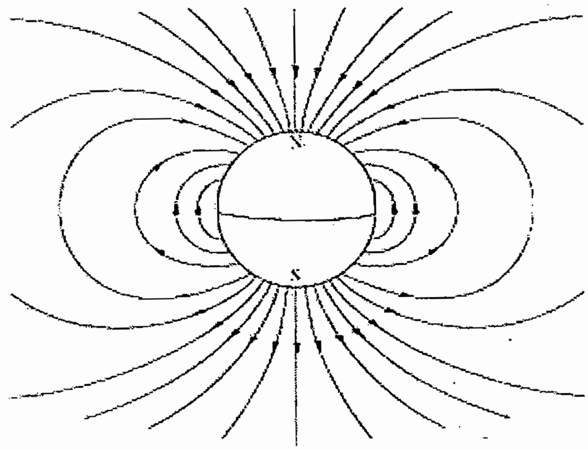


The Earth's magnetic field approximates a dipole. The Earth's magnetic field is shaped roughly as a magnetic dipole, with the poles currently located proximate to the planet's geographic poles. According to dynamo theory, the field is generated within the molten outer core region where heat creates convection 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.[J] 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°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.

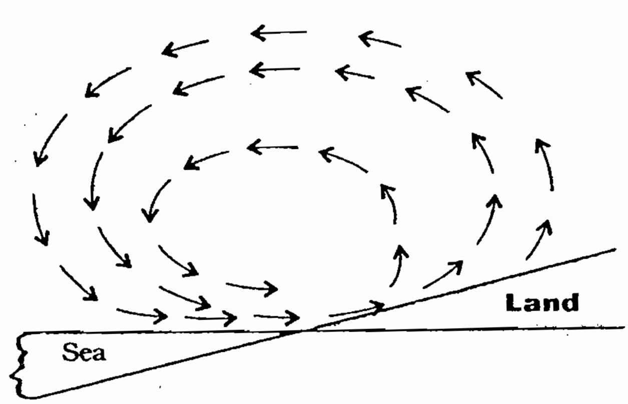
c) **The Prevailing Westerlies (or simply "Westerlies" because they blow out of the west):** They blow outside the Tropics, in the Temperate Zone, on the poleward side of the Trade Winds, and between 30° and 60° north and south. The weather in their area is characterised by a constant procession of cyclones (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.



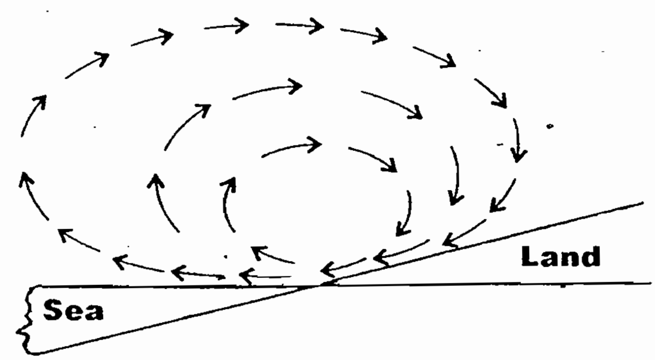
Sea Breeze

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

SRIRAM'S IAS

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} km³. 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

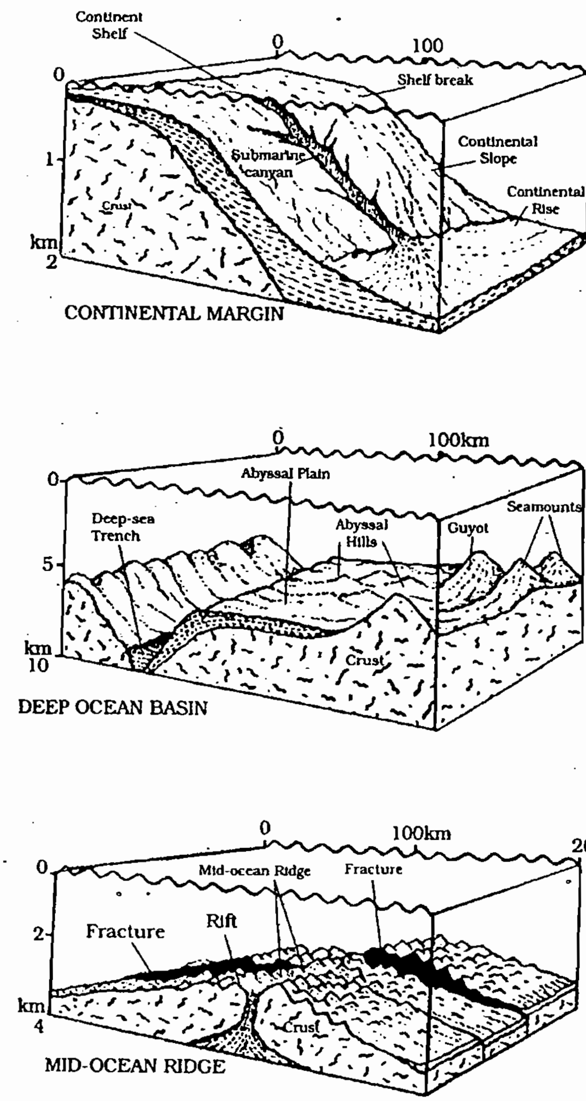
OCEAN FLOOR

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.



Relief features of ocean floors

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.

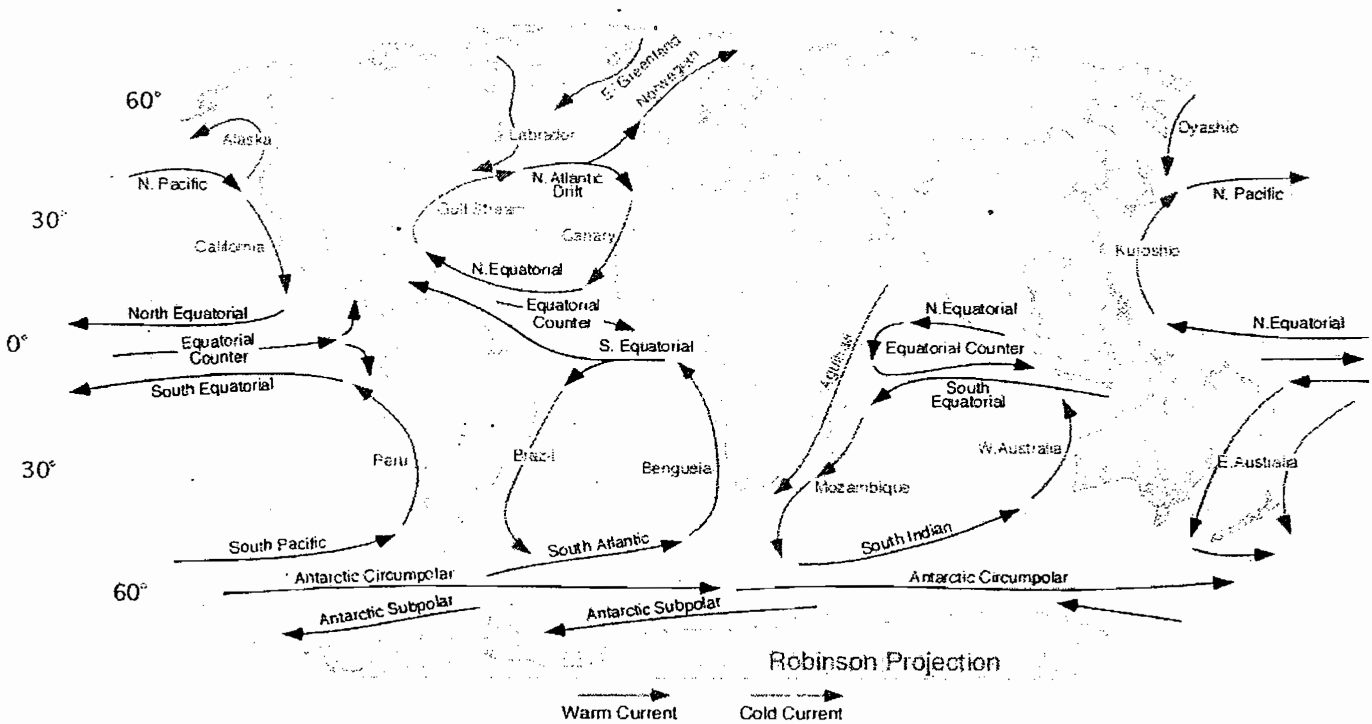
MAJOR OCEAN CURRENTS

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).

SRIRAM'S IAS

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 19th Century. The first train was started on 27th 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.

SRIRAM'S IAS

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GEOGRAPHY-II

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Geography-II
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LANDFORMS OF EXTRA-PENINSULAR INDIA

By Dr. D B KUMAR

The Extra-Peninsular region of the Indian Subcontinent comprises the mountainous region of the Himalayas and their extensions into Baluchistan (Pakistan) and Myanmar (i.e. the Arakan Yoma of Burma). It is a region of folded and overthrust mountains of geologically recent origin with youthful rivers which carve out deep and steep-sided gorges. — deep river valley forming & resembling as arch

Process of mountain formation (especially by the upward movement of earth's crust)

Geological Phases in Origin of Himalayas : The Himalayas are a part of a great arcuate orogenic belt extending from Spain to Indonesia which evolved as a result of repeated deformation of the sedimentary pile that accumulated in a geosyncline i.e. the *Tethy's Sea* and its forerunner, the *Proto-Tethys* (the Proto-Tethy's existed during the *Paleozoic era*). In fact, the Himalayas, the Alps, the Carpathians, the Zagros, the Sulaimans, the Arakan Yoma and the Indonesian Island Arc, are all part of a complex, physically continuous orogenic belt that originated broadly in the *Cenozoic era.* The Himalayas evolved as part of five phases in the convergence of the Indian plate and the Eurasian plate. The earliest collision took place 75 millions ago the latest phase began 1.8 million years ago.

STRUCTURE AND PHYSIOGRAPHY OF HIMALAYAS :

* width more in west as compared to east -

The Himalayas extend for a length of **2400 km** from the gorges of Indus in Kashmir in the west to Brahmaputra in the east. The width is between **240 km** (in the **east** i.e. Assam) and **500 km** (in the **west** i.e. Kashmir). The Himalayas cover an area of 5 lakh square kms comprising entire Jammu and Kashmir, all Northeastern States and entire Sikkim, Dehradun and Kumaon regions of U.P., parts of Himachal Pradesh and Darjeeling region of

W. Bengal. The *Convexity* of Himalayas is to the South i.e. towards the Indo-Gangetic plains.

1. **Siwaliks** : These constitute the outermost (towards the Ganga Plains) ranges and foothills. The Siwaliks evolved in the *last stage* of Himalayan orogeny and hence are youngest in the Himalayan system. These extend from Jammu and Kashmir to Arunachal Pradesh. The average elevation is 1500 m. They are a system of continuous ranges and run for a length of 2400 kms like the Greater Himalayas. The only huge break in the continuity of the Siwaliks is the valley of river Teesta. The Siwaliks are separated from the Lesser Himalayas by the Main Boundary Fault. The Siwaliks were the last ranges to be formed. The Siwaliks are called by different names in different regions like the Daffla, Abhor, Miri and the Mishmi hills in Arunachal Pradesh, the Jammu hills in Jammu and kashmir, and the Darjeeling hills in northen W.Bengal. The Duars are the gaps across the Darjeeling hills. The Duar region of W. Bengal resembles the Terai region of Uttarakhand.

Doors →

2. **The Lesser Himalayas** : These lie to the north of the Siwaliks and are the second youngest. The Lesser Himalayas also called as Himachals, are separated from the Siwaliks in the south by the Main Boundary Fault. The average elevation is 3000 m and the average width is 60 - 80 km. The Himachals are made up of a series of parallel ranges separated by valleys. The main parallel ranges are : The Lesser Himalayas are well developed in the Western Himalayas and are a system of discontinuous but parallel ranges. At the junction of the Lesser Himalays and the Greater Himalayas, valleys filled with lake deposited sediments occur. These are called the Doons or the Duns. Dehradun, Patli, Chaukhamba, etc. are

After G.H born himalayan rivers start flowing through himalaya. The L.H born the duns in Uttarakhand whereas Udhampur is the dun of Jammu and Kashmir.

The most prominent ranges of the Lesser Himalayas are :

i) The Pir Panjal Ranges : They form the southern boundary of the Valley of Kashmir and extend between Jhelum and Beas. A very prominent fact about the Pir Panjals is that they were the last to be uplifted in the uplift of the Himalayas. The prominent pass across the Pir Panjals are - the Banihal Pass (which has the Jammu - Srinagar highway). The Pir Panjal ranges are cut by rivers Kishenganga (a tributary of Jhelum), the Chenab and Jhelum. The Chamba valley of H.P. lies within the Pir Panjal ranges.

they underwent the cycle of (evolution) uplifting 2 times. Second time with Shivalik (when Shivalik formed)

ii) The Dhualadhar Ranges : These are the southeast continuation of the Pir Panjals and arise near the peak of Badrinath. Shimla, Dalhousie and Dharamsala are the hill stations on the Dhualadhar range.

iii) The Mussoorie Range : This forms the water divide between Ganga and Sutlej. The Mussoori range extends between Lansdowne and Mussoori. Nainital, Chakrata, etc. are the important hill stations on Mussoori range.

iv) The Nag Tibba Range : This is the continuation of the Dhauladhar range into Nepal.

3. **The Greater Himalayas** : Also called as **Himadris,** and extend from Nanga Parbat (8126 m) in the west to Namcha Barua (7756 m) in the east. The average elevation is 6,100 m. The Greater Himalaya are made up of the **oldest rocks** i.e. the Pre-Cambrian igneous and metamorphic rocks. The **Tethyan Himalayan Zone** occurs **within** the Greater Himalayas. These constitute the most continuous mountain range of the

Dharwar rocks

contorted

world. They have the oldest rocks of all the ranges, making up the Himalayan system. The Greater Himalayas boast of 14 of the 28 tallest peaks in the world. The four tallest peaks of the Greater Himalayas are Mt. Everest (8850 m), Kanchenjunga-I (8598 m) and Lhotse-I (8501 m) and Makalu (8481 m). The other prominent peaks are Dhaulagiri (8172 m), Annapurna, Mansalu(8156 m), Everest South Peak and Nanga Parbat (8126 m). The Great Himalayas are cut by some prominent passes like - the Burzil pass, Zozilla Pass (in Jammu and Kashmir), the Bara Lacha La and Shipki Pass in Himachal Pradesh, the Thaga Pass, the Niti Pass and the Liphu Lekh Pass in Uttarakhand the Natu La and Jelep La Passes in Sikkim, and the Raxaul pass and the Jogabani Passes in Bihar. The Greater Himalayas have some very large glaciers which are Rongbuk, Gangotri (30 km long in Kumaon-Garhwal), Zemu and Kanchenjunga, in descending order. The Greater Himalayas are separated from the Lesser Himalayas in the south by the Main Central Thrust (a group of faults).

