
3	Gentle breeze		12-19	Twigs move; light flag unfurls
4	Moderate breeze		20-29	Dust and paper blown about; small branches move
5	Fresh breeze		30-39	Wavelets on inland water; small trees move
6	Strong breeze		40-50	Large branches sway; umbrellas turn inside out
7	Near gale		51-61	Whole trees sway; difficult to walk against wind
8	Gale		62-74	Twigs break off trees; walking very hard
9	Strong gale		75-87	Chimney pots, roof tiles and branches blown down
10	Storm		88-101	Widespread damage to buildings
11	Violent Storm		102-117	Widespread damage to buildings
12	Hurricane		Over 119	Devastation

CYCLONES AND ANTICYCLONES: A Cyclone is a small low pressure system with winds blowing anti-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. The pressure falls rapidly in the centre with strong winds spiraling around it. Cyclones are roughly circular or oval in form, hence the isobars on weather maps are also shown circular or oval. Cyclones originate as a wave along a frong separating two masses of air differing in temperature, densities and directions. They bring rain because in a cyclone the warm moist air is made to rise over a mass of cold heavier air. With the approach of a cyclone the sky becomes dull and overclouded and these is heavy rain accompanied by lightning and thunder. A **cyclone** is always on the move and follows in the direction of the regular wind system in the particular area. Thus in the region of the Westerlies, most cyclones move forward eastwards, while in the trade wind regions the movement is in a westerly direction.

Cyclones and Depressions: Tropical cyclones are somewhat different from the cyclone (or Depressions as they are called) of the Temperate regions. The Depressions in the

Temperate regions are much larger, sometimes being as much a 3000 km across and are generally oval in shape. They are not violent and they travel in fairly well defined paths at average speeds of 35 to 50 km an hour. **Tropical cyclones** originate mostly over the oceans in the tropical or sub-tropical regions. The winds are more violent and cause severe damage to life and property. They occur frequently in the Gulf of Mexico, the Carribean Sea, the western Pacific, of the east and west coast of India, east of Southern Africa and north of Australia. They are known by different names in different parts of the world : hurricanes in the West Indies, typhoons in the China Seas and cyclones in the Indian Ocean. Similar storms of northern Australia are locally known as willy willies. Another type of cyclone is the tornado which often blows in the Mississippi basin in the U.S.A. The winds in them may attain the velocity of over 300 km per hour. Where it touches the ground it causes unbelievable destruction.

Anticyclones: An Anticylone is an area of high atmospheric pressure which goes on diminishing outward from the centre. The winds are usually light and blow clockwise in the Northern Hemisphere (anti-clockwise in the Southern Hemisphere). They are also roughly circular or oval in shape.

The ***anticyclones*** do not move in any definite direction. They also move very slowly and sometimes may drift about and gradually disperse or remain stationary for several days. As the air is warmed when descending, it has a tenancy to gather moisture rather than deposit it. There is, therefore, less cloudiness and very little rain in an anticyclone. Jet Streams: They are powerful currents of air that move along west to east courses at heights between 9,000 metres and 15,000 metres. They attain speeds of 650 km per hour. They are created by air temperature differences where weather fronts meet. Scientists say that their behaviour has a great effect on weather patterns throughout the world.

Clouds :

Cloud is a mass of minute water droplets or tiny crystals of ice formed by the condensation of the water vapour in free air at considerable elevations. As the clouds are formed at some height over the surface of the earth, they take various shapes. According to their height, expanse, density and transparency or opaqueness clouds are grouped under four types: i) cirrus; ii) cumulus; iii) stratus; iv) nimbus.

Cirrus : Cirrus clouds are formed at high altitudes (8,000-12,000m). They are thin and detatched clouds having a feathery appearance. They are always white in colour.

Cumulus : Cumulus clouds look like cotton wool. They are generally formed at a height of 4,000-7000 m. they exist in patches and can be seen scattered here and there. They have a flat base.

Stratus : As their name implies, these are layered clouds covering large portions of the sky. These clouds are generally formed either due to loss of heat or the mixing of air masses with different temperatures.

Nimbus : Nimbus clouds are black or dark gray. They form at middle levels or very near to the surface of the earth. These are extremely dense and opaque to the rays of the sun. sometimes, the clouds are so low that they seem to touch the ground. Nimbus clouds are shapeless masses of thick vapour.

PRECIPITATION

The process of continuous condensation in free air helps the condensed particles to grow in size. When the resistance of the air fails to hold them against the force of gravity, they fall on to the earth's surface. So after the condensation of water vapor, the release of moisture is known as precipitation. This may take place in liquid or solid form. The precipitation in the form of water is called rainfall, when the temperature is lower than the 0^{o}c, precipitation takes place in the form of fine flakes of snow and is called snowfall. Moisture is released in the form of hexagonal crystals. These crystals form flakes of snow. Besides rain and snow, other forms of precipitation are sleet and hail, though the latter are limited in occurrence and are sporadic in both time and space.

Sleet is frozen raindrops and refrozen melted snow-water. When a layer of air with the temperature above freeing point overlies a subfreezing layer near the ground, precipitation takes place in the form of sleet. Raindrops, which leave the warmer air, encounter the colder air below. As a result, they solidify and reach the ground as small pellets of ice not bigger than the raindrops from which they are formed. Sometimes, drops of rain after being released by the clouds become solidified into small rounded solid pieces of ice and which reach the surface of the earth are called hailstones. These are formed by the rainwater passing through the colder layers. Hailstones have several concentric layers of ice one over the other.

Types of Rainfall : On the basis of origin, rainfall may be classified into three main types- the convectional, orographic or relief and the cyclonic or frontal.

Convectional rain: The, air on being heated, becomes light and rises up in convection currents. As it rises, it expands and losses heat and consequently, condensation takes place and cumulous clouds are formed. With thunder and lightening, heavy rainfall takes place but this does not last long. Such rain is common in the summer or in the hotter part of the day. It is very common in the equatorial regions and interior parts of the continents, particularly in the northern hemisphere.

Orographic rain : When the saturated air mass comes across a mountain, it is forced to ascend and as it rises, it expands; the temperature falls, and the moisture is condensed. The chief characteristic of this sort of rain is that the windward slopes a receive greater rainfall. After giving rain on the windward side, when these winds reach the other slope, they descend, and their temperature rises. Then their capacity to take in moisture increases and dry. The area situated on the leeward side, which gets less rainfall is known as the rain-shadow area. It is also known as the relief rain.

Cyclonic rain : Cyclonic rain is associated with cyclones and depressions. Warm air and cold air are of different densities, and they do not mix well. The warm air, being less dense, rises gradually over the mass of cold air, expands further and cools and rain falls.

Rainbow : A rainbow is an isolated optical effect caused by the Sun's ray being refracted (bent) and reflected as they pass through millions of raindrops. For a rainbow to occur there needs to be bright sunshine and rain occurring at the same time.

Cloud seeding : *Cloud seeding, a form of weather modification, is the attempt to change the amount or type of precipitation that falls from clouds, by dispersing substances into the air that serve as cloud condensation or ice nuclei, which alter the microphysical processes within the cloud. The usual intent is to increase precipitation (rain or snow), but hail and fog suppression are also widely practiced in airports*

Process :

1. Aircraft or artillery spray chemicals (often silver iodide or dry ice) into clouds to encourage tiny vapour droplets to coalesce

2. Droplets of supercooled water (liquid below freezing) coalesce into snow and melt as they fall

3. Heat released as the droplets freeze boosts updrafts, which pull more moist air into the cloud

WORLD DISTRIBUTION OF RAINFALL

Different places on the earth's surface receive different amounts of rainfall in a year and that too in different seasons. In general, as we proceed from the equator towards the poles, rainfall goes on decreasing steadily. the costal areas of the world receive greater amounts of rainfall than the interior of the continents. The rainfall is more over the oceans than on the landmasses of the world because of being great sources of water. Between the latitudes 35° and 40 ° N and S of the equator, the rain is heavier on the eastern coasts and goes on decreasing towards the west. But, between 45° and 65° N and S of equator, due to the westerlies, the rainfall is first received on the western margins of the continents and it goes on decreasing towards the east. Wherever mountains run parallel to the coast, the rain is greater on the coastal plain, on the windward side and it decrease towards the leeward side.

On the basis of the total amount of annual precipitation, major precipitation regimes of the world are identified as follows:

The ***equatorial belt***, the windward slopes of the mountains along the western coasts in the cool temperate zone and the coastal areas of the monsoon land receive heavy rainfall of over 200 cm per annum. Interior continental areas receive moderate rainfall varying from 100-200 cm per annum. The coastal areas of the continents receive moderate amount of rainfall. The central parts of the tropical land and the eastern and interior parts of the temperate lands receive rainfall varying between 50-100 cm per annum. Areas lying in the rain shadow zone of the interior of the continents and high latitudes receive very low rainfall-less than 50 cm per annum. Seasonal distribution of rainfall provides an important aspect to judge its effectiveness. In some regions rainfall is distributed evenly throughout the year such as in the equatorial belt and in the western parts of the cool temperate regions.

Snow : In this case precipitation takes the form of ice crystal of a delicate, feathery structure. Snow is formed from water vapour in the atmosphere at temperatures below freezing point. In hot countries this snow is melted into rain as it falls through the lower warmer air, but in cold countries and on the tops of high mountains and plateaus it is not melted but falls in flakes like tiny feathers, covering everything with a soft white mantle. On the tops of high mountains such as the Himalayas practically all rainfall is in the form of snow. On the average it requires 10-12 cm of snow to equal 1 cm of rain. **Hail** consists of the hard pellets of ice which fall from cumulonimbus clouds and are often associated with thunderstorms. They are of various shapes and sometimes they have been known to weigh nearly 1 kg. A severe hair-storm can cause great damage to growing crops. **Dew** is the moisture deposited on the earth's surface, or on objects near to the earth's surface such as blades of grass and small bushes. It occurs at night under calm clear conditions when radiation from the ground has cooled the lower layers of the atmosphere below the Dew Point and the water vapour has condensed into drops. Calm weather and a clear sky provide the best conditions for production of dew. **Frost** forms when air temperatures have fallen below the freezing point. Conditions favourable for frost are a mass of dry cool polar air followed by clear, calm nights during which the surface air may be reduced to below freezing. Frost is common in temperature lands. It is very harmful to plants. Most crops are sensitive to frost.

Fog is the dense mass of small water drops on smoke or dust particles in the lower layers of the atmosphere. Fog is essentially a cloud at the surface of the earth. A Fog will arise also when a warm damp current of air passes over a cold surface.

Mist is the result of condensation of water droplets on particles of smoke and dust. Mist is said to prevail as long as the visibility exceeds between 1 and 2 km i.e., when visibility is better than in a fog.

Meteorology

Meteorology is the scientific study of the atmosphere and weather. A person who studies the weather is called a meteorologist. Meteorologists use many different tools to learn about the weather in the world.

Meteorologists and Weather Forecasters are very important because they can predict what the weather is going to be like in the future. To do this, they use very specialized equipment. Within the last 50 years, meteorologists have used *weather balloons, satellites, radar, and computers* to improve the accuracy of their forecasts.

- **WEATHER BALLOONS** carry an instrument called "Radio-sonde" which measures temperature, pressure, and humidity at different altitudes in the atmosphere. Special recording equipment in the balloons converts readings from these instruments into electrical impulses and transmits the impulses to earth. The balloons are tracked with radar to find wind speed and direction. Eventually the balloon bursts, and the instrument floats back to the ground by parachute.
- **WEATHER SATELLITES** send back information about storms, fronts, cloud cover, geographical features of the earth, and air and ocean temperatures.
- **RADAR** sends out radio waves which bounce off raindrops, snow, or hail inside a cloud and reflect energy back to a radar antenna, which usually looks like a huge dish sitting on its side.
- **COMPUTERS** can do millions of operations per second, figuring out math equations that relate to the movements of fronts, air pressure systems, and storms.