4. **The Trans - Himalayas** : They occur north and northwest of the Greater Himalayas and are around 40 km wide in the east and west, and around 222 km wide in the central portions. The Trans-Himalayas are made up of the Karakoram, Zaskar and Ladakh ranges.

i) **The Karakorams** : They form India's frontier with Afghanistan and China. They extend from the Pamir Knot. The average elevation of Karakorams is around 5500 M. The four tallest peaks of the karakorams are :

Mt. Godwin Austen or K^2 with an elevation of 8611 m, followed by Gasherbrum-I (8068 m), the Broad Peak (8047 m) and then the Gasherbrum-II (8035 m) peak. The prominent passes across the Karakorams are Muztagh pass , the Hispar Pass, the Karakoram pass, the Sia La Pass and the Bilafond la pass. The Karakorams have some very large glaciers and also include the largest glacier outside the polar region i.e., the Siachen glacier, 75 km long. It may also be noted that nearly half of the snow bound area of the Himalayas occurs within the Karakorams. The 4 largest glaciers of the Karakorams are - Siachen , Fedchenko, Hispar, Biafo and Baltoro.

ii) **The Ladakh Range** : It starts in the west from the confluence of Indus with Shyok. River Indus separates the Ladakh from the Zaskar ranges (which lie to the south of the Ladakh ranges). The tallest peak of the Ladakh range is Rakaposhi and another prominent peak is Gurla Mandhata. The prominent passes across the Ladakh range are Digar La, Chang La and Chorbat. The Soda plains, Aksai Chin, Depsang and Chang Chenmo are plains in the Ladakh ranges. The Rakaposhi – Haramosh ranges and Kailas ranges are extensions of Ladakh range.

iii) **The Zaskar Ranges** : These lie south of the Ladakh range. River Sutlej cuts through the Zaskar ranges at Shipki pass in H.P. The valley of Kashmir lies between the Pir Panjal ranges (in the south) and the Zaskar ranges (in the north). The tallest peak of Zaskar range is Mt. Kamet.

Himalayas : Regional Make-up:

1. **Kashmir Himalayas** : This region includes the Himalayas of Jammu and Kashmir covering an area of 350,000 sq kms. The region boasts of the largest share of snow and glaciers. Pir Panjals are the dominant ranges and the Kashmir valley is a striking geomorphic unit. Banihal and Pir Panjal are the important passes.

2. **Punjab Himalayas** : This region stretches northwest from Sutlej and extends for 570 km and covers an area of 45,000 sq kms. The northern slopes enclose plateaux with lakes like Mansarovar and Rakas Tal. Zozilla and Bara Lapcha La are the important passes.

3. **Kumaon Himalayas :** This occurs between rivers Sutlej and Kali for a length of 320 kms covering an area of 38,000 sq kms. The important peaks are Kamet, Badrinath, Nanda Devi, Kedarnath and Gangotri. Important lakes are Nainital and Bhim Tal. Ganga and Yamuna are the prominent rivers.

4. **Central Himalayas** : This covers the region between the rivers Kali and Teesta and extends for a length of 800 km, covering an area of 1,16,800 sq kms. The region includes the Sikkim Himalayas (Sikkim), Darjeeling Himalayas (Darjeeling) and Bhutan Himalayas (Bhutan). The important peaks are Mt. Everest, Annapurna, Dhaulagiri, Mansalu, Makalu and Kanchenjunga.

5. **Assam Himalayas** : This region occurs between rivers Teesta and Brahmaputra, extending for a length of 720 km and covering an area of 67,500 sq kms.

The Purvanchal Hills : The hills of Northeast India extending from Arunachal Pradesh to Mizoram constitute the Purvanchal hills and represent the continuation of Himalayas. Through the Purvanchal hills, the Himalayas continue to form the Arakan Yoma ranges in western Burma. The various Purvanchal hills are :

1. **Patkai Bum Range** : Forms the international frontier between Arunahcal Pradesh and Burma. It merges with the Naga hills close to Saramati Peak in the south.
2. **Naga Hills** : These are the main ranges in Nagaland. The tallest peak of Naga hills in Mt. Saramati.
3. **The Manipur Hills** : They form the boundary between Manipur and Burma.
4. **The Barail Range** : This range separates the Naga hills from the Manipur hills. It is mostly in Nagaland. It joins up with Jaintia, Khasi and Garo hills of Meghalaya.
5. **The Mizo Hills** : These lie south of the Manipur Hills and are the main ranges in Mizoram. They are also called Lushai Hills.

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GEOGRAPHY OF PENINSULAR INDIA

By Dr. D B Kumar

Introduction: Peninsular India is a triangular plateau with the apices of the triangle at Broach (Gujarat), Kanya Kumari (Tamil Nadu) and Rajmahal hills (West Bengal). Peninsular India is 1400 km wide (E-W) and 1600 km long (N-S). Peninsular India occupies 16 lakh square kms, half the land of area. It may be noted that the area north of the Tropic of Cancer is twice that of the area south of the Tropic of Cancer. The Narmada – Tapti graben divides the peninsular plateau into Central Highlands and the Southern Plateau and Hills regions. The Central Highlands include the Aravallis, the Malwa Plateau and the Bundhelkhand Plateau. The Southern Plateau and Hills region includes the W. Ghats, the Eastern Ghats, the Satpura Ranges, the Deccan Plateau and the plateaus of south India. The physiography of each of these regions is briefly brought out in the following section.

Total area of whole India

The Aravallis : These are the oldest fold mountains of India. They are between Palanpur (Ahmedabad) and Delhi. The general elevation is between 400-600 mts. They have lower elevations between Delhi and Ajmer. They extend for 800 kms in a NNE - SSW direction. The Aravallis are remnants of *folded tectonic mountains*. The average elevation of the Aravallis ranges between 300-800 m. The Aravallis are continuous ranges south of Ajmer. The Aravallis are unbroken between Mewar and Merwara hills. Mt. Abu block (1158 m) is the highest section of the Aravallis and includes the Gurushikar Peak (1722 m), the tallest point of the Aravallis. Mt. Abu is separated from the rest of Aravallis by river Banas. The Borhat Plateau is another high block of the Aravallis. Delhi Ridge in the northernmost range of the Aravallis

NNE SW

and forms the Indo-Gangetic Divide. Mahi and Luni have their birth in the Aravallis and cross them.

The Malwa Plateau : This include most districts of western M.P., the Mewar region of southern Rajasthan and the districts of Dhulia and Jalgaon of Maharashtra. The plateau is made up of diverse rocks including the volcanic basalts of the Deccan Plateau and the oldest Archean or Dharwar rocks of the Peninsular crust. The plateau lies east of Aravallis and west of Vindhyan ranges. It has the basins of river systems that drain into both the Bay of Bengal and the Arabian Sea. Malwa Plateau includes the courses of Betwa, Mahi and the upper course of Chambal. The course of Chambal in Malwa plateau shows the badland topography of gullies and ravines. The Narmada Gorge is a prominent structure of the Malwa plateau. Its average height is 500 m – 250 m above the sea level. It is covered by thick forests. The Malwa plateau includes the upper courses of Sindh, Betwa and Ken rivers, besides the Chambal and its right bank tributaries (Kali and Parbati). Chambal badlands represent a prominent landform of the Malwa Plateau.

river valley

The Bundelkhand Plateau : It is between Vindhyan ranges and the Malwa Plateau and south of Yamuna. Its average height is 300-600 m above the sea level. It includes 5 districts of U.P. (Jalaun, Jhansi, Lalitpur, Hamirpur and Banda, 4 districts of M.P. (Chhatarpur, Panna, Tikamgarh and Datia). It is bounded by the Yamuna in the north, the Vindhyans in the south, the Chambal in the northwest and the Panna hills in the southeast. The Bundelkhand region includes the Bundhelkhand plains and the Bundhelkhand – Vindhayan highlands. The Bundhelkhand Plateau is made up of Dharwar igneous and gneissic (metamorphic) rocks of the Archean era. The drainage basins of has a flat top and sloping sides

Yamuna, Betwa and Ken like within the Bundhelkhand region. The Bundhelkand region has a series of mesas and buttes.

flat tableland with steep edges. A hill that rises abruptly from the surrounding region.

The Satpura – Maikala Hills Region : Satpura means seven hills. The seven mountains stretch between Rajpipla hills in the west and Maikala hills in the east. The Satpuras constitute the highest east-west tectonic mountains of Peninsular India. The Satpura range attains its maximum height near Pachmarhi (1350 m). The Maikala plateau reaches it maximum height of 1127 m near Amarkantak. The Mahadev hills are part of the Satpura system. The Mahadev hills include the Pachmarhi ranges. The Maikala hills constitute the eastern section of the Satpura system. The Amarkantak Plateau is within the Maikala hills. While Narmada takes its birth in the Amarkantak Plateau (1127 m), Tapti takes its birth in the Betul plateau of the Satpura hills.

fold mountain

Baghelkhand Region: This lies east of the Maikala hills and south of Son. It is bounded by river Son in the north and the Mahanadi in the south. It includes parts of Chattisgarh, Mirzapur district of U.P. and portions of Jharkhand. It includes the drainage basins of Son and Rihand. The Baghelkhand plateau region includes the Narmada- Son trough and the Maikala, Rewa and Panna plateaus. It is a water-divide between river Son in the north and Mahanadi in the south.

Rajmahal Hills : These are by origin, relict or residual mountains. They define the eastern boundary of the Chotanagpur Plateau. * The Rajmahal hills are made up of volcanic rocks. Between the Rajmahal hills and the Garo hills (of Meghalaya) lies the Rajmahal – Garo Gap, via which the Ganga drains into the Bay of Bengal.

The Vindhyan Range: They form an escarpment forming the northern edge of the Narmada-Tapti Trough. The ranges are more or less parallel to the Narmada valley for a length of 1200 kms between Gujarat to Sasaram. The general elevation of the Vindhyans is 300 to 650 m. In the eastern part, the Vindhyans form excellent scarps in the form of the Bharner and the Kaimur hills. The Vindhyan – Kaimur scarp acts as a watershed between the Ganga system in the north and the river systems of South India.

The Chotanagpur Plateau : The second largest plateau of India, the Chotanagpur plateau is a continental plateau. It is the northeast projection of the Indian peninsula. It is made up of the very old igneous and metamorphic rocks of the Dharwar age. The average elevation of the Chotanagpur plateau is 700 m. The Chotanagpur plateau consists of a series of plateaus occurring at different heights called patlands. Here the Chotanagpur plateau reaches its highest elevations of around 1100 m. From the Patlands in the middle-west, the height of the Chotanagpur Plateau descends in all directions. River Damodar drains centrally across the Chotanagpur plateau. To the north of Damodar river, the Chotanagpur plateau is made up of the Hazaribagh Plateau with an average elevation of 600 m. South of river Damodar lies the Ranchi plateau. The western parts of the Ranchi Plateau typically have the Pats. The Chotanagpur plateau is India's richest mineralised region and accounts for 40% of the metallic mineral deposits of India. The Chotanagpur Plateau includes the drainage of North Koel, South Koel, Damodar and Suvarnarekha rivers. It is over the Chotanagpur plateau that the Bay of Bengal and the Arabian Sea branches of the southwest monsoon converge.

The Deccan Plateau : This is the largest plateau of India and the largest physiographic unit of peninsular India. It is a triangular plateau bounded by the Satpura and Vindhyan ranges in the northwest, the Mahadev and Maikala hills in the north, the W. Ghats in the west and the Eastern Ghats in the east. The average elevation of the Deccan plateau is 600 m but in the south it is 1000 mts. The Deccan plateau is made up of volcanic rocks called basalts which have given birth to the black regur soils. The plateau is made up of horizontal layers of solidified lava flows. The solidified lava flows give to the Deccan plateau the Trap Structure i.e., a surface made up of a series of steps. Balaghat plateau within the Deccan plateau makes up Balaghat Ranges. The Ajanta range within the Deccan Plateau lies south of river Tapti. The W. Ghats of the north i.e., the Sahyadris, constitute the western edge of the Deccan plateau. Telangana Plateau is the extension of Deccan Plateau into A.P. while Mysore Plateau is an extension of the Deccan Plateau in Karnataka.

The Deccan plateau includes :

a) **Maharashtra plateau** : This includes the Ajanta ranges to the south of river Tapti.

b) **Khandesh** : This includes the valleys of Tapti and its tributary Purna. Khandesh is a narrow region bounded by the Satpura hills in the north and the Ajanta hills in the south. The region includes the Tapti rift valley.

The Karnataka Plateau : This is also called the Mysore Plateau. It has an average elevation of between 600-900 m and its northern portions include parts of the Deccan plateau. It is made up of the very old Dharwar igneous and metamorphic rocks. The northern part of the Karnataka plateau is called Malnad. The Malnad is a hilly forested region. The most prominent ranges of Malnad are the Bababudan hills in Chickmagalur district. The southern part of the Karnataka plateau is called Maidan. This is a rolling plain of low height.

The Telangana Plateau : This makes up the northern and western parts of A.P. It is made up of very old Dharwar rocks. It is a low lying surface often described as a peneplain. The average elevation is between 500-600 m. The Godavari, the Krishna and the Pennar drain the Telangana plateau.

when high land are completely eroded by river (and convert into lo lying surface

The Chattisgarh Plateau: It is actually a low lying rolling plain in the middle of plateaus and hills of Peninsular India. It is a saucer like basin in the upper Mahanadi region. It is between Maikala hills and Orissa hills. Its average elevation is between 330-250 m. The region includes the upper course of Mahanadi and the tributary of Godavari, Wainganga. * Much of the Plateau is made of the plane of river mahanadi and its tributory.

The Meghalaya or the Shillong Plateau : This is considered to be part of peninsular India. It is separated from the Peninsular plateau by the Rajmahal – Garo Gap. The Shillong plateau is made up of igneous and metamorphic rocks of Dharwar age. Garo, Khasi and Jaintia hills are highland portions of the Meghalaya plateau. The Garo hills (900 m) are the water- divide between rivers Surma and Brahmaputra and continue into Sylhet in Bangladesh. The Khasi and Jaintia hills have an average height of 1500 m. The Shillong Plateau descends into the Surma Valley of Assam and to its north lie the Mikir hills.

Kathiawar : This is part of the Deccan Plateau and has a series of volcanic hills like Gir, Junagarh and Pavagarh hills. The Kathiawar peninsula is bounded in the east by the Little Rann and in the northeast by the Nal Sarovar Lake. In the centre of Kathiawar region occur the Mandav hills with Mt. Girnar. The Gir ranges lie in the southern part of Kathiawar.

The Western Ghats : These are also called the Sahyadris in the northeastern part. They extend between 21° N to 11° N. They rise to 1000 m from the Arabian Sea coast. The Sahyadris (i.e., W. Ghats north of Coorg) are the edges of the Deccan Plateau. Kathiawar Peninsula is the western outlier of the W. Ghats and is made up of schists and gneisses. The Sahyadris are between 21° N to 16° N i.e., between river Tapti to North Goa. Their average height is 1200 m. They form excellent scarps along the coast particularly north of Karnataka.* Mahabaleshwar Plateau (1438 m, the birthplace of Krishna) is the highest plateau of the Sahyadris. Between Goa and the Tapi valley, the Sahyadris have an average elevation of 1200 m. The prominent peaks here are Salher, Kalsubai, Mahabaleshwar and Harishchandragarh Peak. The Bhorghat Pass (Bombay – Pune link) and the Thalghat Pass (the Bombay – Nasik link) are prominent passes across the Sahyadris in the north.

is made of volcanic rock called basalt

The Middle Sahyadris lie between 16° N to Nilgiris i.e., they include the Western Ghats between Goa and Nilgiris.* Here the W. Ghats are not plateau edges of the Deccan plateau. The middle Sahyadris are of an average height of 1200 m. The middle Sahyadris are made up of Dharwar igneous and metamorphic rocks. The prominent peaks are Vavul Mala, Kudremukh, and Pushpagiri. The Nilgiris join the Sahyadris near Gudalur. The Nilgiris mark the junction between the Western Ghats and the E. Ghats. Doddabeta (2637 m, at whose foothill lies the hill station, Ooty) is the tallest peak of the Nilgiris. Jog or Gersoppa Falls (250 m) is developed by Shravati in W. Ghats.