Weather Forecasters use many signs and symbols when they are describing what is going on in the weather and how weather is happening all across the country.

Metereological instruments

INSTRUMENT	PARAMETER MEASURED
Standard Raingauge	Rainfall
Automatic Raingauge	Continuous record of rainfall, storm
Cupcounter Anemometer	Windrun
Campbell, stoke sunshine recorder	Sunshine hours
Evaporation Pan	Evaporation
Stephenson Screen	Housing for instruments
Dry & Wet bulb Thermometer	Dry & Wet bulb temperature
Thermohygrograph	Temperature & Humidity
Grass Minimum	Grass Minimum temperature
Soil Thermometers	Soil temperatureat different Depths
Piche Evaporimeter	Evaporation
Gun-Bellani Radiometer	Solar-radiation

Meteorologists also measure the amount of cloud cover in "oktas" from 1 to 8. 0 oktas means the sky is clear, 8 oktas means the sky is completely covered. The height of a cloud is measured by how far it is above sea level.

Hydrosphere

The abundance of water on Earth's surface is a unique feature that distinguishes the "Blue Planet" from others in the solar system. The Earth's hydrosphere consists chiefly of the oceans, but technically includes all water surfaces in the world, including inland seas, lakes, rivers, and underground waters down to a depth of 2,000 m. The deepest underwater location is **Challenger Deep of the Mariana Trench in the Pacific Ocean with a depth of −10,911.4 m.** The average depth of the oceans is 3,800 m, more than four times the average height of the continents. The mass of the oceans is approximately 1.35×10^{18} metric tons, or about 1/4400 of the total mass of the Earth, and occupies a volume of 1.386×10^{9} km^3. If all of the land on Earth were spread evenly, water would rise to an altitude of more than 2.7 km About 97.5% of the water is saline, while the remaining 2.5% is fresh water. The majority of the fresh water, about 68.7%, is currently in the form of ice.

About 3.5% of the total mass of the oceans consists of salt. Most of this salt was released from volcanic activity or extracted from cool, igneous rocks. The oceans are also a reservoir of dissolved atmospheric gases, which are essential for the survival of many aquatic life forms. Sea water has an important influence on the world's climate, with the oceans acting as a large heat reservoir. Shifts in the oceanic temperature distribution can cause significant weather shifts, such as the El Niño-Southern Oscillation.

WATER

Water is a common chemical substance that is essential for the survival of all known forms of life. In typical usage, *water* refers only to its liquid form or state, but the substance also has a solid state, *ice*, and a gaseous state, *water vapor* or *steam*. About 1.460 petatonnes (Pt) (10^{21}kilograms) of water covers 71% of the Earth's surface, mostly in oceans and other large water bodies, with 1.6% of water below ground in aquifers and 0.001% in the air as vapor, clouds (formed of solid and liquid water particles suspended in air), and precipitation. Saltwater oceans hold 97% of surface water, glaciers and polar ice caps 2.4%, and other land surface water such as rivers, lakes and ponds 0.6%. A very small amount of the Earth's water is contained within water towers, biological bodies, manufactured products, and food stores. Other water is trapped in ice caps, glaciers, aquifers, or in lakes, sometimes providing fresh water for life on land.

EARTH'S OCEANS

Oceans cover about 70% of the Earth's surface. The oceans contain roughly 97% of the Earth's water supply. The oceans of Earth are unique in our Solar System. No other planet in our Solar System has liquid water (although recent finds on Mars indicate that Mars may have had some liquid water in the recent past). Life on Earth originated in the seas, and the oceans continue to be home to an incredibly diverse web of life.

The oceans of Earth serve many functions, especially affecting the weather and temperature. They moderate the Earth's temperature by absorbing incoming solar radiation (stored as heat energy). The always-moving ocean currents distribute this heat energy around the globe. This heats the land and air during winter and cools it during summer.

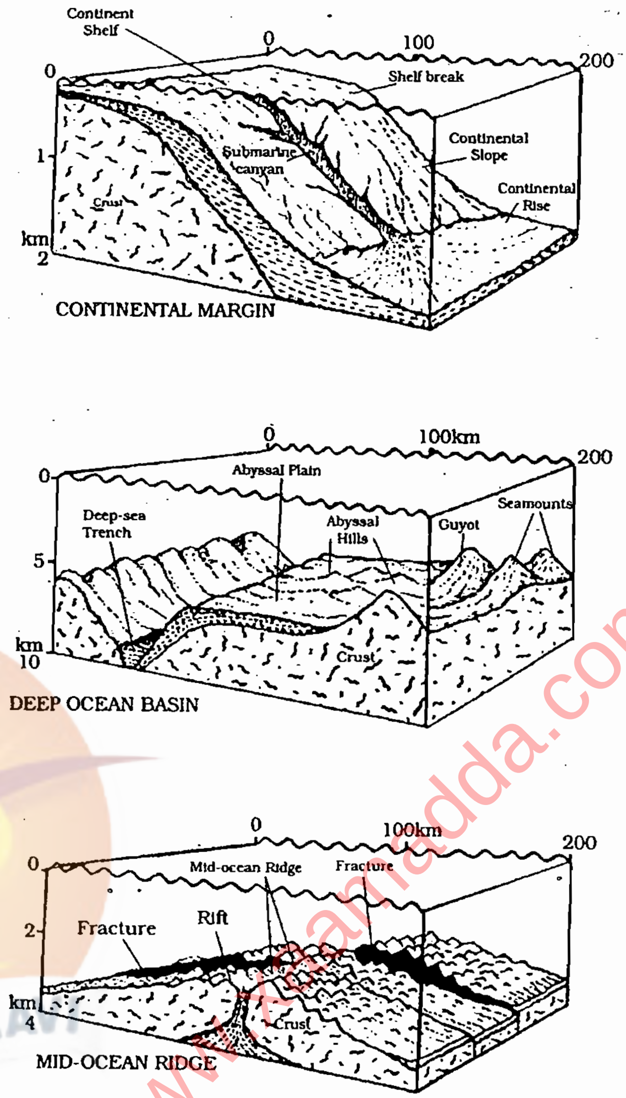
The Earth's oceans are all connected to one another. Until the year 2000, there were four recognized oceans: the Pacific, Atlantic, Indian, and Arctic. **In the Spring of 2000,**

the International Hydrographic Organization delimited a new ocean, the Southern Ocean (it surrounds Antarctica and extends to 60 degrees latitude).

There are also many seas (smaller branches of an ocean); seas are often partly enclosed by land. The largest seas are the South China Sea, the Caribbean Sea, and the Mediterranean Sea.

Ocean	Area (square miles)	Average Depth (ft)	Deepest depth (ft)
Pacific Ocean	64,186,000	15,215	Mariana Trench, 36,200 ft deep
Atlantic Ocean	33,420,000	12,881	Puerto Rico Trench, 28,231 ft deep
Indian Ocean	28,350,000	13,002	Java Trench, 25,344 ft deep
Southern Ocean	7,848,300 sq. miles (20.327 million sq km)	13,100 - 16,400 ft deep (4,000 to 5,000 meters)	the southern end of the South Sandwich Trench, 23,736 ft (7,235 m) deep
Arctic Ocean	5,106,000	3,953	Eurasia Basin, 17,881 ft deep

OCEAN FLOOR



Relief features of ocean floors

The Ocean floor may be divided into four parts

1) The Continental Shelf is one of the most important relief features of the ocean bottom. It is the name given to the fringe of shallow water (upto about 100 fathoms or 180 m deep) that surrounds the continents. It is a relatively narrow platform and found especially where the mountain ranges occur close to the coasts of continents.

In these shallower parts, waves and tides constantly distribute silt and rock fragments that have been broken by waves from the shore lines. Much of the waste of the land brought by rivers is also spread over the continental shelf. Again, the shallowness of the continental shelf enables the sunlight to penetrate through the water. This fosters growth of minute plants and micro-organisms which directly or indirectly provide food for other marine life. This is one of the reasons why the world's chief fishing grounds are found in the shallow waters of the continental shelf, such as those in the North Sea and the Grand Banks off New Foundland.

The slope of the shelf is usually gentle, but beyond the 180 metre line it descends steeply to the bed of the ocean. This line is called the continental edge.

2) The steep which descends from the edge of the continental shelf to the deep ocean bed is known as the continental slope.

3) The Deep Sea Plains are wide and almost level areas forming most of the ocean floor. They are generally 3 to 5 km below sea level.

4) In some places these plains plunge to great depths known as Ocean Deeps. Most of the deeps or Trenches. As many as 57 deeps have been explored so far ; out of which 32 are in the Pacific Ocean : 19 in the Atlantic ocean and 6 in the Indian ocean. The deepest is the Mariana Trench in the Pacific, about 10,800 m. below sea level.

One of the most unusual features of the sea floor is a series of underwater mountains called Mid-ocean ridges. The peaks of these ridges are higher than those of most continental mountain systems.

THE MAJOR OCEANS

The major oceans of the world are the Pacific, the Atlantic, the Indian, the Arctic and the Antarctic. The Pacific Ocean is the largest and deepest covering one third of the globe. Its average depth is 4,200 m. Its basin contains high and abrupt ridges, deep trenches, volcanic mountains and other features. The deepest hollows are in the Philippine Trench about 10,380 m and the Mariana Trench about 10,800 m. Some of these ridges project above sea level and form islands most of which are either volcanic or coral. The highest volcanic islands form Hawaii, Tahiti and Samoa.

The Atlantic Ocean is smaller and shallower. Its 'S' shaped curve is similar to that of the coastline bordering it. This ocean also has many ridges. Though the Atlantic is smaller than the Pacific its total coastline is more than that of the Pacific and the Indian Ocean combined. It also receives many great rivers such as the Rhine, Senegal, Niger, Congo, St. Lawrence, Mississippi, Amazon, Orinoco and La Plata. There is a long submarine ridge running north southwards in the middle of the Atlantic. It is the greatest mountain chain in the world. it is some 16,000 km. It is known as the Dolphin Ridge in the North Atlantic and the Challenger Ridge in the South Atlantic. On each side of the central Atlantic ridge are the great deeps, the deepest is the Nares Deep (8,500 m). The Atlantic is the greatest commercial highway of the world. Most of the world's great ports lie on its coasts.

The Indian Ocean is small in size but has an average depth of 4,000 m. There is a Mid-Indian ridge which runs in a southward direction several hundred kilometres from the coast of India. The two great bays on either side of the peninsular of India, namely, the Bay of Bengal and the Arabian Sea belong to the Indian Ocean. The principal rivers draining into it are the Zambesi, the Indus, the Ganga and the Irrawaddy.

Around the north pole is the Arctic Ocean, a small ocean only one-thirtieth of the sea's area. It is almost completely covered with ice to a depth of about 3 or 4 m. The remaining area of the sea is included in the Antarctic Ocean surrounding the Antarctic Continent.

OCEAN CURRENTS

In addition to tides and waves, currents of various kinds cause movements in ocean waters. In fact, ocean current are the primary means by which both water and heat are transported horizontally and vertically in the ocean. The ocean currents and drifts that affect the surface layers of water are caused primarily by the movements of the atmosphere (persistent prevailing winds). Other controls are the density of the water as affected by variations in temperature and salinity, the coriolis effect, the shape and depth of the sea or ocean basin and the size and shape of the ocean or sea.

SURFACE AND SUBSURFACE OCEAN CURRENTS

An ocean current can be defined as a horizontal movement of seawater at the ocean's surface. Ocean currents are driven by the circulation of wind above surface waters. Frictional stress at the interface between the ocean and the wind causes the water to move in the direction of the wind. Large ocean currents are a response of the atmosphere and ocean to the flow of energy from the tropics to polar regions. In some cases, currents are transient features and affect only a small area. Other ocean essentially permanent and extend over large horizontal distances.

On a global scale, large ocean currents are constrained by the continental masses found bordering the three oceanic basins. Continental borders cause these currents to develop an almost closed circular pattern called a gyre. Each ocean basin has a large gyre located at approximately 30° North and South latitude in the subtropical regions. The currents in these gyres are driven by the atmospheric flow produced by the subtropical high pressure systems. Smaller gyres occur in the North Atlantic and Pacific Oceans centered at 50° North. Currents in these systems are propelled by the circulation produced by polar low pressure centers. In the Southern Hemisphere, these gyre systems do not develop because of the lack of constraining land masses.

A typical gyre displays four types of joined currents: two east-west aligned currents found respectively at the top and bottom ends of the gyre; and two boundary currents oriented north-south and flowing parallel to the continental margins. Direction of flow within these currents is determined by the direction of the macro-scale wind circulation. Boundary currents play a role in redistributing global heat latitudinally.

Surface Currents of the Subtropical Gyres

On either side of the equator, in all ocean basins, there are two west flowing currents: the *North* and *South Equatorial* .These currents flow between 3 and 6 kilometers per day and usually extend 100 to 200 meters in depth below the ocean surface. The *Equatorial Counter Current*, which flows towards the east, is a partial return of water carried westward by the North and South Equatorial currents. In El Nino years, this current intensifies in the Pacific Ocean. Flowing from the equator to high latitudes are the *western boundary currents*. These warm water currents have specific names associated with their location: North Atlantic - Gulf Stream; North Pacific - Kuroshio; South Atlantic - Brazil; South Pacific - East Australia; and Indian Ocean - Agulhas. All of these currents are generally narrow, jet like flows that travel at speeds between 40 and 120 kilometers per day. Western boundary currents are the deepest ocean surface flows, usually extending 1000 meters below the ocean surface. Flowing from high latitudes to the equator are the *eastern boundary currents*. These cold water currents also have specific names associated with their location: North Atlantic - Canary; North Pacific - California; South Atlantic - Benguela; South Pacific - Peru; and Indian Ocean - West Australia. All of these currents are generally broad, shallow moving flows that travel at speeds between 3 and 7 kilometers per day.

In the Northern Hemisphere, the east flowing *North Pacific Current* and *North Atlantic Drift* move the waters of western boundary currents to the starting points of the eastern boundary currents. The *South Pacific Current*, *South Indian Current* and *South Atlantic Current* provide the same function in the Southern Hemisphere. These currents are associated with the *Antarctic Circumpolar* (*West Wind Drift*). Because of the absence of landmass at this latitude zone, the *Antarctic Circumpolar* flows in continuous fashion around Antarctica and only provides a partial return of water to the three Southern Hemispheric ocean basins.

Surface Currents of the Polar Gyres : The polar gyres exist only in the Atlantic and Pacific basins in Northern Hemisphere. They are propelled by the counterclockwise winds associated with the development of permanent low pressure centers at 50° of latitude over the ocean basins. Note that the bottom west flowing current of the polar gyres is the topmost flowing current of the subtropical gyres.

Subsurface Currents : The world's oceans also have significant currents that flow beneath the surface .Subsurface currents generally travel at a much slower speed when compared to surface flows. The subsurface currents are driven by differences in the density of sea water. The density of sea water deviates in the oceans because of variations in temperature and salinity. Near surface sea water begins its travel deep into the ocean in the North Atlantic. The downwelling of this water is caused by high levels of evaporation which cools and increases the salinity of the sea water located here. The high levels of evaporation take place in between Northern Europe and Greenland and just north of of Labrador, Canada. This sea water then moves south along the coast of North and South America until it reaches Antarctica. At Antarctica, the cold and dense sea water then travels eastward joining another deep current that is created by evaporation occuring between Antarctica and the southern tip of South America. Slightly into its eastward voyage the deep cold flow splits off into two currents, one of which moves northward. In the middle of the North Pacific and in the Indian Ocean (off the east coast of Africa), these two currents move from the ocean floor to its surface creating upwellings. The current then becomes near surface moving eventually back to the starting point in the North Atlantic or creating a shallow warm flow that circles around Antarctica. One complete circuit of this flow of sea water is estimated to take about 1,000 years.

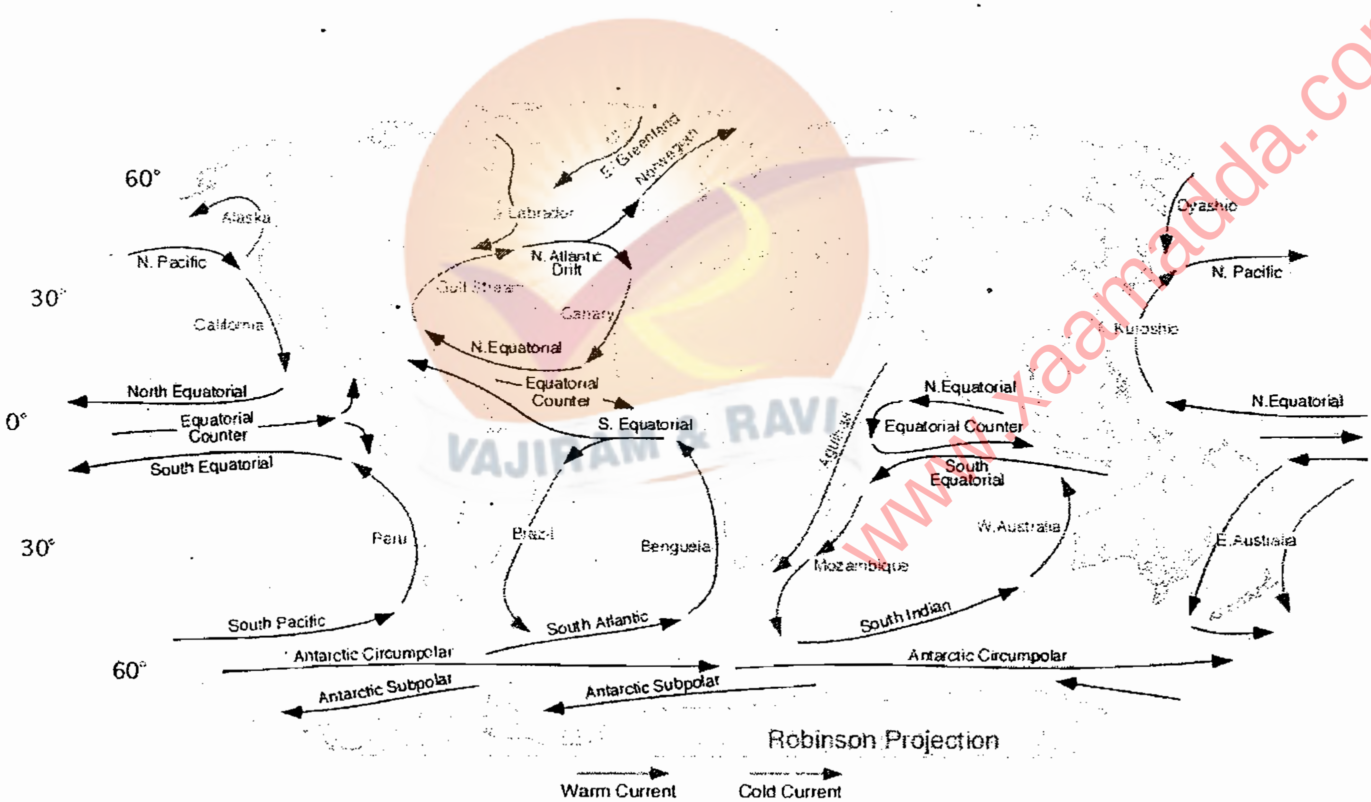
MAJOR OCEAN CURRENTS

This is a listing of the seventeen major surface ocean currents.

Agulhas Current	Indian	Warm
Alaska Current	North Pacific	Warm
Benguela Current	South Atlantic	Warm/Cool
Brazil Current	South Atlantic	Warm

California Current	North Pacific	Cool
Canaries Current	North Atlantic	Cool
East Australian Current	South Pacific	Warm
Equitorial Current	Pacific	Warm
Gulf Stream	North Altantic	Warm
Humboldt (Peru) Current	South Pacific	Cool
Kuroshio (Japan) Current	North Pacific	Warm
Labrador Current	North Atlantic	Cool
North Atlantic Drift	North Atlantic	Warm
North Pacific Drift	North Pacific	Warm
Oyashio (Kamchatka) Current	North Pacific	Cool
West Australian Current	Indian	Cool
West Wind Drift	South-Pacific	Cool

Surface Ocean Current Map



OCEAN TIDES

An ocean tide refers to the cyclic rise and fall of seawater. Tides are caused by slight variations in gravitational attraction between the *Earth* and the *moon* and the Sun in geometric relationship with locations on the Earth's surface. Tides are periodic primarily because of the cyclical influence of the Earth's rotation. The moon is the primary factor controlling the temporal rhythm and height of tides .The moon produces two tidal bulges somewhere on the Earth through the effects of gravitational attraction. The height of these tidal bulges is controlled by the moon's gravitational force and the Earth's gravity pulling the water back toward the Earth. At the location on the Earth closest to the moon, seawater is drawn toward the moon because of the greater strength of gravitational attraction. On the opposite side of the Earth, another tidal bulge is produced away from the moon. However, this bulge is due to the fact that at this point on the Earth the force of the moon's gravity is at its weakest. Considering this information, any given point on the Earth's surface should experience two tidal crests and two tidal troughs during each tidal period.

The timing of tidal events is related to the Earth's rotation and the revolution of the moon around the Earth. If the moon was stationary in space, the tidal cycle would be 24 hours long. However, the moon is in motion revolving around the Earth. One revolution takes about 27 days and adds about 50 minutes to the tidal cycle. As a result, the tidal period is 24 hours and 50 minutes in length.

The second factor controlling tides on the Earth's surface is the Sun's gravity. The height of the average solar tide is about 50% the average lunar tide. At certain times during the moon's revolution around the Earth, the direction of its gravitational attraction is aligned with the Sun's .During these times the two tide producing bodies act together to create the highest and lowest tides of the year. These spring tides occur every 14-15 days during full and new moons.

When the gravitational pull of the moon and Sun are at right angles to each other, the daily tidal variations on the Earth are at their least. These events are called neap tides and they occur during the first and last quarter of the moon.

TYPES OF TIDES : The geometric relationship of moon and Sun to locations on the Earth's surface results in creation of three different types of tides. In parts of the northern Gulf of Mexico and Southeast Asia, tides have one high and one low water per tidal day .These tides are called diurnal tides. Semi-diurnal tides have two high and two low waters per tidal day.They are common on the Atlantic coasts of the United States and Europe.

- Annual Precipitation: 262 cm. (103 in.)
- Latitude Range: 10° S to 25 ° N

Rainfall is heavy in all months. The total annual rainfall is often more than 250 cm. (100 in.). There are seasonal differences in monthly rainfall but temperatures of 27°C (80°F) mostly stay the same. Humidity is between 77 and 88%.

High surface heat and humidity cause cumulus clouds to form early in the afternoons almost every day.

The climate on eastern sides of continents are influenced by maritime tropical air masses. These air masses flow out from the moist western sides of oceanic high-pressure cells, and bring lots of summer rainfall. The summers are warm and very humid: It also rains a lot in the winter

Global Position: Amazon Basin; Congo Basin of equatorial Africa; East Indies, from Sumatra to New Guinea.