The southern Western Ghats are separated from the main Sahyadris by the Palghat Pass which separates the Nilgiris from the Anamalai hills. The Palghat Pass is divide between northern western ghats and southern western ghats. The Anamalai hills fan out from the Anaimudi peak (2695 m, the tallest peak in south India). The Anamalai hills have an average elevation of 2000 m-1800 m. The Palani hills (average elevation is 1200 m- 900 m) are an offshoot of the Anamalai hills. The Kodaikanal resort is located in the Palani hills. The Cardomom hills lie south of the Shencottah Pass (which separates the Anamalai hills from the Cardomom hills). The Cardomom hills divide the Malabar coast from the Tamil Nadu coast.

The Eastern Ghats : These are a chain of discontinuous hills stretching between Mahanadi in Orissa to river Vaigai in Tamil Nadu.* Eastern Ghats are made up of old Archean rocks of the Peninsula and also rocks of the Cuddapah System. The total run of the Eastern Ghats is about 800 km. The Ghats are 200 kms wide in Orissa and narrow down to 100 km southwards.

Dharwar Rocks.

Between Krishna and Pennar, the E. Ghats are made up of the Nallamala, Palkonda and Velikonda hills. The Eastern Ghats take the form of true mountains between Godavari and Mahanadi. The Garjhat hills are the northeastern hills of Orissa and are part of the E. Ghats. The E. Ghats of Andhra Pradesh are called the Nallamalai hills (average height is 850 m- 650 m). The southern part of Nallamalai hills are called the Palkonda ranges. The E.Ghats of Tamil Nadu are the Javadi, Shevaroy and the Palani hills. The E. Ghats join the Western Ghats in Nilgiris via the Palani hills.

Gondwana Troughs : These are the rift valleys within which Damodar, Mahanandi and Godavari flow. The rift valleys formed in the Paleozoic era and contain thick deposits of coal of the Gondwana formations.

Narmada and Tapti Troughs : These are rift valleys within which Narmada and Tapti flow west. The Satpura uplands lie between the Narmada and Tapti troughs.

ISLANDS OF THE INDIAN UNION

By Dr. D B Kumar

The Union of India has 247 islands of which 204 lie in the Bay of Bengal (the "Andaman and Nicobar Group) and 43 islands lie in the Arabian sea (Lakshadweep Group) as well as between India and Sri Lanka in the Palk Strait.

Andaman and Nicobar Group: These lie between 6°39' N and 13°34' N. The northernmost island of the Andaman and Nicobar group occurs about 901 kms from the mainland while the southernmost tip lies about 146.5 kms from Sumatra. The Andamans are made up of North, Middle and South Andaman and are separated from the Nicobar group by the Ten Degree Channel. (which is about 121 km wide). *Saddle Peak* (738 m) in N. Andaman and *Mt. Thulier* (642 m) in Great Nicobar are prominent peaks. The Duncan Passage occurs between South Andaman and Little Andaman. The Nicobar Group has about 19 major islands, the largest being Great Nicobar. *Barren* islands and *Narcondom* islands in the Andaman Group constitute active and sleeping volcanoes. About 86% of the Andaman and Nicobar Group is covered by dence tropical evergreen and mangrove forests.

The Lakshadweep Group : All islands of the Arabian sea are coral islands. The Lakshadweep occupy an area of 32 sq kms and lie between 8°N-11°N. The Minicoy island, the largest of the Lakshadweep Group (4.5 sq km), lies ~~south~~ North of the Eight Degree Channel.

Pamban Island: This is situated between India and Sri Lanka and is a rocky island and represents the extension of peninsular landsmass in the Ramnad district of Tamil Nadu.

LANDFORMS : THE INDO-GANGETIC PLAINS

aggrade : v : Built to a level by depositing sediments

By Dr. D B Kumar

Introduction: The Great Plains, covering an area of about 7.5 lakh sq. ms are aggradational plains. The Great plains stretch in an east-west direction for 24,000 kms from the arid plains of Rajasthan in the west to the Ganga delta in the east. They extend between Himalayas in the north to the peninsular plateau in the south. These plains are drained by Beas and Sutlej (of the Indus system) in the west, Ganga and its tributaries in the east and Brahmaputra in the farther east. The average depth of the Great Plains is 1300 - 1400 metres with maximum depth between Delhi and Rajmahal hills. The plains have an average elevation of 150 m ranging from almost nothing in the Bengal delta to nearly 300 m in the foothills. The plains display a gentle slope towards the east in Rajasthan while the Ganga plains slope towards the south. *The Delhi ridge,* which is a subdued expression of Aravallis, divides the Great Plains into Western Plains and Eastern Plains. The Western Plains are made up of Thar desert, Malwa Plains (M.P.) and Punjab - Haryana Plains. The Eastern Plains are made up of the Ganga and Brahmaputra plains.

A) **Punjab - Haryana Plains**: These extend 640 kms in a NE-SW direction and 300 kms in an East-West direction The Aravalli range (upto Delhi) forms the eastern boundary. The plains merge with the plains of Rajasthan in the South and Plains of Indus in the West (in Pakistan). The height of the plains varies from 300 m in the north to 200 m in the South. For most part, there are no perennial rivers. The Ravi, Beas Sutlej and the Yamuna are the only perennial rivers. Though Ghaggar is perennial in its upper course, it becomes dry after flowing for a short distance from the hills. The soils are of an alluvial character. The upper Bari doab, the Bist doab and the Malwa plains are relatively higher upland plains. The **Bets** are the Khadar Plains in Punjab, the **Dhaya** are gullied bluffs which flank the Khadar Plains, **Chos** are narrow streams with large number of gullies, especially in Hoshiarpur district of Punjab.

Be located at the sides of something

A higher steep bank.

B) **The Rajasthan Plains**: The Rajasthan plains include the Marusthali and the adjoining Bagar (steppe land) to the west of Aravalli. The Rajasthan Plains account for **one-third of the Great Plains,** with elevation ranging from 300 m in the northeastern part to 150 m in the south. The region receives less than 50 cms of rainfall, mostly from the monsoons. Except the southeastern portion, the rest of the Rajasthan plain is an area of inland drainage with a series of salt lakes - Sambhar, Dagana, Didwana, Kuchaman, Pachpadra etc. The biggest is Sambhar which covers an area of 300 sq m during the rainy season. The shifting sand dunes are called Dhrian while the playa lakes are called Ranns. The most important river flowing in the region is Luni, which rises in the Aravallis and flows southwest. It reaches the Rann of Kutch only during the rainy season. The Rajasthan plains are only partly aggradational. They are believed to have resulted due to uplift of shelf sands due to regression of sea followed by long spells of dry and wet conditions.

inland drainage → those drainage (rivers) which does not reach up to a sea.

playa → temporary lake in a desert

C) **Ganga Plains** : The Ganga plains of UP, Bihar and W.Bengal occupy an area of 3.57 lakh sq kms. The plains drain towards southeast into Bay of Bengal. The Ganga plains can be divided into the upper Ganga Plains, Middle Ganga Plains and Lower Ganga Plains:

a) **Upper Ganga Plains** : These lie between Yamuna and Allahabad (east). The average depth is 1300 - 1400 m which decreases gradually towards the south. Along the northern margins of the plains lie two narrow bands making up the Terai-Bhabbar Sub-montane belt. The bhabhar is a piedmont plain composed of unsorted debris from the Himalayas. The surface streams disappear in this zone of boulders / sands to reappear later. Immediately below the Bhabar is a 15 - 30 km wide low lying Terai region which makes up the swampy foot hills. The terai is characterised by finer sediments, natural forest cover, high water-table resulting in swamps and marshes.

1 gentle slope leading from the base of a mountains to a region of flat land

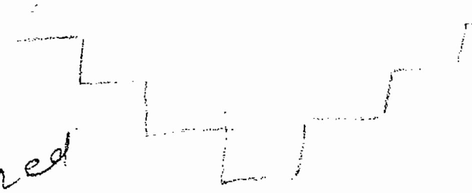
The 3 micro physiographic regions making up the upper Ganga Plains are a) The Bhabar - Terai Sub-montanne belt b) The Ganga-Ghaghara doab c) The Ganga-Yamuna doab. East of the Ganga-Yamuna doab lie the low lying *Rohilkhand plains* which merge into the Avadh plains farther east. The Yamuna, Ramganga and the Ghaghara are the major rivers draining the upper Ganga Plains. From the south, the Chambal is the most important river draining the region. Bangar is the older, upland alluvium occupying the zones above general flood limits. Khadar is the younger, lowland alluvium which is renewed annually in the floodplains.

Bha
Tera
Ban (Bum)
Kha

b) **Middle Ganga Plains**: These make up eastern U.P. (Avadh Plains) and Bihar. The long line of marshes along the northern Bihar plains are called Caurs.

Lower Ganga Plains: The plains are the Bengal plains. The Bengal plains are mostly made up of the Ganga delta, including the Sunderbans delta. The Bengal plains forms the Ganga-Brahmaputra doab in the north and a piedmont plain between Huoghly and Chotanagpur plateau in the south.

D) **The Brahmaputra Plains**: The Brahmaputra plains extend between Sadia and Dhubri in Assam for a length of 640 kms and an average width of 100 kms. The Brahmaputra or the Assam plains are made up alluvial terraces of the Brahmaputra and its tributaries (Sesiri, Luhit and Dibang). The plains slope to the east and south and have many paired terraces and different levels of floodplains (due to frequent flooding of the Brahmaputra).



Paired Terraces

LANDFORMS - LAKES OF INDIA

By Dr. D B Kumar

The lakes of India can be put under different categories based on the geographical setting and nature. The chief categories are :

A) **Tectonic Lakes**: These are formed due to differential earth movements (like faulting, folding, subsidence etc). The old pleistocene lakes of Kashmir and Kumaon Himalaya belong to this type.

B) **Volcanic Lakes:** These are developed within volcanic craters. The *Lonar Lake* in Buldana district of Maharashtra is an example.

C) **Solution Lakes**: These are formed due to the subsidence of surface rocks due to solution of soluble rocks below the surface. Some of the Lakes in Kumaon belong to this type.

D) **Glacial Lakes**: These are formed due to glacial erosion or when glacial moraine forms barriers across glacio-fluviatile streams. The tarn lakes on the northeastern slopes of Pir Panjal ranges belong to the *former type* while those of Kumaon belong to the latter type. Some of the *margs* of Kashmir are moraine bound basins.

E) **Alluvial Lakes:** These are formed by uneven deposition of sediments in deltas and are called *Jhils*. Some alluvial lakes are Ox-bow lakes which are found in great abundance in the Ganga plains of eastern UP and Bihar.

F) **Aeolian Lakes**: These are temporary lakes in blowouts in deserts i.e., playas. Western Rajasthan has many of these type.

G) **Rock Fall Lakes**: These are produced by landslides or landslips which obstruct stream courses. The *Gohna Lake* of Garhwal formed due to a landslide across Ganga.

H) **Lagoons:** These form due to deposition of sand bars along the coast. The Chilka lake of Orissa, the Pulicit lake (due to Sriharikota island as a sand bar) and the Kayals of the Kerala coast are examples.

Lakes of Kumaon: Nainital district in Uttaranchal abounds in lakes which include Nainital, Bhimtal, Naukuchiatal, Khurpatal, Sattal, Punatal, Malwatel etc.

Lakes of Kashmir: The glacial lakes of Kashmir are Dal, Wular, Anantnag, Sheshnag, Verinag, Gandharvabal, Nagin and Manasbal.

Lakes of Rajasthan: Several salt water lakes occur in the Thar, the biggest being Sambhar. The others are Didwana, Lunkaransar, Falodi, Kachhor, Rivasa etc. The *freshwater lakes* of Rajasthan are Udaisagar, Fatehsagar, Pichhola, Jai Samand, Rajasamand and others.

Lakes of South India: Ashatmudi and Vembanad (Kerala), Pulicat and Kolleru (A.P.), Chilka (Orissa) and Lonar (in Maharashtra) are the most prominent.

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DRAINAGE OF INDIA

By Dr. D B Kumar

Classification of River Systems : The river systems of India are classified into the following based on hydrological characteristics.

1. **Himalayan Rivers** : These are perennial and snow-fed. These belong to the Indus, Ganga and Brahmaputra systems. The Himalayan river systems encompass a drainage area of one million sq kms and cover a region with good ground water potential.

2. Peninsular Rivers : These are seasonal and get their water from rainfall. These include the Deccan rivers and the Coastal rivers.

Classification by size :

1. **Major Drainage Basins** : These are river basins having a drainage area of 20,000 sq kms or more. Indian territory is basically made up of large sized basins.

2. **Medium Drainage Basins** : These are river basins having a catchment area of 2000 - 20,000 sq kms.

3. **Minor Drainage Basins** : These are river basins with a catchment area of less than 2000 sq kms.

Contrast between Himalayan and Peninsular Rivers :

HIMALAYAN RIVERS	PENINSULAR RIVERS
1. These are snow-fed or glacier fed.	1. These are rainfed.
2. These origniate at great elevations	2. Originate at much lower altitudes
3. The volume of waters discharged is less in winter i.e. the lean period is in winter	3. The discharges are very low in the non-rainy months but heavy during the south-west monsoon period.

4. Are uncertain and unpredictable in their behaviour.	4. Are more predictable in their behaviour.
5. Show meandering courses at places.	5. Are devoid of meanders
6. The Himalayan rivers are youthful and descend down steep slopes.	6. Peninsular rivers are quite old and rain an old and a senile topography.
7. These develop their courses freely in the Great plains and have a general dendritic pattern. These also show characteristics of antecedent rainage and these are instances of river capture in the basins of Kosi, Gandak and Ghaghara.	7. These follow major structural lines like joints and faults in the old crystalline rocks of the Peninsula and hence show evidences of superposed drainage and river capture due to the differences in rock formations.
8. The Himalayan rivers are best suited for irrigation because they are perennial and also because canals can be easily dug in the alluvial plains they drain.	8. These rivers are better placed for hydel power development because they drain a hilly terrain and fall from steep scarps at many places, especially in the W. Ghats.

Contrast between West flowing and East flowing rivers :

WEST FLOWING RIVERS	**EAST FLOWING RIVERS**
1. These are short and flow swiftly.	1. These are long and drain slowly.
2. These flow in narrow valleys and extend their courses headwards.	2. These flow through broad valleys with gentle slopes.
3. River-courses have not yet been graded to their base level.	3. River courses are graded almost upto their sources.
4. These descend the steep slopes of W.Ghats through waterfalls and rapids.	4. These descend over relatively gentler slopes / scarps.

5. These usually flow between two mountain ranges and hence their catchments are more elongated and narrow.	5. These have wide and fan shaped courses.
6. These do not built deltas due to their great velocity and fast flow.	6. All these typically build large deltas.

1. **Indus** : Arises near Mansarovar lake, flows between Ladakh and Zaskar ranges and encircles Leh. It is joined by Zaskar near Leh. It is joined by Shyok close to Skardu. It has cut a gorge at Bunji, north of Nanga Parbat. It's mountain tributaries are Gilgit, Gortang, Dras, Shigar and Hunza. It flows through the Potwar plateau of Pakistan and crosses the Salt Range. Near Mithankot, it receives the waters of its five eastern tributaries - i.e., the Panchnad. Out of its total length of 2880 km, only 709 km is in India.