- Wet-Dry Tropical Climates (Aw) savanna
  - Temperature Range: 16 °C
  - Annual Precipitation: 0.25 cm. (0.1 in.). All months less than 0.25 cm. (0.1 in.)
  - Latitude Range: 15 ° to 25 ° N and S

A seasonal change occurs between wet tropical air masses and dry tropical air masses. As a result, there is a very wet season and a very dry season. Trade winds dominate during the dry season. It gets a little cooler during this dry season but will become very hot just before the wet season.

Global Range: India, Indochina, West Africa, southern Africa, South America and the north coast of Australia

- Dry Tropical Climate (BW) desert biome
  - Temperature Range: 16° C
  - Annual Precipitation: 0.25 cm (0.1 in). All months less than 0.25 cm (0.1 in).
  - Latitude Range: 15° - 25° N and S.

These desert climates are found in low-latitude deserts approximately between 18° to 28° in both hemispheres. these latitude belts are centered on the tropics of Cancer and Capricorn, which lie just north and south of the equator. They coincide with the edge of the equatorial subtropical high pressure belt and trade winds. Winds are light, which allows for the evaporation of moisture in the intense heat. They generally flow downward so the area is seldom penetrated by air masses that produce rain. This makes for a very dry heat. The dry arid desert is a true desert climate, and covers 12 % of the Earth's land surface.

Global Range: southwestern United States and northern Mexico; Argentina; north Africa; south Africa; central part of Australia

Group II

Mid-latitude Climates: Climates in this zone are affected by two different air-masses. The tropical air-masses are moving towards the poles and the polar air-masses are moving towards the equator. These two air masses are in constant conflict. Either air mass may dominate the area, but neither has exclusive control.

- Dry Midlatitude Climates (BS) steppe
  - Temperature Range: 24° C (43° F).
  - Annual Precipitation: less than 10 cm (4 in) in the driest regions to 50 cm (20 in) in the moister steppes.
  - Latitude Range: 35° - 55° N.

Characterized by grasslands, this is a semiarid climate. It can be found between the desert climate (BW) and more humid climates of the A, C, and D groups. If it received less rain, the steppe would be classified as an arid desert. With more rain, it would be classified as a tallgrass prairie.

This dry climate exists in the interior regions of the North American and Eurasian continents. Moist ocean air masses are blocked by mountain ranges to the west and south. These mountain ranges also trap polar air in winter, making winters very cold. Summers are warm to hot.

Global Range: Western North America (Great Basin, Columbia Plateau, Great Plains); Eurasian interior, from steppes of eastern Europe to the Gobi Desert and North China

- Mediterranean Climate (Cs)
  - Temperature Range: 7 °C (12 °F)
  - Annual Precipitation: 42 cm (17 in).
  - Latitude Range: 30° - 50° N and S

This is a wet-winter, dry-summer climate. Extremely dry summers are caused by the sinking air of the subtropical highs and may last for up to five months.

Further subgroups are designated by a second, lower case letter which distinguish specific seasonal characteristics of temperature and precipitation.

f - Moist with adequate precipitation in all months and no dry season. This letter usually accompanies the **A**, **C**, and **D** climates.

m - Rainforest climate in spite of short, dry season in monsoon type cycle. This letter only applies to **A** climates.

s - There is a dry season in the summer of the respective hemisphere (high-sun season).

w - There is a dry season in the winter of the respective hemisphere (low-sun season).

To further denote variations in climate, a third letter was added to the code.

a - Hot summers where the warmest month is over 22°C (72°F). These can be found in **C** and **D** climates.

b - Warm summer with the warmest month below 22°C (72°F). These can also be found in **C** and **D** climates.

c - Cool, short summers with less than four months over 10°C (50°F) in the **C** and **D** climates.

d - Very cold winters with the coldest month below -38°C (-36°F) in the **D** climate only.

h - Dry-hot with a mean annual temperature over 18°C (64°F) in **B** climates only.

k - Dry-cold with a mean annual temperature under 18°C (64°F) in **B** climates only.

Three basic climate groups

Three major climate groups show the dominance of special combinations of air-mass source regions.

Group I

Low-latitude Climates: These climates are controlled by equatorial a tropical air masses

- Tropical Moist Climates (Af) rainforest
  - Average temperature: 18 °C (°F)

Many parts of the world experience mixed tides where successive high-water and low-water stands differ appreciably (). In these tides, we have a higher high water and lower high water as well as higher low water and lower low water. The tides around west coast of Canada and the United States are of this type.

WORLD CLIMATE ZONES

Climate is the characteristic condition of the atmosphere near the earth's surface at a certain place on earth. It is the long-term weather of that area (at least 30 years). This includes the region's general pattern of weather conditions, seasons and weather extremes like hurricanes, droughts, or rainy periods. Two of the most important factors determining an area's climate are air temperature and precipitation.

Köppen Climate Classification System

The Köppen Climate Classification System is the most widely used for classifying the world's climates. Most classification systems used today are based on the one introduced in 1900 by the Russian-German climatologist Wladimir Köppen. Köppen divided the Earth's surface into climatic regions that generally coincided with world patterns of vegetation and soils.

The Köppen system recognizes five major climate types based on the annual and monthly averages of temperature and precipitation. Each type is designated by a capital letter.

A - Moist Tropical Climates are known for their high temperatures year round and for their large amount of year round rain.

B - Dry Climates are characterized by little rain and a huge daily temperature range. Two subgroups, **S** - semiarid or steppe, and **W** - arid or desert, are used with the **B** climates.

C - In Humid Middle Latitude Climates land/water differences play a large part. These climates have warm,dry summers and cool, wet winters.

D - Continental Climates can be found in the interior regions of large land masses. Total precipitation is not very high and seasonal temperatures vary widely.

E - Cold Climates describe this climate type perfectly. These climates are part of areas where permanent ice and tundra are always present. Only about four months of the year have above freezing temperatures.

Plants have adapted to the extreme difference in rainfall and temperature between winter and summer seasons. Sclerophyll plants range in formations from forests, to woodland, and scrub. Eucalyptus forests cover most of the chaparral biome in Australia. Fires occur frequently in Mediterranean climate zones.

Global Position: central and southern California; coastal zones bordering the Mediterranean Sea; coastal Western Australia and South Australia; Chilean coast; Cape Town region of South Africa.

- Dry Midlatitude Climates (Bs) grasslands biome
  - Temperature Range: 31 °C (56°F).
  - Annual Precipitation: 81 cm. (32 in.).
  - Latitude Range: 30° - 55° N and S

These dry climates are limited to the interiors of North America and Eurasia.

Ocean air masses are blocked by mountain ranges to the west and south. This allows polar air masses to dominate in winter months. In the summer, a local continental air mass is dominant. A small amount of rain falls during this season.

Annual temperatures range widely. Summers are warm to hot, but winters are cold.

Global Position: western North America (Great Basin, Columbia Plateau, Great Plains); Eurasian interior.

- Moist Continental Climate (Cf) Deciduous Forest biome
  - Temperature Range: 31 °C (56 ° F)
  - Average Annual Precipitation: 81 cm (32 in).
  - Latitude Range: 30° - 55° N and S (Europe: 45° - 60° N).

This climate is in the polar front zone - the battleground of polar and tropical air masses. Seasonal changes between summer and winter are very large. Daily temperatures also change often. Abundant precipitation falls throughout the year. It is increased in the summer season by invading tropical air masses. Cold winters are caused by polar and arctic masses moving south.

Global Position: eastern parts of the United States and southern Canada; northern China; Korea; Japan; central and eastern Europe

Group III

High-latitude climates: Polar and arctic air masses dominate these regions. Canada and Siberia are two air-mass sources which fall into this group. A southern hemisphere counterpart to these continental centers does not exist. Air masses of arctic origin meet polar continental air masses along the 60th and 70th parallels.

- Boreal forest Climate (Dfc) taiga biome
  - Temperature Range: 41 °C (74 °F), lows; -25 °C (-14 °F), highs; 16 °C (60 °F).
  - Average Annual Precipitation: 31 cm (12 in).
  - Latitude Range: 50° - 70° N and S.

This is a continental climate with long, very cold winters, and short, cool summers. This climate is found in the polar air mass region. Very cold air masses from the arctic often move in. The temperature range is larger than any other climate. Precipitation increases during summer months, although annual precipitation is still small.

Much of the boreal forest climate is considered humid. However, large areas in western Canada and Siberia receive very little precipitation and fall into the subhumid or semiarid climate type.

Global Position: central and western Alaska; Canada, from the Yukon Territory to Labrador; Eurasia, from northern Europe across all of Siberia to the Pacific Ocean.

- Tundra Climate (E) tundra biome
  - Temperature Range: -22 °C to 6 °C (-10 °F to 41 °F).
  - Average Annual Precipitation: 20 cm (8 in).
  - Latitude Range: 60° - 75° N.

The tundra climate is found along arctic coastal areas. Polar and arctic air masses dominate the tundra climate. The winter season is long and severe. A short, mild season exists, but not a true summer season. Moderating ocean winds keep the temperatures from being as severe as interior regions.

Global Position: arctic zone of North America; Hudson Bay region; Greenland coast; northern Siberia bordering the Arctic Ocean

- Highland Climate (H) Alpine Biome
  - Temperature Range: -18 °C to 10 °C (-2 °F to 50°F)
  - Average Annual Precipitation: 23 cm (9 in.)

- Latitude Range: found all over the world

Highland climates are cool to cold, found in mountains and high plateaus. Climates change rapidly on mountains, becoming colder the higher the altitude gets. The climate of a highland area is closely related to the climate of the surrounding biome. The highlands have the same seasons and wet and dry periods as the biome they are in.

Mountain climates are very important to midlatitude biomes. They work as water storage areas. Snow is kept back until spring and summer when it is released slowly as water through melting.

Global Position: Rocky Mountain Range in North America, the Andean mountain range in South America, the Alps in Europe, Mt. Kilimanjaro in Africa, the Himalayans in Tibet, Mt. Fuji in Japan.

Biosphere

The outer layer of the planet Earth can be divided into several compartments: the hydrosphere (or sphere of water), the lithosphere (or sphere of soils and rocks), and the atmosphere (or sphere of the air). The biosphere (or sphere of life), sometimes described as "the fourth envelope," is all living matter on the planet or that portion of the planet occupied by life. It reaches well into the other three spheres, although there are no permanent inhabitants of the atmosphere. Relative to the volume of the Earth, the biosphere is only the very thin surface layer that extends from 11,000 meters below sea level to 15,000 meters above. It is thought that life first developed in the hydrosphere, at shallow depths, in the photic zone. Multicellular organisms then appeared and colonized benthic zones. Photosynthetic organisms gradually produced the chemically unstable oxygen-rich atmosphere that characterizes our planet. Terrestrial life developed later, after the ozone layer protecting living beings from UV rays formed. Diversification of terrestrial species is thought to be increased by the continents drifting apart, or alternately, colliding.

Biodiversity is expressed at the ecological level (ecosystem), population level (intraspecific diversity), species level (specific diversity), and genetic level. Recently technology has allowed the discovery of the deep ocean vent communities. This remarkable ecological system is not dependent on sunlight but bacteria, utilizing the chemistry of the hot volcanic vents, are at the base of its food chain.

The biosphere contains great quantities of elements such as carbon, nitrogen, hydrogen, and oxygen. Other elements, such as phosphorus, calcium, and potassium, are also essential to life, yet are present in smaller amounts. At the ecosystem and biosphere levels, there is a continual recycling of all these elements, which alternate between the mineral and organic states.

Although there is a slight input of geothermal energy, the bulk of the functioning of the ecosystem is based on the input of solar energy. Plants and photosynthetic microorganisms convert light into chemical energy by the process of photosynthesis, which creates glucose (a simple sugar) and releases free oxygen. Glucose thus becomes the secondary energy source that drives the ecosystem. Some of this glucose is used directly by other organisms for energy. Other sugar molecules can be converted to molecules such as amino acids. Plants use some of this sugar, concentrated in nectar, to entice pollinators to aid them in reproduction.

Cellular respiration is the process by which organisms (like mammals) break the glucose back down into its constituents, water and carbon dioxide, thus regaining the stored energy the sun originally gave to the plants. The proportion of photosynthetic activity of plants and other photosynthesizers to the respiration of other organisms determines the specific composition of the Earth's atmosphere, particularly its oxygen level. Global air currents mix the atmosphere and maintain nearly the same balance of elements in areas of intense biological activity and areas of slight biological activity.

Water is also exchanged between the hydrosphere, lithosphere, atmosphere, and biosphere in regular cycles. The oceans are large tanks that store water, ensure thermal and climatic stability, and facilitate the transport of chemical elements thanks to large oceanic currents

Ecology

Ecology is the scientific study of the distribution and abundance of life and the interactions between organisms and their natural environment.. The environment of an organism includes physical properties, which can be described as the sum of local abiotic factors such as insolation (sunlight), climate, and geology, and biotic ecosystem, which includes other organisms that share its habitat. The word "ecology" is often used more loosely in such terms as social ecology and deep ecology and in common parlance as a synonym for the natural environment or environmentalism. Likewise "ecologic" or "ecological" is often taken in the sense of environmentally friendly.

Ecology is usually considered as a branch of biology, the general science that studies living organisms. Organisms can be studied at many different levels, from proteins and nucleic acids (in biochemistry and molecular biology), to cells (in cellular biology), to individuals (in botany, zoology, and other similar disciplines), and finally at the level of populations, communities, and ecosystems, to the biosphere as a whole; these latter strata are the primary subjects of ecological inquiry.

Ecology is a multidisciplinary science. Because of its focus on the higher levels of the organization of life on earth and on the interrelations between organisms and their environment, ecology draws on many other branches of science, especially geology and geography, meteorology, pedology, genetics, chemistry, and physics. Thus, ecology is considered by some to be a holistic science, one that over-arches older disciplines such as biology which in this view become sub-disciplines contributing to ecological knowledge.."

The ecosystem concept : A central principle of ecology is that each living organism has an ongoing and continual relationship with every other element that makes up its environment. The sum total of interacting living organisms (the biocoenosis) and their non-living environment (the biotope) in an area is termed an *ecosystem*. Studies of ecosystems usually focus on the movement of energy and matter through the system.

Almost all ecosystems run on energy captured from the sun by primary producers via photosynthesis. This energy then flows through the food chains to primary consumers (herbivores who eat and digest the plants), and on to secondary and tertiary consumers (either carnivores or omnivores). Energy is lost to living organisms when it is used by the organisms to do work, or is lost as waste heat.

Matter is incorporated into living organisms by the primary producers. Photosynthetic plants fix carbon from carbon dioxide and nitrogen from atmospheric nitrogen or nitrates present in the soil to produce amino acids. Much of the carbon and nitrogen contained in ecosystems is created by such plants, and is then consumed by secondary and tertiary consumers and incorporated into themselves. Nutrients are usually returned to the ecosystem via decomposition. The entire movement of chemicals in an ecosystem is termed a biogeochemical cycle, and includes the carbon and nitrogen cycle.

Ecological factors that affect dynamic change in a population or species in a given ecology or environment are usually divided into two groups: abiotic and biotic.

Abiotic factors are geological, geographical, hydrological, and climatological parameters. A **biotope** is an environmentally uniform region characterized by a particular set of abiotic ecological factors. Specific abiotic factors include:

- Water, which is at the same time an essential element to life and a milieu
- Air, which provides oxygen, nitrogen, and carbon dioxide to living species and allows the dissemination of pollen and spores
- Soil, at the same time a source of nutriment and physical support
  - Soil pH, salinity, nitrogen and phosphorus content, ability to retain water, and density are all influential
- Temperature, which should not exceed certain extremes, even if tolerance to heat is significant for some species

- Light, which provides energy to the ecosystem through photosynthesis
- Natural disasters can also be considered abiotic

Biocenose, or community, is a group of populations of plants, animals, microorganisms. Each population is the result of procreations between individuals of the same species and cohabitation in a given place and for a given time.

Biotic ecological factors also influence biocenose viability; these factors are considered as either ***intraspecific*** or ***interspecific relations***.

Intraspecific relations are those that are established between individuals of the same species, forming a population. They are relations of cooperation or competition, with division of the territory, and sometimes organization in hierarchical societies. An antlion lies in wait under its pit trap, built in dry dust under a building, awaiting unwary insects that fall in. Many pest insects are partly or wholly controlled by other insect predators.

Interspecific relations—interactions between different species—are numerous, and usually described according to their beneficial, detrimental, or neutral effect The most significant relation is the relation of predation (to eat or to be eaten), which leads to the essential concepts in ecology of food chains (for example, the grass is consumed by the herbivore, itself consumed by a carnivore, itself consumed by a carnivore of larger size). A high predator to prey ratio can have a negative influence on both the predator and prey biocenoses in that low availability of food and high death rate prior to sexual maturity can decrease (or prevent the increase of) populations of each, respectively. Selective hunting of species by humans that leads to population decline is one example of a high predator to prey ratio in action. Other interspecific relations include parasitism, infectious disease, and competition for limited resources, which can occur when two species share the same ecological niche.

The existing interactions between the various living beings go along with a permanent mixing of mineral and organic substances, absorbed by organisms for their growth, their maintenance, and their reproduction, to be finally rejected as waste. These permanent recycling of the elements (in particular carbon, oxygen, and nitrogen) as well as the water are called biogeochemical cycles. They guarantee a durable stability of the biosphere (at least when unchecked human influence and extreme weather or geological phenomena are left aside). This self-regulation, supported by negative feedback controls, ensures the perenniality of the ecosystems. It is shown by the very stable concentrations of most elements of each compartment. This is referred to as homeostasis. The ecosystem also tends to evolve to a state of ideal balance, called the climax, which is reached after a succession of events (for example a pond can become a peat bog).

Spatial relationships and subdivisions of land : Ecosystems are not isolated from each other, but are interrelated. For example, water may circulate between ecosystems by means of a river or ocean current. Water itself, as a liquid medium, even defines ecosystems. Some species, such as salmon or freshwater eels, move between marine systems and fresh-water systems. These relationships between the ecosystems lead to the concept of a *biome*. A biome is a homogeneous ecological formation that exists over a large region, such as tundra or steppes. The biosphere comprises all of the Earth's biomes -- the entirety of places where life is possible -- from the highest mountains to the depths of the oceans. Biomes correspond rather well to subdivisions distributed along the latitudes, from the equator towards the poles, with differences based on the physical environment (for example, oceans or mountain ranges) and the climate. Their variation is generally related to the distribution of species according to their ability to tolerate temperature, dryness, or both. For example, one may find photosynthetic algae only in the *photic* part of the ocean (where light penetrates), whereas conifers are mostly found in mountains. Though this is a simplification of a more complicated scheme, latitude and altitude approximate a good representation of the distribution of biodiversity within the biosphere. Very generally, the richness of biodiversity (as well for animal as for plant species) is decreasing most rapidly near the equator and less rapidly as one approach the poles. The biosphere may also be divided into ecozones, which are very well defined today and primarily follow the continental borders. The ecozones are themselves divided into ecoregions, though there is not agreement on their limits.

Ecosystem productivity : In an ecosystem, the connections between species are generally related to food and their role in the food chain. There are three categories of organisms:

- *Producers* -- usually plants that are capable of photosynthesis but could be other organisms such as bacteria around ocean vents that are capable of chemosynthesis.
- *Consumers* -- animals, which can be primary consumers (herbivorous), or secondary or tertiary consumers (carnivorous and omnivores).
- *Decomposers* -- bacteria, mushrooms which degrade organic matter of all categories, and restore minerals to the environment. And decomposers can also decompose decaying animals

These concepts lead to the idea of biomass (the total living matter in a given place), of primary productivity (the increase in the mass of plants during a given time), and of secondary productivity (the living matter produced by consumers and the decomposers in a given time). These last two ideas are key, since they make it possible to evaluate the load capacity -- the number of organisms that can be supported by a given ecosystem. In any food network, the energy contained in the level of the producers is not completely transferred to the consumers. And the higher one goes up the chain, the more energy and resources are lost and consumed. Thus, from an energy and an environmental point of view, it is more efficient for humans to be primary consumers (to subsist from vegetables, grains, legumes, fruit, etc.) than to be secondary consumers (from eating herbivores, omnivores, or their products, such as milk, chicken, cattle, sheep, etc.) and still more so than as a tertiary consumer (from consuming carnivores, omnivores, or their products, such as fur, pigs, snakes, alligators, etc.). An ecosystem(s) is unstable when the load capacity is overrun and is especially unstable when a population doesn't have an ecological niche and overconsumers. The productivity of ecosystems is sometimes estimated by comparing three types of land-based ecosystems and the total of aquatic ecosystems:

- The forests (1/3 of the Earth's land area) contain dense biomasses and are very productive. The total production of the world's forests corresponds to half of the primary production.
- Savannas, meadows, and marshes (1/3 of the Earth's land area) contain less dense biomasses, but are productive. These ecosystems represent the major part of what humans depend on for food.
- Extreme ecosystems in the areas with more extreme climates -- deserts and semi-deserts, tundra, alpine meadows, and steppes -- (1/3 of the Earth's land area) have very sparse biomasses and low productivity
- Finally, the marine and fresh water ecosystems (3/4 of Earth's surface) contain very sparse biomasses (apart from the coastal zones).

Ecosystems differ in biomass (grams carbon per meter squared) and productivity (grams carbon per meter squared per day), and direct comparisons of biomass and productivity may not be valid. Ecosystems are often compared on the basis of their turnover (production ratio) or turnover time which is the reciprocal of turnover.

Humanity's actions over the last few centuries have seriously reduced the amount of the Earth covered by forests (deforestation), and have increased agro-ecosystems (agriculture). In recent decades, an increase in the areas occupied by extreme ecosystems has occurred (desertification).

ECONOMIC GEOGRAPHY

WORLD AGRICULTURAL TYPES

We use the term 'Agriculture' to describe all of man's activities that are dependent upon the soil. It includes growing of crops and the raising of livestock. It is the chief occupation of man, for nearly two-thirds of the labour force the world today is directly engaged in it. Production of industrial crops such as cotton, flax, rubber and raising of animals for meat, wool and hides is also important. The main geographical factors that influence agriculture are Climate, Soil, Relief or Topography.

Climate : (heat, sunshine and moisture) is the most important factor in determining the type of agriculture. There is little that man has ever been able to do against the vagaries of weather, such as unexpected drought, unseasonal frosts and excessive rainfall. Of course, to a limited extent man does modify most of these factors, as for example, when he carries water by irrigation to places where moisture is deficient or supplies fertilizers where the soil is different.

Soil : Different crops have different soil requirements.

Topography : Plains, river valleys and deltas are more suitable for cultivation than hilly areas Well-drained hill-slopes may be suitable for some crops (tea, coffee) while other crops (rice may require marshy lands.

Other factors such as market for the commodity, transport, capital, labour, government policy also influence agriculture.

TYPES OF CROPS

Broadly we can classify crops as :

Food Crops, such as wheat, rice, maize, millets, oats, barley, rye, spices and fruits.

Commercial crops, such as cotton, jute flax, tobacco, rubber, oilseeds, tea, coffee and cocoa. Crops like sugarcane may also be known as commercial crops although they may be used as food.

AGRICULTURAL ACTIVITIES

Agricultural activities may be divided into two broad categories: 1) Subsistence farming, and 2) Commercial farming. If the agricultural occupation is carried on to supply local wants and needs, it is called subsistence farming. If it is carried on to furnish that which other people desire, it is called commercial farming.