2. **Jhelum**: It arises near Verinaag at the foothills of Pir Panjal ranges in southeastern Kashmir valley. It bends sharply at Muzzafarabad beyond which it is joined by the Kishanganga. It's main tributaries are Lidar and Sind. It forms the India-Pakistan boundary for 170 kms and emerges in Potwar Plateau near Mirpur. It enters the plains in Pakistan near Jhelum city. It's total length is 724 kms. The third longest tributary of Indus, it joins Chenab.

3. **Chenab** : It arises near Bara- Lacha la pass in Kulu hills of Himachal in Lahul-Spiti region. It enters Jammu and Kashmir as Chenab. It has cut a gorge at Kishtawar. It emerges in the plains at Akhnoor (in J&K). It is the largest tributary of Indus. It's total length is 1180 km. It is the river of Chamba valley of H.P. It has cut a gorge close to Kishtawar. Chenab joins Sutlej after receiving waters of Ravi and Jhelum.

4. **Ravi :** It arises in the Kulu hills of H.P. close to Rohtang Pass. It drains between Pir Panjal and Dhauladhar ranges. It has cut a gorge across Dhauladhar ranges. It enters Pakistan below Amritsar and joins Chenab close to Rangpur. It is the second longest tributary of Indus.

5. **Beas :** The shortest tributary of Indus. It is also born in the Kulu hills of H.P., close to the Rohtang Pass. It has cut a gorge across Dhauladhar ranges. It joins Sutlej in Harike. It's total length is 460 km.

6. **Sutlej :** It is born close to Mansarovar lake near Darma pass in Tibet. It has cut a large canyon in Nari Khorsan province of Tibet which is 900 m deep. River Spiti joins Sutlej near Shipki pass. It has cut another gorge in Naina Devi in India where the Bhakra dam has been constructed. It enters the plains in Roopnagar, Punjab. It forms the boundary between India-Pakistan between Ferozpur and Fazilka. It joins Indus near Mithankot. It's total length is 1450 km of which 1050 km is in India.

Brahmaputra System : Arises in the Chemayungdung Glacier in Kailas range. It's total length is 2900 km. It is known as Tsangpo in Tibet and Yarlung Zangbo Jiangin in Chinese. It swings north close to Namcha Barwa (7756 m) and swings south into India through the Dihang or the Siang Gorge. It enters the plains of Assam near Sadiya where it is called Siang and Dihang. The Dibang from the north and Lohit from the south join it near Sadiya. It flows till Dhubri for 720 kms as Brahmaputra. In Assam plains, the tributaries joining it from the north (i.e., the right bank tributaries) are Subansiri, Kameng, North Dhansiri, Teesta and Manas. The tributaries which join it from the south (the left bank tributaries) are Dibru, Buri Dihing, South Dhansiri and Kalang. It is called Jamuna till it joins Ganga at Goalunda.

Ganga System: The Ganga basin covers 26.3% of India's geographic area. The basin covers ten states. Uttaranchal and U.P. accouont for 34.2% of basin area followed by M.P. and Chhattisgarh, Bihar and Jharkhand, Rajasthan, Himachal and Delhi.

A) **Ganga** : Originates as Bhagirathi in Gangotri glacier in Uttar Kashi district of Uttaranchal. Bhagirathi meets Alakananda at Devaprayag. Ganga enters plains near Haridwar. From its source to its mouth along Hooghly, Ganga is 2525 kms.

B) **Yamuna** : It orginates in Yamunotri glacier on the Bandarpunch Peak in Garhwal. It cuts across the Nag Tibba and Mussoorie ranges. It enters plains near Tajewara. Tons is its main tributary which also arises from the Bandarpunch Peak. Between Agra and Allahabad, Yamuna is joined by Chambal, Sind, Betwa and Ken. The total length of Yamuna is 1370 km. It is the longest and largest tributary of Ganga. The important tributaries of Yamuna are :

1) **Chambal** : It arises southwest of Mhow in Janapao hills of Vindhyan ranges. It drains the Malwa plateau. Chambal joins Yamuna in Etawah district of U.P. The total length of Chambal is 1050 km. Banas is an important tributary of Chambal. It originates in the Aravalli ranges and joins Chambal near Sawai Madhopur, Rajasthan.
2) **Sind:** It originates in the Vidisha plateau of M.P. It flows for 415 km before joining Yamuna.
3) **Betwa** : Arises in Vindhyan ranges of Bhopal and joins Yamuna near Hamirpur after flowing for 590 km.
4) **Ken** : Arises in Barner Ranges of M.P. and joins Yamuna near Chila.

C) **Ghaghara** : It is the second longest tributary of Ganga. It arises in the Gurla Mandhata peak of Ladakh ranges, south of Mansarovar. It joins Ganga near Chapra, Bihar, after flowing for 1080 km. Sarda, Sarju and Rapti are its important tributaries. About 45 % of the catchment of Ghagghara is in India.

D) **Gomati** : It is the third longest tributary of Ganga.

E) **Gandak** : It originates along Nepal- Tibet border. It enters the plains near Tribeni. It joins Ganga near Hajipur and flows for 425 km in India.

F) **Burhi Gandak** : It arises in Sumesar hills along India-Nepal border. It joins Ganga apposite Monghyr. It flows for 610 kms.

G) **Kosi** : It is due to seven headstreams and hence called Saptkosi. The most important tributaries are Tumar Arun and Sun Kosi. The headstreams unite in Triveni in the Mahabharat Ranges of Nepal. Kosi flows for 730 km in India and joins Ganga near Kursela, Bhagalpur.

H) **Ramganga** : It is born in the Nainital hills of Garhwal. It flows for 596 kms and joins Ganga at Kannauj, Farukkabad, U.P.

I) **Kali** : It arises in the Trans-Himalayas of Nepal- Kumaon boundary. It is called Sarda after it enters the plains near Tanakpur.

J) **Son** : It is born in the Amarkantak Plateau. It flows parallel to the Kaimur range and joins Ganga at Danapur in Patna district. It flows for 784 km.

K) **Damodar** : It is born in Chotanagpur hills close to Palamu. It flows for 541 kms before it joins Ganga (Hooghly), south of Kolkata.

Peninsular Rivers :

A. **Godavari** Flows for 1465 kms. It is born in the Trimbak Plateau of Sahyadris in Nasik, 80 kms from the Arabian sea. Manjira, 724 km long, is the only important right bank tributary. It joins Godavari near Kondalwadu after passing through Nizamsagar. Penganga (676 km) arises in Buldana range and joins Wardha near Ghughus. Wardha (483 km) joins Wainganga. The united river of Wardha and

Wainganga is called Pranahita which joins Godavari. Downstream of Sironcha, Indravati joins Godavari.

B. **Krishna** : It arises in Mahabaleshwar Plateau, 64 kms from the Arabian Sea. It flows for 1400 kms. The longest tributary is Bhima which arises in Matheron hills. Bhima joins Krishna near Raichur after flowing for 861 kms. Bhima is a left bank tributary. Tungabhadra, a confluence of Tunga and Bhadra, arises from Gangamula hills of Sahyadris. It is a right bank tributary and flows for 531 kms. the other tributaries are Musi, Malprabha, Ghataprabha, and Koyna.

C. **Cauvery** : It arises as Talakaveri in Brahmagiri hills in Coorg district. Its flows for 800 kms. It descends from Karnataka plateau into Tamil Nadu plains as Sivasamudram falls (101 m). It starts forming a delta near Tiruchirapalli. It's northern tributaries are Arkavati, Srimsha, Himavati, Lokpavani and Herangi. The southern tributaries are Lakhshmanatirtha, Kabani, Bhavani and Amaravati. The longest tributary is Bhavani.

D. **Mahanadi**: It is born in the foothills of Dandakaranya near Sihawa in Raipur. The main tributaries in its upper course are Ib, Mand, Hasdeo, Sheonath on the left bank and Ong, Jonk and Tel on the right bank. The total length of Mahanadi is 857 km.

E. **Brahmani**: Flows for 800 kms after its birth near Rourkela. Its headstreams are Koel and Sankh.

F. **Suvarnarekha** : It is born in the Ranchi Plateau and forms part boundary of Bengal and Orisha in its lower course. It joins Bay after flowing for 395 km. Its basin states are Jharkhand (71%), Orissa (16%) and W.Bengal (18%).

G. **Pennèru**: It is born in the Nandi Durg hills of Karnataka. It enters A.P. and then flows into Bay after flowing for a total distance of 597 km.

H. **Narmada** : It is born in Shahdol district of M.P. in the Amarkantak plateau. It flows via the rift between Vindhyas and Satpuras. It's total length is 1310 km of which 1078 km lies in M.P. In Jabalpur, it forms the Dhuandhar falls (15 m). Its tributaries are Hiran which is a right bank tributary and joins Narmada close to Chhindwara. The other right bank tributaries are Barna, Kolar, and Orsang. The left bank tributaries are Burnher, Banjar, Shakkar, Tawa, Kundi and Shar.

I. **Tapti**: It arises in Betul plateau in a tank in Multai in Satpura hills. Its main traibutary is Purna which joins Tapti in Khandesh (between Satpura and Ajanta Ranges). It flows for 730 kms and its lower 48 km is in a tidal stretch. The other tributaries are Arunavati, Gomai and Ganjar.

J. **Sabarmati:** It is born due to confluence of Hathmati and Sabar. It arises in Mewar hills and flows for 320 kms. The tributaries are Wakul, Vatrak and Hathmati.

K. **Mahi** : It is born in the Vindhyan ranges. It flows for 533 kms. The basin states are Rajasthan, M.P. and Gujarat.

L. **Lune** : Also called as Salt river. It is born in the Aravallis of Ajmer. It flows for 482 kms.

LANDFORMS - COASTAL PLAINS OF INDIA

By Dr. D B KUMAR

West Costal Plains : The west coast is about 1400 kms long, and 10-80 kms broad. The Konkan coast (about 500 kms long) stretches between Daman and Goa. The Konkan coast is a **submerged coast** and is a faulted coast. Rocky hills of the Sahyadris reach the sea in and around Goa. The Kanara coast occurs off Karnataka and is a submerged coast. It is very narrow and confined to stream courses. The maximum width of the Kanara coast occurs in the valley of **Netravati** in Mangalore. From Cannanore to Kanya Kumari, the west coast is called Malabar coast. It runs for a length of 550 kms and is anywhere between 20-100 km wide. It is an emerged coast and falls in the category of a belted coast Periyar is the longest river along the Malabar coast.

East Coastal Plains: These lie between 8°-2°N and are broader than the west coastal plains with well developed deltas of major rivers. The general name of east coastal plains is Coromandel coast. The east coast is an *emerged coast* and is characterised by a straight shore line. The coast off Tamil Nadu is the Tamil Nadu plains which stretch for about 675 kms. The middle stretch is called the Andhra Plain where the *east coast becomes the broadest.* The coast off Orissa constitutes the Utkal plains with many beach ridges. Lake Chilka is the largest saline lake of Asia lying within the Utkal coast.

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SOILS OF INDIA

By Dr. D B KUMAR

1. **Black Soils** : Derived from the basalts (the volcanic rocks) of the Deccan plateau. The black colour is due to the presence of titanium bearing iron and to a certain extent humus. Also called Regur soils, Black Cotton soils or Tropical Chernozem soils. The soils are poor in nitrogen, phosphorous but rich in humus, potassium, calcium, magnesium and lime. The soils are fertile because they contain water soluble salts and because they retain moisture. The largest occurrence of Black soils is in Maharashtra. They also occur in Malwa and Kathiawar.

2. **Alluvial Soils** : The most dominant soils by volume. In the northern plains they show belts in the form of Bhabhar, Terai, Bangar and Khadar. They do not show any horizons and have a loamy texture. Poor in humus, nitrogen and phosphorous but rich in Potassium. Their fertility is due to diversity of mineral species within them and due to the rich subsurface water resources. Usar soils are alluvial soils of Punjab with high concentration of sodium salts.

3. **Red Soils** : These are made up of Red and Yellow soils. They have been developed from the very old granitic rocks of Peninsular India. They red colour is due to iron oxides. The yellow soils have a coating of hydrated oxide of iron which is yellow in colour. The Red soils are poor in nitrogen, phosphorous, humus and lime (calcium oxide) but are rich in iron and potassium. They red soils are the most widespread in Tamil Nadu and occur throughout peninsular India wherever the granitic rocks occur. The red soils are the most widely distributed soils of India.

4. **The Lateritic Soils** : These occur as cappings on hill tops/ plateau tops. They have developed due to intense chemical weathering of rocks (i.e., intense leaching) and hence have only iron and aluminium oxides (because every other element has been leached away). They are very infertile. They are clayey and show a lumpy appearance. These soils are residual.

5. **The Desert Soils** : The desert soils of Rajasthan represent the sands of the continental shelf of the Arabian sea. They are light coloured and have a high percentage of water soluble salts. They are poor in nitrogen, humus and clay. They are rich in phosphorous, potassium, calcium and sodium. The desert soils of Thar are very rich in phosphates.

6. **Forest Soils** : These are rich in humus. In higher mountainous regions the forest soils are called Podsols which are acidic. In higher elevations, the forest soils are called mountain meadow soils.

7. **Saline and Alkaline Soils**: These soils contain high concentrations of sodium, magnesium, and calcium. The alkaline soils are deficient in nitrogen but rich in calcium and magnesium. The saline and alkaline soils are called by different names like Reh, Kallar, Usar, Chopan and Tur.

VEGETATION AND FORESTS OF INDIA

By Dr. D B KUMAR

Types of Forests :

A) **Tropical wet forests**. These are made up of Tropical Evergreen, Tropical semi-evergreen Tropical Dry Evergreen and Tropical Moist Deciduous forests.

1. **Tropical Evergreen Forests** : These develop in regions with rainfall more than 250-300 cms a year. They cover 49% of total forest area. They are found in areas below a height of 900 metres in W. Ghats, Northeast, Andaman and Nicobar and West Coastal Plains. The species are broadleafed evergreens. The species are Rosewood, Ebony, Mahogony, Rubber, Ironwood, Gurjan and Sissoo.
2. **Tropical Semi-evergreen Forests** : They occur in regions receiving between 250-200 cms of rainfall. They are made up of evergreen and deciduous species. They occur in northern parts of W. Bengal, Orissa hills and Coast, and parts of Andaman and Nicobar. The species are Champa, Rosewood, Laurel and Aini.
3. **Tropical Dry Evergreen Forest** : These occur along Tamil Nadu coast and have developed under northeast monsoon rainfall. The average annual rainfall is above 100 cms. The species are evergreen and include Palms, Casuarina, Khirni, Jamun and Neem.
4. **Tropical Moist Deciduous Forests** : These have developed in regions with 100-150 cms of rainfall. Sal is more widespread than Teak because Sal grows in

more humid conditions. The other species besides Sal and Teak are Sandalwood, Kussum, Ebony,-Khair and Shisham. They are distributed in northeast, eastern slopes of Himalayas and Central Plateaus.

B) **Tropical Dry Forests** : These are made up of :

1. **Tropical Dry Deciduous Forests** : They develop in regions with rainfall between 75-100 cms. They occur on the low hills of A.P., T. Nadu, Karnataka, Maharashtra and M.P.. The species are teak, (which dominates in western and central India) Sal (which dominates in east, northeast and north India), Khair, Tamarind and others.

2. **Tropical Thorn Forests** : These have developed in regions with rainfall between 60-100 cms. The vegetation is deciduous, of low density and made up of low trees which are thorny. These forests are distributed in Rajasthan, northern Gujarat, the drier parts of Deccan etc. The species are Tamarind, Babul, Kikar, Date Palm Euphorbia and Cacti.