Subsistence farming : The term "subsistence" is a relative one and varies in significance with time and from place to place. Again, subsistence agriculture may be of various types. It may be primitive, such as is found in some parts of the equatorial and tropical forests, where people use simple tools or implements and produce food for their own immediate needs. In shifting cultivation, a patch of ground is cleared, very often with fire (hence this types of cultivation is sometimes called "slash and burn") and the ground cultivated for a few years until the soil is exhausted. The cultivators keep on shifting from one part to another where they clear new patches of ground.

Subsistence agriculture elsewhere: In densely populated areas, as in India and China, farmers may consume directly nearly all the grain which they produce and only a small surplus may be left for exchange against other goods. These farmers work hard in order to obtain maximum yield from their lands. They use manures like animal dung, household waste, fertilizers and night soil and may also make use of irrigation water. This is an example of intensive subsistence type of agriculture.

Commercial farming: In this type of farming, the farmer produces crops for sale usually for world markets. Commercial farming may be extensive or intensive.

Extensive Commercial farming: It implies employment of greater area of land in proportion to capital and labour. Land may be left fallow for a year or two to enable it to region its fertility. If this is the case, farming operations may be highly mechanised and farming concerned with one principal commercial crop. This commercial grain farming in the United States, Canada, Argentina and Australia are examples of extensive commercial farming.

Intensive commercial farming: There is also intensive commercial farming such as is practiced in the lands around the Mediterranean Sea. Fruits like grapes, oranges and lemons, olives and figs are produced on a commercial scale. Cooperatives are generally found useful in collecting, processing and marketing the farm produce. Intensive commercial farming is practiced where farm land is of high value. Population pressure reduces the size of individual holdings, as is the case in the delta regions of the great rivers of Asia. In other places, such as the irrigated areas (in Egypt) or reclaimed areas (in Denmark and Netherlands), land is available for cultivation only with great expense and energy. There is much capital or labour or skill (or all three) applied for a small area. No land is left fallow and fertilizers are much used. This type of farming has, therefore, developed mainly in the densely populated countries with limited arable land.

Mixed Farming: In this type there is cultivation of arable crops and the rearing of livestock on the same farms. Farming techniques are highly advanced. Modern machinery, selected seeds and great use of chemical fertilizers are common. The farmers also practice crop rotation, growing root crops like potatoes, beets, turnips and legumes like beans and peas. This maintains the fertility of soil. In addition to dairy animals, he may also keep pigs and poultry. This is one of the most important forms of agriculture found in highly developed parts of the world, particularly in the cool, moist regions such as N.W. Europe, S.E. Canada, the "hay and dairy belt" of N.E. United States, in large parts of the Soviet Union and to some extent in South Africa.

Market Gardening: There is intensive cultivation of vegetables, flowers and fruits for nearby urban areas. Farms are generally small and located where there are good communications with the urban areas. It is usually very labour intensive, the work being done by hand labour, though some machinery may be used. Soil fertility is maintained by application of manures or fertilizers. The American farm, known as truck farming, operates on a large scale and is more specialised, as in California and Florida.

Plantation Farming: This type of farm organisation has developed within the tropics and subtropics. It was developed in the early days of colonisation when the industrial nations of western Europe wanted tropical and subtropical products for their manufactures.

The Dutch had also set up sugar plantations in Java.

Plantations vary, from area to area and with different crops, but their general characteristics are similar. It involves clearing of forest, preparing ground, laying roads, power supplies, houses, schools, hospital and other amenities for the workers. It requires efficient and scientific methods of cultivation, special types of implements, skilled but relatively cheap local labour and world-wide marketing facilities. A plantation is thus a large unit producing a single-crop on a scale that resembles factory production. The important plantation crops are rubber, coffee, cotton, tea, bananas, coconut, caco, sisal, oil palm, pineapples and cinchona. A great proportion of these products enter international trade. Plantation farming requires large capital investment. In most cass it takes several years before the first crop is ready for harvesting. Hence it is undertaken by companies backed by large capital resources and with proper managerial skills. The development of plantation system has given the world a large supply of tropical products at lower prices for the consumer and a more uniform and better quality of product.

Most of the plantations of the world are situated in tropical zone (Malaysia, Indonesia, Sri Lanka, East and West Africa, West Indies, India).

Dry Farming: It involves special methods of cultivating land in places where there is water shortage (e.g. in arid and semi-arid regions) and where irrigation water is not available. One method is to crop the land in alternate years, leaving it fallow in every other year. There is constant harrowing to prevent ground water from moving to the surface by capillarity. The land is also protected by spreading vegetable matter, such as straw, over the surface; this reduces surface evaporation. Wheat is widely grown under this method. Other crops are oats, barley, rye and cotton.

Collective Farming: This development began after the Communist Revolution in the Soviet Union in 1917 and prevailed in the former Soviet Union and Eastern Europe (Poland, Rumania, Hungary, Czechoslovakia, etc.). Farming is organised by the state, using labourers. In Israel, most of the agricultural land is organised into settlements such as the Kibbutz. Each kibbutz has several hundred members who work without formal payment but get all their requirements of housing, clothing, education of the young and medical care, with some extra money.

Co-operative Farming: This type of farming is based on the principles of co-operation. The owner and the tenant farmers pool their resources together. In this way some of the advantages of large-scale financial and technical organisation can be achieved without individuals surrendering their independence. Cheaper seed, fertilizers, implements and better prices for products can be obtained as a result of collective buying and selling. Dairies, bacon factories egg and fruit grading, marketing and warehousing are in many cases owned collectively. It plays a very important role in such countries as Denmark, Belgium and Netherlands. In Denmark, the prosperity of the farmer is due mainly to the co-operative movement. Almost every farmer is a member of the co-operative societies. Co-operative farming has been introduced in many states of the Indian Union.

DAIRY FARMING : Keeping animals for the purpose of producing milk as food is called dairy farming. It is an advanced type of farming, involving use of scientific methods at every step. In dairy farming there is also income from sale of calves, poultry, eggs and pigs.

Commercial dairy farming: Dairy farming is practiced in its intensive form in many parts of the world. The three largest areas in the world are Western Europe, the north-eastern regions of North America, Australia and New Zealand.

1. **Western Europe**: The best known dairy produces are Denmark and Netherlands.In the mountainous areas of Scandinavia and Switzerland, transhumance is practiced. In summer. the animals graze on mountain pastures and dairy men move with their herds and manufacture cheese on the spot. In winter, the animals are led to the valleys where they are fed in their stalls. France and Italy are also noted for the excellence of their dairy products. The development of co-operatives, and promotion of scientific methods, coupled with quality control by the government and the nearness to urban markets have made dairy farming more prosperous than agriculture.

2. **The North-Eastern Regions of North America:** Dairying is common to practically all farming areas in Canada but more particularly in the provinces of Ontario and Quebec. In the United States, the most favourable conditions are found in the Hay and Dairy Belt which stretches from Minnesota through Michigan to Maine.

3. **Australia and New Zealand:** Dairy farming in these countries has developed in recent years. The most important regions are in south-eastern part of Australia (humid, coastal districts of Victoria, New South Wales and South-eastern Queensland) and the North Island of New Zealand. Plenty of grass is available nearly all the year round and cattle can be kept outdoors all the time. This fact, together with extremely effective farm management and the use of labour-saving devices enable these two countries to

reduce production costs. Co-operative societies are a special feature in New Zealand and her dairymen are probably the most efficient producers of milk in the world. The development of refrigeration has given a great filip to their dairy industry as it enables them to find markets in far-away lands of Europe.

Nomadic herding: Nomadic herding is confined to sparsely populated parts of the world, mainly in Africa and Asia. The rainfall in these regions is low and seasonal, so that vegetation thrives at certain times of the year. This makes it necessary to drive the animals from pasture to pasture (e.g. Tuaregs of Sahara, the Fulani of West African Savannas, the Masai of East Africa, the Bantu and Hottentots in Southern Africa). Improved farming techniques, including irrigation facilities, have reduced the areas for nomadic herding, for example, in large areas of the grasslands of Central Asia, nomadism is being displaced by state farming system.

Commercial Grazing: Commercial grazing from nomadic herding in many respects. There is no migration from one pasture to another. The ranchers live in permanent farms (or ranches or "estancias") from which they can reach all parts of their ranches. The estates or ranches are very large, some covering as much as 10,000 or more sq km and are run on most modern and scientific lines. This kind of grazing occurs in the drier lands and where population density is very low. The largest of these areas are in North America, southern parts of South America, Australia, southern parts of South Africa and the Steppe region of the Soviet Union.

WORLD AGRICULTURAL RESOURCES

CEREALS

RICE

Rice (Oryza sativa) is primarily a crop of the Tropics and sub-tropics. It is the chief food of about half the world's population.

Climate: It requires temperatures of over 22°C. during the growing season and over 26°C at the time of ripening. It thrives very well in plenty of bright sunshine and water. Abundant rainfall, ranging from 150 to 200 cm is necessary. Plenty of water is required at the time of early growth and transplantation.

Soil: It grows on a wide variety of soils. The supply of water is the most important factor. However, alluvial friable loam with sub-soil of clay is ideal. It is impermeable and water will not drain away. Low-lying level lands, especially the alluvial soils of the river valleys and deltas are very suitable. It is also grown on man-made terraces on the slopes of hills.

Methods of cultivation: Rice is normally sown in nursery plots and not directly in the paddy field where it is to mature (rice, with husk on, is called "paddy"). It is transplanted in small bunches into the fields after about 6 weeks. Transplanting makes the plant grow faster and gives a greater yield. The crop is ready in 3 or 4 months, depending on the type. Dry season is essential at the time of harvesting. In most rice lands of Asia, ploughing, sowing, transplanting, harvesting and other work is done by hand. In the U.S. and Japan, these operations are performed mechanically as also on the large collective farms in China. About 90 per cent of the world's rice is grown in East and South Asia.

WHEAT

Wheat is the most important cereal in the temperature zone. It is the best bread-making grain.

Climate: There are several varieties and different varieties require different climatic conditions; for example, it is grown on spring rains as in America and Russia and winter rain as in the Mediterranean lands. In India it is a winter (rabi) crop. The Temperature range is 15° to 23°C during the growing season. There should be warm and sunny weather at the time of ripening. A Rainfall of 50 to 100 cm is required during the growing season. On irrigated lands a rainfall of 40 to 50 cm is sufficient.

Soil : It should be stiff enough to support the plant and retain the moisture. Clay loam soils or fertile silt are desirable. Level or undulating ground facilities farming operations with the help of machinery. It grows well in all the temperature grasslands of the world such as the Pampas, the Prairies and the Steppes. The large scale commercial production also occurs in Australia and on the Pampas of South America. France is the largest producer.

MAIZE

Maize is the third great cereal used for human consumption. It is cultivated in regions with many different types of climate. It is found throughout the tropics and with irrigation it grows even in the deserts.

Climate: Maize requires temperatures varying from 20° to 32°C and rainfall from 50 to 100 cm. The Soil should be sandy deep and well-watered.

Maize is an important food crop in Central America, South America, Africa and to a lesser degree in India and China. About half of the world's maize is grown in the United States, but 80% of it is used for animal feed and corn oil and not for direct human consumption.

Potatoes : It is an important food crop that grows best in a mild and humid climate. It is now grown throughout the humid mid-latitudes. Eastern European countries and the CIS produce more than 50% of the world's crop. United States, Peru, China, India and Japan are others major producers.