Temperate Forests : These include temperate evergreen forests, and coniferrous forests.

1. **Temperate Broadleaf Hill Forest** : These occur in altitudes between 900-1800 metres where the annual rainfall is 75-125 cms. The forests are a mixture of tropical and temperate evergreen forests. These are found in highlands of

Chattisgarh, Nilgiri and Palni Hills and lower slopes of Eastern Himalayas. The species are Magnolia, Deodhar and Hemlock. Evergreen Oak and Chestnut are the temperate hardwood species.

Shola Forest is a special type of temperate broad leaf hill forest. It a type of rainforest which originated millions of years ago and is found in Nilgiris (especially in Silent Valley region of Kerala). The trees are short with leathery leaves and the forests are dense.

2. **Sub-Tropical Dry Evergreen Forest** : This occurs in a restricted are in the Bhabar, the Siwaliks and the Western Himalayas upto 1000 m. The rainfall is between 100 cm – 50 cm. This is a shrub forest of evergreen trees and grasses. Olive and Acacia are the important species.
3. **Montanne Wet Temperate Forests** : These occur in altitudes between 1800 m – 3000 m where rainfall is 150-300 cms. They occur in the higher hills of Tamil Nadu, Kerala, Eastern Himalayas of Assam and W. Bengal. The important species are Oak Deodhar (a conifer), Pine and Magnolia.
4. **Montanne Moist Temperate Forests** : These occur in the temperate region of eastern and western Himalayas between heights of 1600 m to 3500 m. The rainfall is between 250-150 cms. The dominant species are the conifers though some temperate broadleaf evergreen species like the Oak occur. The conifers are Spruce, Deodhar, Pine and Birch.
5. **Alpine Forests** : These occur at elevations between 2900-3500 meters. They are a mixed forest of low height (i.e., shrub) temperate deciduous and temperate evergreen

species. They are made up of Fir, Spruce, Birch, Juuniper and Rhododendron. At elevations higher than 3500 m (and upto 4500 m) the vegetation is made up of Alpine Grass.

Tidal / Littoral / Swamp Forests : These are tropical forests which grow in inter-tidal zones of the littoral areas where rainfall is between 40 cms to 200 cms. They are made up of the salt tolerant species which grow in brackish water conditions. They include the mangrove forests. They are evergreen. The typical species are Sundari, Pine, Coconut, Agar etc.

CLIMATE OF INDIA

By Dr. D B KUMAR

The India Meteorological Department (IMD) has divided India's climate into the following :

A) **Cold Dry Season** : This lasts between November to March. The northern two-thirds of India has mean temperatures below 21 degrees centigrade. The southern one-third is relatively warmer and does not have a distinct winter. The 20 degrees centigrade. isotherm follows the Tropic of Cancer. South of the Tropic of Cancer, temperatures are above 20 degrees centigrade. For e.g., January temperatures over Thiruvananthapuram is 31 degrees centigrade. January in this season is the coldest month and Dras and Kargil record lowest temperatures. India is affected by Western Disturbances - the temperate cyclones born over the Mediterranean and Red Sea. These occlusions bring snowfall to Western Himalayas and rainfall to north India. J & K, Delhi, Punjab, Chandigarh, Haryana and Rajasthan get some rainfall in January and February. NE India also gets rainfall in this season due to Northeast Monsoons. The isotherm of 18 degrees centigrade. is representative of India in this season. The northern state are frequently affected by cold waves in this season.

B) **Hot Dry season** : This lasts between March to beginning of June . The season has no prevailing winds. The highest air temperatures of 48 degrees centigrade. are recorded at Barmer, Rajasthan in May and the highest temperature in Punjab and Haryana are recorded in June in Rajasthan and adjoining M.P. N. India is affected by heat waves and also dust storms. Towards the end of May, thunderstorm related rainfall occurs. These are the pre-monsoon showers called Mango showers in Kerala, Bordoichilla in w. Bengal and Assam, and Kalbaisakhi in W. Bengal. The 30 degrees centigrade. isotherm encloses most of India.

Malabar may receive between 25-15 cm of rain in this season and Assam may get 50 cms of rain. Maximum May temperature of select stations are : Sri Ganganagar – 54 degrees centigrade. 2. Jodhpur – 41 degrees centigrade.

C) **Hot Wet Season** : This is between June and September and is the season of Southwest monsoons. It is the season of maximum rainfall. The landmass of India gets 78.7% of the rain in this season. Monsoon depressions i.e., low pressure systems are born in the monsoon trough covering the head of the Bay of Bengal. These bring rainfall to east India. The southwest monsoon is in the form of two branches – the Arabian Sea branch and the Bay of Bengal branch. Both these branches eventually merge over the Chotanagpur Plateau. The stream of Arabian Sea branch are: first stream reaches Western Ghats between 10°-20° north. Bombay gets 190 cms of rain, Khandala (50 km east) gets 460 cms of rain and Pune (160 kms away from Bombay) gets 50 cms of rain. The second stream blows through Narmada – Tapti trough giving rainfall to Khandesh and Nagpur. The third stream is parallel to the Aravallis except southeastern Aravallis where Mt. Abu gets 170 cms of rain. The streams of the Bay of Bengal branch - The first stream crosses the Ganga delta and reaches Meghalaya. Cherrapunji (25° north) gets 1102 cms of rain, Mawsynram (16 kms from Cherrapunji but on the same latitude) gets 1221 cms of rain. Guwahati (90 kms from Cherrapunji) gets 161 cms of rain. The second stream reaches the Himalayan foothills and brings the rain to the plains. Kolkata gets 119 cms, Patna – 105 cms, Allahabad – 91 cms, Delhi – 51 cms and Bikaner – 24 cms. The Tamil Nadu coast is the rainshadow region of Arabian Sea branch and is parallel to the Bay of Bengal branch. The southwest monsoon establishes itself by 1st June over the Malabar Coast, by 10th June over Bombay, by 15th June over the Ganga plains and by 1st July over the Punjab-Haryana plains. On 60% of the occasions the onset is between 29th May to 7th June. The 7th June isoline is on Kolkata.

The rainfall in July of select stations is: 1. Cherrapunji – 2446 mm 2. Jaisalmer–90 mm

Origin of the Monsoon :

A) Classical Theories :

1. **Halley's Thermal concept** : Indian monsoon is because of thermal contrast between Indian Subcontinent and adjoining Indian Ocean. Halley's theory, suggested in 1686, considers the summer monsoon to be a regional phenomenon.

2. **Aerological concept** : This was suggested by R. Scherhag in 1948. According to this theory, monsoonal circulation develops due to changes in air temperature at all levels over the Indian Subcontinent and adjoining Indian Ocean.

B) Modern Theories :

1. **Dynamic Theory :** Flohn (1951). According to Flohn, the monsoon is a global phenomenon due to global shift in pressure belts. The shift in pressure belts bring the ITC much more into the northern hemisphere and its northern margin is around 30 degrees north over the Indian Subcontinent. This brings the SE trades over the Indian subcontinent as south westerly monsoons. Similarly, the shift in pressure belts globally when it is winter for the N. Hemisphere pushes the ITC to a little more south of the equator. This brings the sub-tropical high on to the southern slopes of Himalayas and hence the NE

trades blow from northeast to southwest as northeast monsoons.

2. **Tibet and Easterly Jet** : Dr. P. Koteshwaram and Flohn concluded that heating of Tibet in summer strengthens the monsoonal circulation. With an average height of 4 kms above the MSL, Tibetan surface is warmed in summer and generates ascending warm air. The air turns to its right and sinks over the Arabian sea and joins the southwesterly winds thereby strengthening the monsoon. This circulation is part of the tropical easterly jet stream.

3. **Role of Sub-Tropical westerly Jet** : The Sub-tropical Westerly Jet normally located on the south slopes of Himalayas and the northeast plains disintegrates in summer due to intense heating of the northern plains and the global shift in pressure belts to the north in summer of the northern hemisphere. This facilities the onset of the monsoon over India by facilitating the development of the monsoon trough.

4. **The Somali Jet :** The offshore areas of Somalia develop cold waters due to upwelling giving birth to the Somali Current. The cold waters lead to low temperature along Somali Coast (15 degrees centigrade) whereas along Mumbai, the temperature is 30 degrees cent centigrade. This thermal gradient leads to development of the Somali Jet stream blowing from Western Arabian sea to the eastern Arabian sea. This adds moisture bearing winds to the southwest monsoon.

AGRICULTURE

By Dr. D B KUMAR

Basic Facts: The largest area under foodgrain and the largest producer of foodgrain is U.P. The largest area uder non-foodgrain crop and the largest producer is Maharashtra. The largest producer of kharif foodgrain and rabi foodgrain is U.P. The largest average size of land holdings 1. Rajasthan 2. Punjab 3. Gujarat 4. MP (smallest is in Kerala).

Facts about crops :

Rice: Most of the rice crop is raised in regions with an average monthly temperature of 24° C and average annual rainfall of 150 cms. Deep fertile clayey soils or loamy soils are best. In east coast plains, Bengal plains and Konkan plains, rice is raised throughout the year and hence these regions are rice monoculture zones. The largest area under rice and the largest producer is West Bengal. The second and third largest producers are Punjab and U.P.

Wheat: This is the most important rabi cereal crop. In India wheat is grown in regions with not more than 75 cms of yearly rainfall. It requires 200 frost free days. The largest area under wheat and the largest producer is U.P. The second and third largest producers are Punjab and Haryana

Coarse cereals :

A) **Jowar (Sorghum or Great Millet):** It is both a rabi and a kharif crop. It is grown in regions with moderate rainfall and in India it is grown in regions with less than 45 cms of rainfall per year. It requires high temperatures between 27°C-32°C. The temperature should not drop below 16°C as jowar cannot withstand frost. The largest area under Jowar and the largest producer is Maharashtra.

B) **Bajra (Rush Millet)**: It is a typical short season kharif crop. It grows in regions with 40-50 cms of rain per year and temperatures between 25°-30°C. It cannot withstand heavy rains and grows in more inferior soils and more dries conditions than jowar. The largest area under Bajra is in Rajasthan and the largest producer of Bajra is Maharashtra.

C) **Ragi** : It is mainly a kharif crop. It grows in regions with an annual average rainfall of 50-100 cms and where temperatres are between 20-30°C. The largest area under Ragi and the largest producer is Karnataka.

D) **Barley** : It is a rabi crop in the northern plains. It requires less rainfall than wheat and can withstand more cool conditions than wheat. It grows in regions with 100-75 cms of rainfall and where temperatures are : 10-15°C. The largest area under Barley and the largest producer is UP

E) **Maize** : It is mostly a kharif crop. It requires high temperatures of around 35°C and where annual rainfall averages around 75 cm. It grows best in fertile alluvial soils. The largest producers are Karnataka, A.P. and Maharashtra.

Oilseeds: India cultivates 9 major oilseeds. India has the largest area under oilseeds. Oilseeds are raised throughout India under varied climatic and soils conditions. They are raised both as kharif and rabi crops. India is the largest producer of oilseeds. The major oilseeds that account for bulk of oilseed output are : **Groundnut:** India is the world's largest producer. The largest area and the largest producer is Gujarat followed by A.P., Tamil Nadu **Rapeseed -Mustard** : The largest area and the largest producer is Rajasthan followed by Haryana and M.P. **Sunflower** : The largest area is in Karnataka and the largest producer is also Karnataka followed by A.P. Maharashtra. **Soyabean**: The largest producer is M.P. In total oilseeds production the leading states are M.P., Rajasthan and Gujarat.

Pulses : India has the largest area under pulses and is the largest producer. Chickpea (gram) and pigeon pea (tur or arhar or red gram) account for half of India's pulses output. The largest producer of gram is M.P. The largest producer of tur is U.P. In general, the largest producers of pulses are M.P., Maharashtra and U.P.

Cotton : It is a kharif crop. India has the largest area under cotton and is the 2nd largest producer after China. Cotton requires temperatures between 21°C to 45°C. It cannot withstand temperatures below 20°C and requires 200 frost free days. The largest producers are Gujarat, Maharashtra and A.P.

Sugarcane : It is a kharif crop. India has the second largest area under cane and is the second largest producer of cane after Brazil. Sugarcane is a typical summer crop as it requires temperatures of 21-27°C throughout the year. It grows best in regions with 150-100 cms of rainfall distributed throughout the year. Sugarcane requires water retentive soils likes clayey soils. The largest producers are U.P., Maharashtra and Karnataka.

Tea : India has the world's largest area and is the second largest producer of tea after China. Tea requires 21° C during its 8-month growing season. It is grown in regions with 200-150 cms of rainfall per year which is distributed throughout the year. It requires well drained humus rich soils which are acidic. The largest area under tea and the largest producer is Assam. India is the fourth biggest exporter of tea in the world.

Coffee : It is a biennial crop. It requires a mean monthly temperature of 24-26°C. It grows best in well drained soils which are slightly alkaline and also potach rich. The coffee tree requires 200-150 cms of yearly rainfall. The largest are under coffee is in Karnataka and the largest producer is also Karnataka. India is the 6th largest producer in the world. 52% of Indian coffee is Robusta and rest is Arabica.

Natural Rubber : It is an equatorial tree. It is the fourth largest producer of rubber in the world. Rubber trees require around 300 cms of rainfall per year which is distributed throughout the year. It requires temperatures between 35°C-25°C and temperature should not drop below 21°C. It grows in well drained soils. The largest area under rubber and the largest producer is Kerala.

Jute : India has the largest area under jute and is the largest producer of jute . jute requires a hot -humid climate with temperatures between 35°C-25°C and yearly average rainfall of 150 cms. It requires a high relative humidity of 90%. It requires flooded swampy soils. The largest area under jute and the largest producer is W. Bengal.

Tobacco : India is the third largest producer of tobacco after China and USA. It is grown best in regions with moderate rainfall and moderate temperatures. It requires 180-120 frost free days. The largest area and the largest producer is A.P.

Other Crops : 1. **Cashewnut**: India has the largest area and is the largest producer and exporter of cashew in the world. The largest producer is Maharashtra 2. **Coconut** : India is the 3rd largest producer of coconuts after Indonesia and the Phillipines. The largest producer of coconut in India is Kerala.

Spices Crops : AP has the largest area under turmeric and is the largest producer. Kerala has the largest area under cardomom, ginger and pepper and is also the largest producer of these crops. Karnataka has the largest area and is the largest producer of arecanut.

Fruits: Largest producer of citrus fruits - Maharashtra. Largest producer of grape – Maharashtra. Largest producer of onion - Maharashtra. Largest producer of banana - T.Nadu. Largest producer of apples - J&K. Largest producer of mango – A.P. Largest producer of lemon – A.P. Largest producer of grape-fruits –A.P.

India is the world's largest producer of pulses, mango, banana, oilseeds and the second largest producer of rice and wheat in the world.

Plantation Agriculture: This occupies 1% of total cultivated area and accounts for 6.5% of agro and allied product exports

Fruits : The largest fruits by area are mango, citrus fruits, papaya and guava. The largest producers of fruits are Tamil Nadu, Maharashtra, A.P. and Gujarat.

Vegetables : The largest area under vegetables is tomato followed by onion, brinjal, tapioca and cabbage.

Spices Crops : The largest crops in spices by output are chilly, garlic, turmeric, ginger and coriander.

ALLIED SECTORS OF AGRICULTURE

By Dr. D B KUMAR

DAIRY

Dairy in India : In terms of total production of milk, India ranks first in the world followed by U.S.A. Traditionally, India was perennially short of milk supply and the meagre amount of milk produced was disposed of in the most haphazard manner, affecting both the consumers and the producers adversely.

Operation Flood-I : It was the Anand pattern which inspired launching of Operation Flood-I. The Anand pattern provides for conversion of surplus milk in the flush season into milk powder which could be blended with liquid milk during the lean season. This ensures uniform prices for milk producers throughout the year. The Anand model had the basic features of the first integrated effort for dairy development with the organisation of milk producers into co-operatives eliminating middlemen, collection of milk from the villages, fair and prompt payment to milk producers and an efficient system of transport and milk supply to urban consumers. The three basic features of the Anand model are : village level dairy co-operatives which collect milk, a milk union formed by a number of dairy co-operatives which is responsible for procurement / processing and marketing milk and, a state federation which provides technical, financial support and support for marketing milk.

Operation Flood-I (OF-I) was launched in 1970-71 with an aid from the World Food Programme in terms of skimmed milk powder and butter oil. The immediate objective was to secure a commanding share of the liquid milk market in Bombay, Calcutta, Delhi and Madras and to stabilise the consumption of milk in these cities.

The ultimate aim of OF-I was to link 18 milksheds in 11 states, to 4 metros.

Operation Flood-II: This was launched in 1979 and ran till 1985. This sought to cover one crore rural milk producer families. It aimed at milk marketing in 144 cities other that the 4 metros and included other features such as improvement of breeds, improving fodder supply to milch cattle, promote animal health care and so on.

Operation flood-III : This was launched in 1987 and was completed in 1996. Its immediate aim was to set up 170 milk centres to benefit 250 districts in 22 states.

As a result of these steps, milk production in India went up from 21 m.t. before operation flood to 127 m.t. in 2010-2011. The per capita availability went up from 124 gms / day in 1950-51 to 281 gms in 2010-11. Around 30% of India's milk is produced by the cooperatives.

Infrastructure for Dairy Sector: The Indian Dairy Corporation was set up in 1970 to administer Operation Flood. Earlier, in 1965, the National Dairy Development Board was constituted to assist the development of the dairy sector. The National Dairy Research Institute, Bangalore has its branches in Karnal (Haryana) which offer graduate and post-graduate programmes in dairy science. In addition, a Central Frozen Semen Production and Training Institute has been set up at Bangalore.

The National Dairy Plan was launched in 2011 with an outlay of 17,300 crore. The aim is to increase milk production by cooperatives from 30% to 65% in the next 15 years. Phase – I of the plan will cover 14 major milk producing states.

The top producers of milk in India are U.P., Rajasthan, A.P. and Gujarat.

FISHERIES

Importance : Though fishery sector contributes less than 1% of Indian GDP, to provides sustenance to 14 million people and is a major forex earner.

Potential : Indian marine fishery has 8,118 km coastline, 2.02 million sq. km of EEZ which includes 0.5 million sq km of continental shelf. Freshwater fishery potential is in 195,210 km of rivers and canals, 2.9 million hectares of minor and major reservoirs and 2.4 million hectares of ponds/lakes and 0.8 million hectares of other water bodies. The EEZ alone has a potential of 3.9 m.t. of which around 60% is exploited presently. The Bay of Bengal has rich potential in crustaceans in deep sea fishery. In the Bay of Bengal, pelagic species like mackerel and tuna are abundant. Arabian Sea is rich in tuna. About 75% of marine fish is caught off the west coast.

Infrastructure : In the 5th and 6th 5- year plans, programmes for development of inland fisheries have been started. These are Fish Farmer Development Agencies (FFDA) and National Programme for Fish Seed Development (NPFSD). Under NPFSD many fish hatcheries have been set up. The Central Institute of Freshwater Aquaculture (Kaushalyanganga, Bhubaneshwar) and Central Inland Capture Fisheries Research Institute provide technology support. The Central Institute of Coastal Engineering for Fishery, Bangalore has been upgraded into a centre for Aquaculture Engineering to increase yield of low yield fish. Deep sea fishing stations have been set up at Mumbai (Sassoon Dock), Kolkata, Kochi, Tuticorin and Vishakhapatnam. The Marine Production Export Development Authority (MPEDA) provides support for upgradation of vessels.

The National Fisheries Development Board was set up in July 2006. Parliament passed Coastal Aquaculture Act in 2005.

Production: Fish output has increased more than 10 fold since 1947. According to FAO, India's fish output doubled between 1990-2010. Inland fishery output of India has been more than marine fishery output since 2000-2001. India ranks second in culture fishery output (aquaculture output) after China in the world. India produced 8.5 m.t., of fish in 2011-12. A.P. is India's biggest producer of fish. Other important fish producing states are West Bengal, Tamil Nadu, Gujarat, Odisha, Kerala and Maharashtra. India ranks 10th in the world fishery output (the top four are China, Peru, Chile and Japan).

Poultry : It is a 55,000 crore industry in India (as on March 31, 2012) It employs 6 million people directly/indirectly. India ranks fourth in world egg production and 5th in broiler meat production. 70% of India's poultry industry is in A.P. and Tamil Nadu. A.P. accounts for 1/3rd of India's poultry industry which is mostly concentrated in Telangana region. In Tamil Nadu, much of the industry is in Chennai and Coimbatore. The other important poultry states are Karnataka, Maharashtra, Punjab and West Bengal.

OTHER LIVESTOCK

Sheep : India with 4% of world sheep population ranks 6th in the world. Rajasthan, Karnataka, A.P., Tamil Nadu and Maharashtra account for around 71% of sheep population.

Rajasthan: It has one fourth of total sheep population and is first in wool productions Lohi and Marwari breeds are popular for blanket wool, Bikaneri for carpet wool and Kutchi for meat and wool. The other breeds are Jaisalmeri, Kathiawari; Pugal, Sonadi and Maipuri.

A.P. : This is second in sheep population and 4th in wool output. The Nellori breed is popular for wool.

Karnataka : It is third in sheep population and also in wool output.

Jammu and Kashmir : In Kishmir, Gurej, Karna, Gaddi, Rampur-Bushair breeds are reared by Gaddis and Gujjars. J & K is the second largest producer of wool.

T. Nadu : Ranks third in sheep population.

GOAT: India has one-sixth of world goat population. About 90% of goats are desi or non-descript with a maximum concentration in Deccan. Angora goat known as Chamba and Gaddi is reared in Himachal, J & K and Haryana. It yields soft Pashmina wool. The Yamuna-Chambal doab has Jamunapuri and provides meat, and milk. The Barabari breed is popular in Western U.P. In Rajasthan, Gujarat and M.P. the Mehsana, Marwari and Zalwadi are cross bred from Jamunapuri. In Deccan, the Barari and Surti are popular.

BUFFALOES: India has 50% of world buffaloes. Buffaloes account for 55% of milk production in India. Murrah is an indigenous breed of Rohtak, Hissar and Gurgaon in Haryana. The Nagpuri belongs to Vidharba of Maharashtra. Nili-Ravi is indigenous to Ferozepur of Punjab. The light coloured Bhadawari is native to Etawah and Agra in U.P. and adjoining parts of M.P. and Rajasthan. The Jaffarabadi with its huge size and large milk yield is native to Gir region of Gujarat. The largest buffalo population is in U.P. followed by Rajasthan A.P. and M.P.

CATTLE: India has around 20% of world cattle. The best milk breeds of cattle are Gir (Gujarat and Rajasthan), Sindhi (Gujarat, Rajasthan and Maharashtra), Sahiwal (Punjab, Haryana, U.P., and Rajasthan) and Deoni (A.P.). Some drought breeds are Nagori (U.P., M.P., Rajasthan and Haryana) Bauchaur (Bihar), Kenkatha or Kenwariya (U.P., M.P.,), Halikar (Karnataka) and Bargur (Tamil Nadu). Some important dual purpose breeds are. Tharparkar (Gujarat and Rajasthan), Nimari (M.P.), Krishna Valley (Maharashtra), Ongole (A.P.) and Kankrej (Gujarat). The largest cattle population is in Bihar followed by U.P., M.P. and Maharashtra. The density of cattle i.e., cattle per 100 hectares of total cropped area is highest in J&K followed by Tripura, Meghalaya and Manipur.

According to 2007 livestock census India has 648.88 million heads of livestock, the highest in the world. India has 304.42 million cattle and buffaloes. The livestock sector contributes 31.6% of agro GDP and 5.26% of total GDP.

IRRIGATION IN INDIA

By Dr. D B KUMAR

Need for Irrigation in India:

1. 70% of the arable land is dependent on the monsoon rains i.e. rainfed. Even during a normal monsoon, the rainfall is adequate for only one-third of the area of the country.

2. Vagaries of the monsoon (like early withdrawal or late onset or a weak monsoon) in even areas of good rainfall makes assured supply of water via irrigation very important.

3. Irrigation is essential to cultivate wet crops (like rice and sugarcane) even in moderate rainfall regions.

4. Irrigation in drought prone areas of India assumes importance because about one-third of the country is drought-prone.

Potential of Irrigation according to the Irrigation Commission (1969 - 1972) :

1. Ganga carries 400 Million Acre Feet (MAF) of water. It is possible to utilise 150 MAF for irrigation purposes.

2. Nearly 300 MAF of the Brahmaputra waters continue to flow annually into the Bay of Bengal. Because of rugged / hilly topography, it is not possible to utilise these waters except through a few medium and lift irrigation schemes in Assam.

3. The entire waters of Godavari, Krishna, Narmada and Tapi can be utilised for irrigation.

4. The west flowing rivers of India (except Tapi and Narmada) carry 200 MAF of water of which 40 MAF can be utilised if they are diverted eastward, and the balance of 160 MAF will continue to flow into the Arabian Sea.

5. The Mahanadi system carries 100 MAF of which 40 MAF Arabian Sea.

6. Cauvery waters have been fully utilised.

Types of Irrigation in India:

1. **Well Irrigation** : Most widely distributed source of irrigation in India and accounts for largest area of the net irrigated area of the country. Well irrigation is popular in Deccan, Gujarat, Maharashtra, Rajasthan and U.P. and to a small extent, in Punjab and Haryana.

2. **Canal Irrigation** : It is the principal source of irrigation in the plains and accounts for the second largest area of the net irrigated area of India. It is most intensely distributed in the Northern Plains of India due to factors such as : perennial nature of Himalayan rivers; gradual and gentle slopes of these plains which make possible canal irrigation in the lower valleys; absence of rocky ground in these plains; definite volumes of water discharged by the Himalayan rivers and finally the fertile soils of these plains which make possible reaping greater yields with irrigation.

3. **Tank Irrigation** : This accounts for the third largest area of the net irrigated area of the country and is well developed in Tamil Nadu, A.P. and Karnataka. W. Bengal, Orissa and Kerala also have considerable acreage under tank irrigation.

Major Irrigation Projects of India:

Important Irrigation Projects :

1. **Bhakra and Nangal** : Across Sutlej. Bhakra is one of the highest gravity dams in the world. It is a joint venture of Punjab, Rajasthan and Haryana. The Govind Sagar lake is the reservoir of Bhakra.
2. **Thein Dam** : It is across Ravi in Punjab.
3. **Dulhasti Project** : It is across Chenab in Jammu and Kashmir.

4. **Salal Project** : It is across Chenab in Jammu and Kashmir.
5. **Beas Project** : Across Beas in Punjab. It is a joint venture of Punjab, Haryana and Rajasthan.
6. **Sharda Sahayak Project** : It is across Ghaghara in U.P.
7. **Rihand Project** : It is across Rihand in U.P.
8. **Mayukrakshi Project** : It is across Mayurakshi in W. Bengal.
9. **Damodar Valley Project** : It is a multipurpose project across Damodar and is shared by Jharkhand and W. Bengal. It includes 4 dams - Maithon and Tilaiya (on Barakar river), Konar (on Konar River) and Panchet (on Damodar river).
10. **Hirakud Project :** It has the world's longest mainstream dam. It is across Mahanadi in Orissa.
11. **Nagarjunasagar Project :** The Nagarjunasagar dam is the world's tallest masonry dam, across Krishna in A.P.
12. **Pochampad Project :** It is across Godavari in A.P.
13. Jayakawadi Project : It is across Godavari in Maharahstra.
14. **Upper Krishna Project :** It is across Krishna in Karnataka.
15. **Tungabhadra Project :** It is across Tungabhadra in Karnataka and is a joint venture between A.P. and Karnataka.
16. **Gandak Project :** It is an international project between India and Nepal across Gandak. It is in U.P.
17. **Kosi Project :** It is another international project between India and Nepal across Kosi in Bihar.

18. **Chambal Project** : It is a multipurpose project between Rajasthan and M.P. It includes the Gandhi Sagar Dam (M.P.), Rana Pratap Sagar Dam (in Rajasthan) and the Kota Dam or the Jawahar Sagar Dam (in Rajasthan) .

19. **Tawa Project :** It is across Tawa, a tributary of Narmada in M.P.

20. **Mahi Project** also called Jamnalal Bajaj Sagar Project. It is across Mahi in Gujarat.

21. **Matatila Project :** It is across Betwa. It is a joint venture between U.P. and M.P.

22. **Ukai Project :** This is across Tapi and is in Gujarat.

23. **Kakrapara Project :** This is across Tapi in Gujarat.

24. **Sharavati Project :** It is near Jog Falls across Sharavathi in Karnataka.

25. **Malprabha Project** : It is across Malprabha, a tributary of Krishna in Karnataka.

26. **Bhima Project** : It is across Bhima in Maharashtra.

27. **Mettur Project** : It is across Cauvery in Tamil Nadu.

28. **Shivasamudram Project** : It is across Sivasamudram Falls created by Cauvery in Karnataka.

29. **Ghatprabha Project** : It is across Ghatprabha, a tributary of Krishna in Karnataka. It is a joint venture between A.P. and Karnataka.

30. **Chukka Project** : An international project between India and Bhutan across Teesta.

U.P. has the largest area under well irrigation followed by Rajasthan, M.P. and Gujarat.

U.P. has the largest area under canal irrigation followed by M.P.. A.P., and Rajasthan.

A.P. has the largest area under tank irrigation followed by Tamil Nadu, Maharashtra and Orissa.

U.P. has the largest area under irrigation.

Miscellany:

1. **Major Irrigation Scheme** : These have a culturable command area of more than 10,000 hectares.

2. **Medium Irrigation Schemes** : These have a culturable command area between 10,000 to 2,000 hectares.

3. **Minor Irrigation Schemes** : These have a culturable command area of less than or upto 2,000 hectares.

ENERGY RESOURCES OF INDIA

By Dr. D B KUMAR

Introduction: Energy resources of India can be divided into commercial and non-commercial. The non-commercial energy resources are traditional and include fuelwood, charcoal, cowdung, agricultural / animal waste and animals on farms. Non-commercial energy sources meet around 40% of India's energy requirement, especially in the rural and the domestic sectors. Among the non-commercial energy sources, fuelwood alone accounts for 65% of the source. The commercial energy sources are coal, oil and gas and electric power. Coal meets 55% of India's commercial energy requirement. Thousands of medium and small scale industries depend on coal for their process and energy requirements. Oil and gas account for around 43% of India's commercial energy sources. In general, the share of non-commercial fuels in the total energy consumption has come down from 74% in 1950-51 to around 35% today. Relatively, the share of commercial energy has gone up in the same period.

Electric Power : This is a major source of commercial energy in India produced from of water, coal, oil and natural gas, uranium and others. The major sources of electric power are however water, coal, followed by radioactive nuclear minerals and oil and natural gas. Of the total installed capacity to generate electric power, the installed capacity in thermal power is around 65.16%, the installed capacity in hydro power is around 21.8%, while it is 2.7% for nuclear power, and renewable energy accounts for 11% of installed capacity. In general, of the total capacity, the central sector accounts for 32% of installed capacity, the states sector accounts for 41% and the Private sector accounts for 27%.