MAJOR AREAS OF RICE, WHEAT, MAIZE AND POTATO PRODUCTION

Rice	Area %	Wheat	Area %	Maize	Area %	Potato	Area %
Asia	91	Asia	38	N.America	48	Europe	31
Africa	3	Europe	24	Asia	25	Asia	26
S. America	3	N. America	17	S.America	11	S.America	4
N. America	1.5	CIS	16	Europe	10	CIS	27
Europe	<1	S. America	2	Africa	5	N.America	9
Oceania	<1	Oceania	2	CIS	1	Africa	3
		Africa	1	Oceania	<1		

IMPORTANT COMMERCIAL CROPS

SUGARCANE

Sugarcane is a tropical crop which seems to have it's original home in eastern and south eastern Asia.

Climate: The cultivation of sugarcane is confined between 37°N and 30°S. The Tropical Savannas with a long wet season and short dry period offer ideal climatic conditions for sugarcane. It requires a summer temperature of 20°C, but 25° to 30°C is preferred. Rainfall should be from 100 to 170 cm. During the growth of the plant plenty of water is essential either as rain or better still through irrigation. Much sunshine is required at the end of the growing season.

Soil : Rich alluvial or lava soil is suitable. Regular supply of manures is essential. It requires plenty of labour for harvesting the crop and preparing the material for the market.

Regions of Production : Brazil, Cuba, Mexico, India, Pakistan, China, Thailand, Indonesia and Australia are the main producers of sugarcane.

TEA

Tea is made from the dried leaves and tender sprouts (two leaves and a bud between them) of the plant. New sprouts are plucked it intervals of a fortnight and the picking season lasts from 8 to 9 months. The finest qualities of tea are grown at high elevations upto 2,000 metres as in Darjeeling in north-east India.

Climate: The tea plant is essentially a tropical and sub-tropical crop. Its temperature range is from 13° 35°C. It requires a rainfall varying between 150 to 250 cm. The rainfall should be well distributed.

Soil: Tea requires a light and friable loam with porous subsoil which allows the water to percolate. Iron in the soil appears to be beneficial. Stagnant water is harmful, hence mountain slopes are preferred. There are two main varieties of tea. To prepare black tea the leaves are dried in the sun and then rolled mechanically between steel rollers and then fermented.

Thereafter they are baked lightly until reddish brown in colour. The leaves are then allowed to ferment. The leaves are processed in the factory located on the tea estates and the factory processes are carried out by machinery.

India, China, Sri Lanka, Bangladesh, Japan, Indonesia, Argentina and Kenya are the main tea producing countries.

COFFEE

Coffee is a typical highland crop of the Tropics. The tree grows to a height of about 9 to 10 metres abut it is pruned regularly to keep the height 3 or 4 metres.

Climate: The coffee plant requires moist and warm conditions, with Temperatures ranging from 18° to 27°C all the year round but direct rays of the sun are injurious to the plant.

Rainfall requirements range from 125 to 200 cm. well distributed throughout the year. The plant has to be protected from hot dry winds, especially in the early stages of its growth. Hence it is often grown in the shade of other trees. Dry period during picking season is desirable. Soil is an important factor, Weathered volcanic soil on well-drained hill sides from 450 to 1,800 metres is suitable. There should be humus in the soil. Brazil, Colombia, Venezuela, Guatemala, Haiti, Jamaica, Ethiopia, and Indenesia are the major producers.

NON FOOD CROPS

COTTON

The plant grows as a bush to a height of 1 or 1.5 metres and the "bolls" are ready for picking in about six months.

Climate: It is essentially a tropical plant but it is cultivated between 40°N and 30°S provided there is no frost. The Summer temperatures of 25°C and abundant sunshine are necessary during the growth of the plant. Rainfall should be from 80 to 120 cm and well distributed throughout the period of growth. Cotton plant is also sensitive to frost. That is why it grows best in hot countries on irrigated lands.

Soil : Light limsestone soil black lava soil is suitable. The Deccan black lava soil (regur) has the quality of retaining moisture.

Plenty of labour is required for ploughing, sowing, weeding and picking cotton as well as for other processes such as ginning, pressing and packing, before the raw material is ready for the textile mills. There are several varieties of cotton. Quality depends of the length of the fibre and also ont he fineness, strength and colour. The length of the fibre varies from 1.2 cm to 5.6 cm. Cotton with a fibre of over 2.8 cm is considered "long staple", while that of less than 2.2 cm is "short staple". Cotton between these lengths is classified as "medium staple". The U.S.A., the Central Asian Republics, India and Brazil, China, Pakistan, Sudan and Turkey are the main producers.

JUTE

Jute is obtained from the stem of a certain plant which grows from one and a half to three metres in height. The seeds are sown in March-April and the plant matures in 5-6 months. The plant is cut or pulled by hand and gathered into bundles and left in stagnant water for "retting" for about 15-20 days. This loosens the fibres and separates them from the stem. After cleaning, the fibres are made into bundles and left to dry.

Climate: The jute plant requires high temperature with a minimum of 27°C during the growth of the plant. It needs a rainfall of 170 to 200 cm. evenly distributed, during the growing period. Plenty of water is required for soaking the plants and for washing the stripped fibre. Hence it is grown in river valleys and deltas.

Soil: Alluvial soil found in the flood plains and deltas or rivers is suitable. Annual floods of the river supply the salts necessary in the soil.

Bangladesh, India, Mexico, Indonesia and the U.S.A. are the some of the producers.

WORLD MINERAL RESOURCES

Most minerals are associated with igneous and certain highly matamorphosed rocks. Generally speaking, metals are found in veins and other deposits deep in the earth. Coal, petroleum and building material such as clay, gypsum, phosphate rock are found in sedimentary rocks. Sometimes gold, tin, platinum and precious stones have been moved by running water from one place to another. An important characteristic of mineral resources is their uneven distribution over the world. Some areas are very rich in a variety of mineral resources, such as the Ural Mts. in the erstwhile U.S.S.R., the Canadian Shield and South Africa, while large areas are comparatively poor. Some minerals are found in great abundance in only a few regions of the world, for example, most of the world's supply of tin seems to be in eastern Asia (Malaysia, Indonesia, Thailand, China). Canada has more than half of the world's reserves of nickel; more than 60 per cent of the world's supply of gold comes from South Africa.

IRON

Iron is the commonest element, nearly 5 per cent of the earth's crust is iron. But the ores must contain at least 30 to 40 per cent of the metal for commercial exploitation.

Iron is never found in a pure state. It contains varying amounts of silica, lime, sulphur, phosphorus and other materials.

Iron ore is first melted in a blast furnace which is filled with iron ore, coke and limestone. Heat from the burning coke melts the ore, and the impurities mix with the limestone and are drawn off as "slag". The molten material runs off into moulds or "pigs". This pig iron is really the raw material of the iron and steel industry. This is then turned into cast iron, wrought iron and steel.

Iron is mixed with carbon to make it very strong. Other metals used are nickel, cobalt, vanadium, molybdenum, manganese, tungsten and chromium according to the special purpose for which the steel is required.

The principal iron producing countries are Ukraine, Russia, Australia, China, India, USA, Canada, Great Britain, Malaysia, Sweden, Spain, Japan, Chile, Brazil, Argentina, Venezuela and Africa.

MANGANESE ORE

Manganese is used in making good quality steel. The addition of manganese makes the steel tough and hard and it does not rust easily. It is also used in several chemical industries as an oxidiser in the preparation of bleaching powder, disinfectants and other chemical. The producers are S. Africa, Ukraine, Russia, Australia, Brazil, Gabon and India.

MICA

It is a transparent mineral found in most igneous rocks. Mica splits easily into thin plates. The chief use is as in insulating material in electrical goods. The producing areas are India, USA, Ural, Ukraine, Russia, Brazil, Republic of S. Africa, Tanzania, Zambia, Norway, Canada and Malagese.

GOLD

Gold differs from other metals in that it is found "native", that is, uncombined with other metals. It occurs as veins running through quartz or other hard rocks. In such a case it is known as "lode" or "reef" gold. This can be exploited only by installing expensive machinery for mining and crushing rock. The chief producing areas are South Africa, CIS, USA, Canada, Colombia, Peru, Equador, Brazil, Australia, China, Japan, Korea and India.

SILVER

Silver often occurs in native form in association with lead and copper ores. The leading producers are Mexico, Canada, USA, Australia, Boliva, Chile, Spain, Germany, Japan, Myanmar, India, Sweden, Italy, France, Finland, Yoguslovia, Romania, etc.

COPPER

Copper was probably the first metal used by man. It has a high conductivity and is used in electrical apparatus. It also forms useful alloys such as bronze, brass, German silver and money metal. The production areas are Chile, Peru, USA, Canada, S. Africa, Zambia, Zaire, Angola, Kenya, Zimbabwe, Russia, Siberia, Ukraine, Balarussia, China, Indonesia, India and Australia.

POWER RESOURCES

Coal is the major source of power. There are three main varieities of coal : lignite, bituminous and anthracite. Anthracite or hard coal is jet black in colour and is ideal for domestic use since it burns slowly without smoke or soot. It is clean to handle and has a high heating value. Coke, required for smelting of iron ore, is derived from bituminous coal. Lignite is brown or brownish in colour and is considered inferior although its by-products can furnish several materials for industries. Coal reserves occur in all the continents and in most of the countries of the world but they are very unevenly distributed. The leading producers are China, USA, the CIS, Ukraine, India, Australia, S. Africa, Germany, Great Britain, Poland, Belgium and France.

Petroleum is another important source of power. It has several other uses. The crude oil is used as fuel for steamships and locomotives. Petrol is used for automobiles and aeroplanes. Kerosene is used as oil for lamps. Hundreds of other by-products are made from it, including lubricants, vaselines, tars, waxes, ink, medicine, soap and terylene. The principal petroleum producing countries are Saudi Arabia, Mexico, Russia, Iran, China, Kuwait, Veneuzela, Iraq and Great Britain.

TRANSPORT

The chief modes of transport are given below :

MODES OF TRANSPORT

Land **Water** **Air**

Pipelines

Roads **Railways** **Oceans** **Inland (Canals, River)**

Land Transport : Roads and Railways are the quickest and most efficient means of land transport. For the movement of commodities over relatively short distances, road transport is supposed to be more efficient than the other modes. The table given below indicates the road routes of various countries:

Road Transport		
No.	**Countries**	**Road routes (in km)**
1.	U.S.A.	62,86,396
2.	India	33,20,000
3.	Brazil	16,58,677
4.	Japan	11,56,000
5.	Russia	5,70,719
6.	China	12,78,474
7.	Canada	9,01,903
8.	Australia	8,08,465
9.	France	8,93,500
10.	Germany	2,30,735

Railways : Railways are comparatively cheaper and a more convenient mode of transport than the roadways in moving goods in bulk over a long distance. Development of the railways commenced in the beginning of 19^{th} Century. The first train was started on 27^{th} September. 1825 in between Stockton to Darlington. Thereafter in 1827 in France, 1830 in U.S.A. 1835 in Germany, 1836 in Russia and 1853 in India.

	MAIN RAIL ROUTES OF THE WORLD	
1.	North France Continental Rail Route	Seattle (U.S.A.) to Newyork.
2.	Mid Trance Continental Rail Route	San-Francisco to Newyork.
3.	Southern France Continental Rail Route	From Los Angeles to Newyork then New Orleans.

MAIN CANALS OF THE WORLD		
1.	Suez Canal	Jons Meditteranean Sea with Red Sea.
2.	Panama Canal	Joins Pacific Ocean with Atlantic Ocean.
3.	Kiel Canal	Joins North Sea with Baltic sea.
4.	Soo-St-Mary Canal	Joins superior lake with Huron lake.
5.	Manchester shipping canal	Joins Manchester with Estham.
6.	North-sea canal	Joins North-sea with Amsterdam.
7.	New shipping canal	Joins North-sea with Rotter Dam.
8.	Stalin Canal	Known as a Volga-Don Canal. Joins Rostar with Stalingrade of C.I.S.
		Gota Canal : Joins Stockholm to Goteburg. All these canals transport iron ore, lime-stone, cereals, cement, pulp and paper coal, petroleum.