Per capita consumption of electric power : The per capita power consumption in India was 778 KWh in 2010 while the world average was 2782 KWh. Western India has the highest per capita power consumption followed by South India, North India, East India and the Northeast. Delhi has the highest per capita consumption of power followed by Punjab.

Hydel Power : The hydel power potential of India is placed around 84,000 MW at 60% PLF. Arunachal Pradesh has the largest hydel power potential of 26,756 MW, followed by Himachal Pradesh (11, 647 MW), Uttar Pradesh (9,744 MW) and Jammu and Kashmir (7,487 MW) in that order. The oldest hydro power plant is the Darjeeling power plant set up in 1897. The following table shows the potential of hydel power and its development in different regions of India.

HYDEL POWER

REGION	POTENTIAL (IN MW)
1. Northeastern	31,857
2. Northern	30,155
3. Southern	10,763
4. Western	5,680
5. Eastern	5,590

Thus, the largest hydel power potential of India is in the Northeast but has been least exploited. Most hydel power development has occurred in the northern region in terms of absolute power generated. But in terms of potential present and developed potential, the southern region leads in India.

Thermal Power : Coal based power plants, atomic power plants and oil/gas based power plants come under this category. It has already been mentioned that thermal electric power is the major source of electric power in terms of installed capacity and output. Coal based thermal power plants account for 56% of installed capacity and 70% of electric power produced. Natural gas based power plants account for around 9.3% of installed capacity in electric power.

The leaders in installed capacity for power generation (from all sources) in respective regions are given below :

A. South : 1. A.P. 2. Karnataka 3. Tamil Nadu 4. Kerala

B. North : 1. Punjab 2. U.P. 3. Rajasthan 4. Haryana

C. East : 1. Orissa 2. Bihar 3. W. Bengal

D. West : 1. Maharashtra 2. M.P. 3. Gujarat

E. Northeast : 1. Meghalaya 2. Assam

Installed capacity in states in Thermal power:

1. Maharashtra 2. Gujarat 3. West Bengal 4. U.P.

Installed capacity in Hydro Power in States:

1. A.P. 2. Karnataka 3. Maharashtra 4. Punjab

Total Installed Capacity : 1. Maharashtra 2. A.P. 3. Gujarat 4. Tamil Nadu

Some Important Power Projects:

1. **Lower Sileru Hydel Power Project :** An important power project in A.P. It is a hydel power project across the sileru, a tributary of the Godavari and the total Potential planned is 600 MW.

2. **Kothagudem Thermal Power Project :** Situated in the Singareni coalfield of A.P. The total installed capacity is 240 MW (completed), and 110 MW (to be completed).

3. **Dhuvaran Thermal Power Satation** : This is located in Dhuvaran, close to Cambay in Kheda district of Gujarat. The total installed capacity is 534 MW. This is based on natural gas.

4. **Sabaragiri (Pamba - Kakki) Hydel Power Project :** An important power project of Kerala, located southeast of Kottayam. It has 3 storage dams, the Pamba dam, the Kakki dam and another flanking dam. The total power potential is 300 MW.

5. **The Idduki Hydel Power Project** : This is the most important power project of Kerala and has three storage dams across Iddiki, Periyar and the Cherutheni rivers, all in Iddiki district of Kerala. The total installed capacity is 390 MW.

6. **Korba Thermal Power Station :** Thi is located near the Korba coalfield in Bilaspur district of M.P. and has a total installed capacity of 300 MW.

7. **Satpura Thermal Power Station :** This is in Betul district of M.P. with a total installed capacity of 342 MW. The power is shared between Rajasthan and M.P.

8. **Koyna Hydel Power Project :** This is across the Koyna in Satara district of Maharashtra and has an underground power house at Pophali below the W. Ghats. The total capacity is 860 MW.

9. **Nagpur Thermal Power Station :** This is located north of Nagpur in Maharashtra and has an installed capacity of 480

MW. This serves the Vidharbha and Marathwada regions and is based on coal locally available at Nagpur.

10. **Kalinadi Hydel Power Plant** : Across Kalinadi, a west flowing river of the W.Ghats and is in N. Kanara district of Karnataka. The power potential to be eventually created is close to 1300 MW.

11. **Sharavati Hydel Power Project** : It is one of the largest hydel power projects in India and is in Shimoga district of Karnataka. The total installed capacity is 891 MW.

12. **Talcher Thermal Power Station** : Located in Talcher in Orisa, it has an installed capacity of 250 MW.

13. **Kundah Hydel Power Project** : It is across the Kundah and its tributaries in the Nilgiri Hills in Tamil Nadu. The ultimate potential will be around 530 MW.

14. **Neyveli Thermal Power Project** : The project is based on the local availability of lignite in Neyueli and has a total installed capacity of 600 MW.

15. **Obra Thermal Power Plant** : This is in Mirzapur district of U.P. and is based on coal supplies from M.P. The total installed capacity is 250 MW and around 900 MW more is planned to be added. The coal is supplied by Singrauli coal field in M.P.

The other power projects in various states are :

1. **National Capital Territory Region of Delhi**
   a. Badarpur Thermal Power Plant
   b. Indraprashtha Thermal Power Plant

2. **Haryana**
   a. Faridabad Thermal Power Plant
   b. Panipat Thermal Power Plant
   c. Surajpur Thermal Power Plant

3. **Jammu and Kashmir**
   a. Kalakote Thermal Power Plant

4. **Punjab**
    a. Bhatinda Thermal Power Plant

5. **U.P.**
    a. Harduaganj Thermal Power Plant
    b. Rensugar Thermal Power Plant
    c. Panki Power Plant
    d. Upper Ganga Hydel Power Project
    e. Sarda Hydel Power Project (across Sarda in Nainital)

6. **Gujarat**
    a. Ukai Thermal Power Plant
    b. Gandhinagar Thermal Power Plant
    c. Uttran Thermal Power Plant
    d. Sabarmati Thermal Power Plant

7. **Madhya Pradesh**
    a. Satpura Thermal Power Project
    b. Amarkantank Thermal Power Plant

8. **Maharashtra**
    a. Nasik Thermal Power Plant
    b. Khaperkheda Thermal Power Plant
    c. Paras Thermal Power Plant
    d. Bhusawal Thermal Power Plant
    e. Parlia Thermal Power Plant
    f. Ballarshah Thermal Power Plant
    g. Tata Hydel Power Project

9. **A.P.**
    a. Vijayawada Thermal Power Plant
    b. Ramagundem Thermal Power Project
    c. Nellore Thermal Power Plant
    d. Machkund Hydel Power Project (between Orissa and A.P. across Machkund in Orissa).

10. **Tamil Nadu**
    a. Ennore Thermal Power Plant
    b. Tuticorin Thermal Power Plant
    c. Pykara Hydel Power Proejct (across Pykara river in Nilgiris).
    d. Mettur Project (across Cauvery).

11. **Bihar**
    a. Patratu Thermal Power Plant
    b. Barauni Thermal Power Plant.

12. **West Bengal**
    a. Calcutta Electric Supply Corporation
    b. Bandel Thermal Power Plant
    c. Durgapur Thermal Power Plant
    d. Satnaidih Thermal Power Plant

13. Assam
    a. Kamrup Thermal Power Plant
    b. Chandrapur Thermal Power Plant
    c. Namrup Thermal Power Plant (based on natural gas)

14. Karnataka
    a. Sivasamudram Hydel Power Project (makes use of Sivasamudram Falls developed by Cauvery).

Non - Conventional Energy Sources

1. **Solar Energy** : The potential of solar energy is 35 times more than the total installed capacity of India. The Ministry of Non-conventional Energy sources has declared the Jodhpur - Jaisalmer stretch of the Thar desert as a Solar Energy Enterprise Zone. The largest installed capacity in Solar Power is in Tamil Nadu.

2. **Tidal Power** : Tidal Power along the Indian coast has a potential of 8000 MW. The Gulf of Cambay and the Gulf of Kutch have a high range of tides and have a potential of over 1000 MW each. Pilot plants to produce tidal power are at Vizhingam (Kerala), Thangaserry (Kerala) and Car Nicobar.

3. **Wave Energy** : The coastline of India has a potential of 40,000 MW of wave energy. A pilot plant to produce wave energy is being set up at Kovalam, Kerala.

4. **OTEC Power :** Ocean Thermal Energy Conversion (OTEC) potential of Indian Coasts is around 50,000 MW. A pilot plant to produce power from OTEC is being set up at Kulashekarapatanam, Tamil Nadu.

5. **Geothermal Energy :** This depends on thermal gradients in the earth's interior in the vicinity of fractures and faults. A pilot plant is coming up at Parbati valley, Himachal Pradesh

7. **Wind Power** : The Wind Power Potential of India is 20,000 MW. India has already created an installed capacity of 17,000 MW. Tamil Nadu has the largest installed capacity

TRANSPORT GEOGRAPHY OF INDIA

By Dr. D B KUMAR

Roadways : The road route length of India is 33,16,452 kms and is the second largest network in the world after USA. In terms of percent of villages connected by all-weather roads, Kerala leads followed by Haryana, Punjab and Gujarat. a) Route length of national highways is highest in M.P. b) Route length of state highways is highest in Maharashtra c) Road density is highest in Kerala. d) Total road route length is longest in Maharashtra.

National Highway Development Programme includes Golden Quadrilateral (Phase-I), North-South Corridor (Phase-II) and East-West Corridor (Phase-II). North-South Corridor will be 4000 kms long between Srinagar and Kanyakumari. East-West corridor will be 3300 kms long between Silchar and Porbander. The Golden Quadrilateral includes : Delhi - Kolkata corridor will have route length of 1453 km. Mumbai - Chennai corridor will have a route length of 1290 km. Kolkata -Chennai corridor will be 1684 km long. Delhi - Mumbai corridor will be 1419 km long.

Asian Highway – I : This touches Dawki (in Meghalaya along India – Bangladesh border) and Moreh (In Manipur along India – Burma border)

Dedicated Freight Corridors: These are part of the Delhi – Mumbai Industrial Corridor Project. The two corridors are : Eastern DFC – This will be between Dankuni (near Kolkata) to Ludhiana with a length of 1804 kms and will pass through U.P., West Bengal, Jharkhand, Bihar, Punjab and Haryana. Western DFC – This will be between Dadri in U.P. to Jawaharlal Nehru Port with a length of 1483 kms and will pass through Rajasthan, Gujarat, Maharashtra and Haryana. Four more freight corridors will be set up separately which will be Kolkata – Mumbai, Kharagpur – Vijayawada, Chennai-Goa and Delhi – Chennai.

Trans Asia Rail : This will be developed by 28 nations. The southern corridor will be between Kunming in China and Bangkok in Thailand till Kapikule in Bulgaria. The Southern corridor will connect China, Thailand, Myanmar, Bangladesh, Pakistan, India, Iran and Turkey. It will enter India in Manipur and go into Bangladesh and again enter India at Gede along India – Bangladesh border and will go to Pakistan via Attari. It is a project of ECOSOC for Asia – Pacific.

Major Ports :

1) Mumbai Port : Biggest port, natural harbour handles dry cargo.

2) Nhava Sheva Port (Jawaharlal Nehru Port) - To ease congestion of Bombay Port. Natural harbour.

3) Haldia – Estuarine port on Hooghly, auxillary port to ease congestion of Calcutta port.

4) Chennai port : Artificial harbour, mainly handles crude oil and iron ore.

5) Vishakapatanam port : Deepest landlocked port, handles iron ore, crude oil and petroleum products.

6) Kolkata Port : Tidal port, a riverine port with 2 docks.

7) Paradweep port : Joined to national highway –5, mainly handles iron ore, coal and dry cargo. Natural harbour.

8) New Tuticorin port : Artificial harbour, mainly handles coal.

9) New Mangalore Port : Has special facilities to export kudremukh iron ore. Natural harbour.

10) Kandla Port : Set up as an import port to import crude and petroleum products. Located on the mouth of Kandla creek.

11) Marmugoa Port : Set up as an export port. Located on mouth of Zuari creek. Natural harbour.

12) Kochi port : Natural harbour. Handles agro exports and crude imports.

13) Ennore Port : Auxillary port of Chennai port. Artificial harbour.

The ports in descending order of cargo handled are 1. Kandla 2. Vishakapatanam 3. JNPT 4. Mumbai 5. Chennai 6. Paradip 7. Marmugao 8. New Mangalore 8. Haldia 10. Tuticorin 11. Kochi 12. Ennore 13. Kolkata

Indian Shipping : India has the largest merchant shipping fleet in the developing world and ranks 19th in the world.

Shipbuiding Industry : Biggest shipyard : Kochi shipyard limited. The other important shipyards are Hindustan Shipyard Ltd. at Vishakapatanam, Hoogly Dock and Port Ltd. with two units at Sakia and Nazirgunge in Howrah, Garden Reach Shipbuilding Yard at Kolkata and Bombay Shipyard which includes Mazagaon Docks Ltd. (to construct battleships for the Indian Navy. The Western India Shipyard Ltd. has ship repair facilities at Marmugao.

Indian Railways: Indian rail network is the fourth largest in the world after USA, China and Russia. Indian Rail accounts for 30% of freight traffic of India. Indian railways is organised into 16 zones. Among the 16 rail zones, the northern zone (headquarters -New Delhi) has the longest rail route length. The important rail works are : Chittaranjan Loco Works - Burdwan, W. Bengal. Makes electric locos. Diesel Loco works - Varanasi; produces diesel engines. Integal Coach Factory - Perambur (near Chennai) – produces all types of coaches. Rail Coach Factory - Kapurthala (Punjab) – produces all types of coaches.Bharat Earth Movers (Bangalore) - manufactures broad guage coaches. The new rail coach factory at Lalgung, Rae Bareli (U.P.), has been commissioned. It is the third of its kind after Integral Coach Factory, Perumbur and Rail Coach Factory, Kapurthala. In budget 2010-11, new undertaking proposed are Rail Axle Factory at Jalpaiguri, Refrigerated Container Factory at Budge Budge (near Kolkata) and Rail Wagon Factories at Bardhaman and Haldia.

Inland Waterways : National Waterway no. 1 - Allahabad-Haldia. 1620 kms. National Waterway no. 2 - Sadia-Dhubri. 891 kms. National Waterway no. 3- Kottapuram- Kollam. Includes West Coast Canal (168 kms), Champakara Canal (23 kms), Udyogamandal Canal (14 kms). India has 14352 kms of navigable waterways of which 5200 kms are navigable by motorized craft

MINERAL RESOURCES OF INDIA

By Dr. D B KUMAR

Fossil Fuel Resources :

Coal : India stands 5th in world reserves of coal and is the 3rd largest producer in the world. India's bituminous coal deposits are contained in Gondwana rocks. The states with the largest reserves of coal (of all categories) are 1. Jharkhand 2. Odisha 3. Chhattisgarh 4. W. Bengal. The largest producer of coal is Jharkhand and the largest producer of lignite is T. Nadu. The main coalfields of India are : Damodar valley coalfields : These include the coalfields of Jharkhand and W. Bengal. These are Giridih, Jharia, Bokaro, Karanpura, Ramgarh and the Ranigunj coalfields. The Mahanadi valley coalfields : These include the coalfields of Orissa, M.P., and Chattisgarh. These include Talcher, Sambalpur, Korba, Raigarh and Sonepat. The Son valley coalfields : These are in M.P., Jharkhand and Chattisgarh. These include Singrauli coalfields, Sohagpur, Umaria, Auranga, Daltongunj and Hullar. The Godavari - Wardha Valley Coalfields : These occur in AP and Maharashtra. The Wardha valley fields of Maharashtra are in Kamptee, Umner and Ballarshah. The Godavari valley coalfields of AP include the Singareni fields (like the Kothagudem and Ramagundem fields).