IMPORTANT JOINING CANALS		
	Canal	**Joining station**
1.	Suez	Mediterranean to Red Sea
2.	Panama	Pacific to Atlantic Ocean
3.	Kiel Canal	North Sea to Baltic Sea
4.	Soo Canal	Superior to Huron
5.	Manchester	Manchaster to Estham
6.	North sea	North Sea to Amsterdam
7.	Stalin or Don-Volga	Rostor to Stalin grade
8.	New shipping Canal	North Sea to Rotterdam

Ocean Transport : Ocean transport is the cheapest transport by which goods can be transported from one place to another. Normally a ship can Cargo 8000 to 10,000 G.M.T. For loading, unloading the goods ports as well as harbours are constructed. Following are the important ocean routes : ✶ North Atlantic Route ✶ Pacific ocean route ✶ Mediterrranean route ✶ Cape of good hope route ✶ South Atlantic route ✶ Caribbean sea route.

Air Transport : Air transport is the fastest but costliest mode of transport. The development of air transport started after the First World War. But the actual development of this transport took place after the Second World War. Four types of services are performed by Air transport :

1.	**Inter-Continental Global**	This includes the longest services e.g., New York –London-Paris-Rome Cairo-Delhi-Kolkota-Hangkong Tokyo. Newyork-SanFranciso-Honolulu-Hongkong-Adilade-Perth.
2.	**Continental Air Route**	These services are performed among the countries within a continent e.g., New york-Chicago-Montreal Route London-Fran Furt-Warsaw-Moscow London-Paris-Frank Furt-Prague-Warsaw. Delhi-Kolkota-Hong Kong-Tokyo.
3.	**National Air Route**	Perform services for long distance within the country e.g., Newyork-Chicago-San Francisco. Laningrad-Moscow-Osrk-Tashkant. Delhi-Mumbai-Chennai or Delhi, Kanpur, Patna, Kolkota.
4.	**Regional Air Route**	This route provides services for short distance e.g., U.S.A, Russia, Germany, Great Britain, Japan, Canada and Australia.

4.	Canadian Pacific Rail Route	Halifex to Vancuvor (Canada).
5.	Canadian National Rail Route	St.John city to Vancuvor.
6.	Trans-Siberia Rail Route	grad to Vladivostok via Moscow.
7.	Trans Caucasus Rail Route	Batur n to Farghana and Krusk.
8.	Cape-Cairo Rail Route	Longest rail route of Africa running from Cape town (S.A.R.) to Cairo city (Egypt).
9.	Oriental Express Rail Route	An important rail route of Europe, Running between Paris (France) to Kustuntunia (Turkey).
10.	Trans Andean Rail Route	The biggest rail route of South America, running from Valperago (Chile) to Buenos Aires (Argentina).
11.	Trans-Australian continental Rail Route	Perth to Sydney.

LENGTH OF RAIL ROUTES

Countries	**Rail route (km)**
U.S.A.	2,22,000
Russia	1,51,000
Canada	65,403
Germany	87,207
China	57,584
India	63,221
U.K.	37,849
Australia	35,780
France	31,821
Brazil	29,706

Water Transport: This includes canals, lakes, river, seas and oceans. The transportation is done inland (nationally as well as internationally). Water Transport can be divided into three categories:

WATER TRANSPORT

Canal Water Transport | Inland Water Transport | Ocean Water Transport

Inland Water Transport is done by rivers. The following table details the Inland Transportation in the different countries.

	Country	Transportation
1.	Northern Europe	River Rhine, Seine, Mayse, Elbe, Weser and Audor.
2.	C.I.S.	Dnieper, Dnester, Don, Volga, Ob, Yenese, Lena.
3.	U.S.A	Great Lakes, Mississippi, Missouri, Ohio.
4.	Asia	a) China-Hawangho and Yangtazekiang, b) India – Ganga and Brahamputra, c) Myanmar- Irrawady etc.
5.	Tropical Countries	Amazon and Congo.

Few Canals of the world are also used. The usage of canals not only reduces the distance among the countries but also made the transportation swift.

LENGTH OF NAVIGABLE CANALS/RIVERS

	Countries	Length (km)
1.	China	1,10,300
2.	Russia	89,089
3.	Brazil	50,000
4.	U.S.A.	41,485
5.	Indonesia	21,579
6.	Vietnam	17,702
7.	India	16,180
8.	Argentina	10,950

HUMAN GEOGRAPHY

DISTRIBUTION OF WORLD POPULATION

Human beings are very unevenly spread over the earth's surface. The greater part of the land surface is practically uninhabited, while large areas are very thinly peopled. Most of the world's population is concentrated in about 25 per cent of the earth's surface. The greatest numbers, about 90 per cent, lie in the Northern Hemisphere and even here, nearly 60 percent live in between latitude 10° and 40° North. The most crowded continents are Asia and Europe. Together they have 70 percent of the world's population.

No single factor can explain the uneven distribution of population. However, a comparison of the world maps of population density with those of physical features, rainfall, temperature and natural vegetation will at once suggest that geographical factors are the most important. People have inhabited those areas where natural conditions have been favourable for human activities.

The stage of technical development plays an important role in the density of population. The progress made in the use of the products of mining and the development of large-scale manufacturing has enabled parts of western Europe (for example, Britain, France, Belgium Netherlands and Germany) and the north-eastern region of the U.S. to support a dense population.

Historical factors are also responsible for higher density of population in some areas. Areas which have been inhabited since ancient times have dense population. Examples of these are the valleys of the Nile, Tigris-Euphrates, the Yangtze and the Ganges.

SPARSELY POPULATED REGIONS :

1. **The Tundra regions** : The Tundra regions have low temperatures and low precipitation which are not favourable for plant growth. Only scattered nomadic peoples, such as the Eskimos are found here. The northern most parts of North America, Eurasia and Greenland are too cold. The Antarctica is uninhabited. Towns are mainly in the mining areas such as Gallivare in Sweden (for iron ore), Fairbanks in Alaska (for mineral oil and gold), Murmansk in Siberia (a mining and trading centre).

2. **Coniferous forest regions**: There are large areas in the northern hemisphere where winters are very cold and rainfall is relatively low. Swamps cover large areas and farming is difficult. There are small settlements dependent on timber industries (Finland) and minding (iron ore at Knob Lake in Labrador).

3. **The Equatorial Regions of the Amazon and Congo Basins**: They are generally unfavourable because of high temperatures and heavy rainfall. In the dense forests tribal people depend on hunting and gathering. In areas cleared for faring and

mining the population is considerable, for example, parts of Indonesia and the Philippines where the population densities are quite high.

4. **Tropical and Temperate Deserts**: The absence of water prevents the growth of vegetation which could provide food for men and animals. Deserts (Sahara, Arabian, Thar, Kalahari, Atacama, Great Australian) occupy large parts of the continents. Temperate deserts such as the Gobi are also very thinly populated. People are concentrated in irrigated regions of the river valleys (Nile Valley, Tigris-Euphrates Valley) or in the mining centres, e.g., Middle East (mineral oil), Kalgoorlie in Australia (gold).

5. **Mountains and High plateaus:** Mountains and many high plateaus of the the world are less favourable for human settlement, because of their ruggedness, unsuitable climate and difficulties of transport (Tibet, Andes, Rockies, and the Himalayas). However, some highlands, particularly plateaus in Africa and the Andes support considerable population, mainly because of mineral wealth.

DENSELY POPULATED REGIONS :

1. **Eastern and Southern Asia**: Nearly half the inhabitants of the world live here. The concentration is the greatest in the low-lying regions such as the river valleys and deltas and the fertile coastal plains where there is sufficient water for irrigation. In Eastern Asia it includes China, Japan and Korea. In South Asia it includes India, Bangladesh, Thailand, Vietnam and Java.

2. **The Northwestern and Central Europe:** This is the world's highly industrialised zone. Nearly one-sixth of the world's population is found here. It includes Britain, France, Belgium, Netherlands, Poland, Germany, Northern Italy and European Russia. Abundant mineral resources, high industrial development and advanced farming methods are the major factors.

3. **The North-Eastern U.S.A.**: This region has favourable climate, fertile soil, mineral deposits, especially coal and iron ore and a good network of railways, roads and canals. The area lies between Baltimore and Boston and includes such large cities as Boston, Chicago, Pittsburg, New York and Philadelphia. In addition to the major areas of dense population mentioned above, there are many smaller areas of very thick population, such as the Nile valley.

Demographic Structure : Sex ratio, age composition, literacy rate, occupational structure are some of the aspects of demographic structure which can be measured and are quantifiable.

Age and Sex Ratio: Age is an important component in demographic structure. If the number of children is large in the population of a country, the chances of the increase of population in future are more. The potential availability of labour is also high. If the number of children in the age-group of 0-14 Yrs, and of the people above 55 years of age is large, it would mean that the size of dependent population large.

The size of population in lower age groups is large in those regions where birth rates are higher e.g. in Africa, Asia and Latin America. In those countries where birth rate is low but life expectancy is high, the number of children is lower but the number of older people is higher.

Sex ratio refers to the ratio of males and females. It is measured in terms of number of females per thousand males.

In those countries, where death rates of male and female children are similar because equal care is taken in bringing up the male and female children, the sex ratio is generally balanced. Besides the differential birth and death rates, the male out migration also causes imbalance in the sex ratio.

Age-Sex Composition: Age and sex ratio is very well represented by age pyramid. In most of the developing countries, the base of the age-sex pyramid is found to be broad and the apex to be narrow. It means children are more and older people are less in numbers. In France, Sweden and some other European countries the base and the central part of the pyramid are of the same width which means that the number of children and middle aged people are the same due to low birth rate. Age pyramid also reflects the future trend of the population in an area. The availability and maturity of human resources depend upon size of the population between 15 to 55 years of age. Therefore, significant clues for human resource planning can be obtained by studying these pyramids.

Literacy: Besides the size of population, the quality of human resource is an important aspect. Literary reflects that social aspect f population by which its quality can be ascertained. There is a wide variation in the literacy rates in the world. The literacy is higher in urban areas as compared to rural areas throughout the world. Likewise the female literacy in rural areas is much lower than the female literacy in urban areas. Major factors influencing literacy rate are, level of economic development, level of urbanisation, standard of living, the status of females and other groups in the society, the availability of educational facilities and the policies of the government. Level of economic development is both a cause and an effect of literacy. Higher level of literacy reflects higher level of economic development.

Urban and Rural Population: The population is divided into urban or rural on the basis of the residence. The urban population increases due to natural growth as well as due to migration of people from rural areas. The higher employment opportunities, availability of different types of social facilities and higher standard of living in urban areas attract the rural population. High urban population is an indicator of economic development of a country. Most of the developed countries have higher proportion of urban population e.g. United States of America, Canada, United Kingdom and Belgium. On contrary, countries with lower levels of economic development such as

Ethiopia, Tanzania, Kenya, Bangladesh, India and Pakistan have about 15, 14, 20, 18, 25 and 29 per cent of their total population as Urban population. Generally, industrially developed countries have higher share of urban population as industrialisation and urbanisation are positively correlated.

Occupational Structure of Population: Occupational structure of population refers to the proportional distribution of people under specific economic activities in any region. United Nations has identified the following categories of occupations.

- Agriculture, forestry, hunting and fishing;
- Minding and quarrying
- Manufacturing industry
- Construction;
- Electricity, gas, water and health services
- Commerce
- Transport, storage and communication services
- Unclassified occupations.

This classification is essential for international comparisons but each country classified its population in different occupational categories according to its own needs.