Coalfieds of the Northeast : The coalfields of the northeast occur in younger rock formations and hence the coal deposits are younger and hence of inferior quality. These occur in A) Assam - Maibum fields and Mikir fields. B) Meghalaya- The coalfields are in Jayanti and Bapung. C) Nagaland - The coalfields are in Tiru valley and Borjan. D) Arunachal Pradesh - The main fields occurs in Namchik.

Lignite Deposits : These occur in rocks of tertiary period of the Mesozoic era. The largest reserves of lignite are in 1. T. Nadu. The Lignite deposits of T.Nadu are at Neyveli, those of Rajasthan at Palana (Bikaner), and those of Gujarat occur in Kutch and Bharuch.

Petroleum and Natural Gas: India's 27 sedimentary basins with an area of 1.72 million sq km are potentially hydrocarbon bearing. Around 60% of the prognosticated reserves are in offshore areas. India has 0.6% of world reserves and is the 22nd largest producer of oil in the world.

The important oil basin are : Bombay High : Contains around 60% of Indian reserves. Important oilfields are South Bassein, Panna, Ratna, and Heera. Cambay Basin (Gujarat) : Accounts for around 20% of India's reserves. Important oilfields are : Nawagam, Ankaleshwar, Lunej, Kalol and Gandhar.
Assam Basin : Accounts for around 19% of India's reserves. The important fields are Nahorkatiya, Moran, Lukwa, Digboi and Kiliboi. The other occurrences are : Tripura : Natural gas at Gojalia. Krishna – Godavari Basin (AP) : It is both onshore and offshore. Important fields are Ravva, Mori and Kaikalur. Cauvery Basin (Tamil Nadu) : It is both onshore and offshore. The important fields are Narimanam, Nannilam and Bhuvanagiri. The largest producer of petroleum crude and natural gas is Maharashtra.

Iron Ore: Orissa accounts for largest reserves of high grade iron ore. The main mines are Gurumahisani (Mayurbhanj) Kiriburu (Keonjhar) and Daitari (Cuttack). Jharkhand has large reserves. The main mines are in Noamundi and Gua (Singhbhum). The main mines in Chattisgarh are Bailadilla (in Bastar) and Dhalli – Rajhara (Durg). In Karnataka the reserves are in Kemangundi and Kudremukh (Bababudan hills, Chickmagalur). In Maharashtra the mines are in Lohara and Pipalgaon (Chandrapur) and Ratnagiri district. The largest producer of iron ore in India presently is Odisha. India has the fourth largest reserves after China, Australia and Brazil.

Manganese: India has the third largest reserves and is the third largest producer in the world. The distribution of manganese ore is in : Orissa : Manganese ore occurs in Keonjhar and Koraput districts. In M.P. the important mines are in Balaghat and Chhindwara. In Maharashtra, huge deposits of manganese occur in Nagpur and Bhandara. In Karnataka, the important mines are in Shimoga, Tumkur, Chitradurga districts. In A.P. the important mines are in Srikakulam and Vishakapatanam districts. The largest producer of manganese is Orissa.

Chromite (Ore of Chromium): India has the 5th largest reserves in the world. The chief mining areas are : Orissa : Sukinda (Cuttack) has very large reserves. Naushahi (Keonjhar) is another important mining region. In Jharkhand the chief mines are in Jojahatu in Singhbhum district. In Karnataka, chromite chiefly occurs in Hassan and Mysore. The largest producer of chromite is Orissa.

Bauxite: India has the 5th largest reserves in the world and is the third largest producer. It is an ore mineral of aluminium. The distribution is : Orissa : Mainly occurs in Kalahandi, Koraput and Sambalpur. Chattisgarh : Main mines are in Amarkantak plateau (Bilaspur and Raigarh districts) and Bailladilla (Bastar). Jharkhand : The chief mines are in Palamu district and Lohardarga district. Gujarat : Huge deposits occur in Banaskantha, Kutch and Jamnagar. M.P. : Main mines are in Katni (Jabalpur). The largest producer of bauxite is Orissa.

Copper: The important mining centres are : Jharkhand : The chief mines are Mosabani and Rakka (Singhbhum district). Rajasthan : Khetri in Jhunjhunu and Dariba in Alwar district. M.P. : Malanjhkand in Balaghat is the main mining centre. Karnataka : Ingladhal in Chitradurga is the main centre. A.P. : Agnigundala (Guntur) and Mailaram (Khammam) are the main centres. M.P. is the largest producer of copper.

Lead: The chief mining centres are : Rajasthan : Mochia – Mogra mines (Zawar mines in Udaipur) and Dariba – Rajpur (in Bhilwara dist.). A.P. : The chief centre is Agnigundala (Guntur). The largest producer is Rajasthan.

Zinc: India has the 4th largest reserves in the world. The chief mining centres are : Rajasthan : Zawar mines (Udaipur) and Dariba (Bhilwara). A.P. : Chief centre is Agnigundala (Guntur). The largest producer is Rajasthan.

Gold: The chief centres are : Karnataka : Kolar Gold Fields (Kolar) and Hutti Gold Field (Raichur) are important mines . A.P. : Ramagiri Gold Fields in Anantapur. Kerala : Gold occurs in

Kozhikode and Wynaad districts. The leading producer is Karnataka.

Mica: India is the world's largest producer of sheet mica. The chief mining regions are: Jharkhand : It is a major supplier of block mica. Koderma district is important. A.P. : The Gudur mica belt (Nellore) is the main centre. Rajasthan : The chief mines are in Bhilwara, Udaipur and Jaipur districts. Bihar : The main mining regions are in Gaya, Monghyr and Bhagalpur. The largest producer of mica is A.P.

Magnesite: It mainly occurs in Uttaranchal : It mainly occurs in Almora and Pithorgarh. Tamil Nadu: It mainly occurs in Chalk Hills of Salem district. Karnataka : It mainly occurs in Mysore and Hassan districts. The largest producer of magnesite is T.Nadu.

Gypsum: It mainly occurs in : Rajasthan : The deposits are large at Nagaur. The other mines are in Jodhpur and Jaisalmer. Uttaranchal : Gypsum mainly occurs in Dehradun, Garhwal and Nainital districts. The largest producer is Rajasthan.

Graphite: It is an allotrope of carbon. The chief centres are : Orissa : It mainly occurs in Koraput and Dhenkanal districts. A.P. : The chief centres are in Khammam and Vishakapatanam districts. Orissa is the largest producer.

Sillimanite: It is a refractory mineral and is fibrous. Large reserves of sillimanite occur in Kerala, Orissa and Meghalaya. The largest producer is Orissa.

Kyanite: It is a fibrous mineral. India has the largest deposits in the world. The largest producer is Jharkhand.

Barytes: It is the ore mineral for barium. India's largest deposits occur in Mangampeta in Cuddapah (A.P.) and other deposits occur in Alwar (Rajasthan). A.P. is the biggest producer.

Diamonds: These occur in rocks called Kimberlites. The chief diamond occurrences are : M.P. : Majhgawan mines in Panna is the chief centre. Chattisgarh : The diamonds occur near Raipur. M.P. is the largest producer of diamonds.

Nuclear Minerals of India: Pitchblende occurs in Narwa Pahar, Dantupa, Jaduguda in Jharkhand. Mineral monazite occurs in Monghyr and Gaya in Bihar and also in the black sands off the coasts of Ganjam and Cuttack. The black sands of the east coasts off Visakhapatnam contain Ilmenite, Monazite and Zircon. The black sands of Malabar contain Monazite, Zircon, Ilmenite and Thorianite. Uraninite occurs in Udaipur, Alwar and Jhunjhunu in Rajasthan.

Thumullapalle in Kadapa of Andhra Pradesh has India's largest reserves of Uranium. UCIL has commissioned the mine and processing facility in 2012. Banduhurang in Singhbhum of Jharkhand is a large open cast Uranium mine.

India's status in mineral output : India ranks 2nd in Barytes, 3rd in Coal, 4th in Iron Ore, 5th in Manganese Ore and Zinc, 6th in Bauxite Ore and 10th in Magnesite Ore in terms of production in the world.

Mineral Output of India : The largest minerals produced by India are 1. Coal 2. Iron Ore 3. Oil and Gas and 4. Lignite.

INDIAN INDUSTRY

By Dr. D B KUMAR

Iron and Steel : The first modern steel plant to produce steel was Sakchi, Jamshedpur in 1907. The **major steel plants are:** Bhilai (Durg dist. Chattisgarh) - set up with Russian help. Bokaro (Jharkhand) - set up with Russian help. Rourkela (Sundargarh district, Orissa) - set up with German help. Durgapur (Burdwan district, W. Bengal) - set up with U.K.'s help. TISCO (Jamshedpur, Jharkhand) - A private sector steel plant. The first modern steel plant in India set up in 1907. Produced pig iron in 1908 and steel in 1913. Indian Iron and Steel Company (IISCO) - Has three units at Burnpur, Hirapur and Kulti. Vishweshwaraya Iron and Steel Works Limited (VISL) - at Bhadravati in Shimoga district of Karnataka. Makes use of power from Jog Falls hydro power project. The **New Steel Plants** are : Vishakapatanam Steel Plant (Rashtriya Ispat Nigam Ltd.). Set up in the 6th plan. Is India's first shore based steel plant. Salem Steel Plant - set up in the 6th plan. It is a major producer of stainless steel. Vijayanagar Steel Plant (located at Hospet, Bellary, Karnataka). Kothagudem Steel Plant (A.P.). First major sponge iron plant. Daitari Steel Plant near Paradwip (Cuttack, Orissa) - India's second shore based plant. Bhandara Steel Plant (Nagpur, Maharashtra). India is the 4th biggest producer of Crude Steel in world.

Copper Industry : Hindustan Copper Ltd. Came into being in 1967 as a public sector undertaking. It took over Indian Copper Corporation in 1972. HCL produces finished copper at A) Indian Copper Complex, Maubhander, Ghatsila, Jharkhand and B) Khetri Copper Complex in Jhunjhunu district (Rajasthan). It's other units producing copper ore are : Malanjhkhand Copper Project - Balaghat, M.P. Rakka Copper Project - Singhbhum, Jharkhand, Dariba Copper Project (Alwar, Rajasthan).

Lead and Zinc Industry : First lead was made at Tundoo. Hindustan Zinc Ltd. (HZL) was set up in 1966. The HZL has been disinvested by the government and the current shareholding of the government is 29.54%. HZL with its headquarters at Udaipur, operates three lead and zinc mines at Zawar (Udaipur) the Dariba mines (Alwar) and Rampura mines

(Bhilwara), all in Rajasthan. HZL operates the Debari Zinc Smelter (Udaipur), Chanderiya Lead-Zinc Smelter (Chittorgarh, Rajasthan) and the Vishakapatanam Smelter (A.P.). The HZL also runs the lead smelter at Tundoo (Dhanbad, Jharkhand).

Aluminium Smelting Industry : First alumina plant was set up at Jaykaynagar in W. Bengal. Bharat Aluminium Company was set up in 1965 as the first aluminium producing PSE. It runs the Korba Aluminium Complex (Bilaspur, Chattisgarh) and the Bhindanbaag Complex in Asansol in W. Bengal. In 2001, the government transferred 51% of its equity and management control to Sterilite Industries Ltd. Hindustan Aluminium Company Ltd. (HINDALCO) has a unit at Renukoot (Mirzapur, U.P.) National Aluminium Company (NALCO) set up in 1981 is the biggest producer of aluminium in India. It has two smelters - the Damanjodi plant (Koraput, Orissa) and the Angul Plant (Angul district, Orissa). Indian Aluminuium Company Ltd. (INDALCO) has units at Belgaum (Karnataka) Alupuram (Kerala), Hirakud (Orissa) and an Alumina plant at Muri (Jharkhand). The private sector Madras Aluminium Company (MALCO) runs a plant at Mettur in Tamil Nadu.

Cotton Textile Industry: Cotton textile industry in India's largest organised industry. The cotton textile industry accounts for 4% of India's GDP and 14% of India's industrial output. The first cotton mill was set up at Fort Glaster, Howrah, West Bengal in 1818. The first modern mill was set up in Bombay in 1851. The largest producer of cotton cloth is Maharashtra. Bombay with 57 mills is a major centre in Maharashtra and Ahmedabad with 67 mills is a major centre in Gujarat. Tamil Nadu has the largest number of mills. The largest centre is Coimbatore.

Jute Industry: India is the largest producer of raw jute and jute goods in the world and the second largest exporter of jute goods in the world. The first jute was produced at Rishra, West Bengal in 1855. West Bengal has the largest number of jute mills (mostly along banks of Hooghly). West Bengal accounts for 73% of output and 72% of the mills.

Silk: India is the only country in the world to produce all commercial varieties of silk - Mulberry silk. Tropical Tasar, Oak

Tasar, Eri and Muga. India is the world's second largest producer of raw silk after China. The first modern silk mill was set up at Howrah in 1883. Karnataka accounts for 70% of raw silk output. It produces mulberry silk. Important centres are Bangalore, Mysore, Kolar, Mandya. Assam is the chief producer of muga silk. Jharkhand is the chief producer of tasar silk.

Woollen Textiles: India is the 7th largest producer of wool in the world. The first modern woollen mill was set up at Kanpur in 1876. Punjab has the largest number of mills. Important centres are Dhariwal, Amristar, Ludhiana. The largest producer of woolen textiles is Punjab. The top Wool producing states of India are Rajasthan and Jammu & Kashmir.

Cement Industry: India is the 2nd largest producer of cement in the world after China. The top producers of Cement in India are A.P., Rajasthan and Karnataka. The first cement mill was set up at Chennai in 1904. The largest producer of cement is M.P.

Sugar Industry: Second largest agro-based industry in India. India is the second largest producer of sugar after Brazil. The first sugar mills arose in eastern U.P. The first white sugar mill was set up at Coimbatore, T.N. The largest producer of sugar is Maharashtra.

Oil Refineries: The public sector refineries are : Indian Oil Corporation Ltd. (IOCL) - has refineries at Guwahati and Digboi (Assam), Barauni (Bihar), Koyali (Gujarat), Haldia (W. Bengal), Mathura (UP) and Panipat (Haryana). Chennai Petroleum Corporation Ltd. Is a subsidiary of IOCL. It has two refineries at Manali and Nagapattanam (both in T. Nadu). Bongaigaon Refineries and Petrochemicals is a subsidiary of IOCL. It runs the refinery at Bongaigaon (Assam). Mangalore Refineries and Petrochemicals Ltd. (MRPL). The refinery is at Mangalore (Karnataka). Hindustan Petroleum Corporation Ltd. (HPCL)- has refineries at Mumbai and Vishakapatnam. Bharat Petroleum Corporation Ltd. (BPCL) - has a refinery at Mumbai. Kochi Refinery Ltd. (KRL) is a subsidiary of BPCL and operates the refinery at Kochi (Kerala). Numaligarh Refinery Ltd. (Assam) - It is a subsidiary of BPCL and runs the Numaligarh refinery (Assam). The Mani Refinery Ltd. (Tatipaka, A.P.) is owned by

ONGC. The Jamnagar Refinery is India's biggest refinery and belongs to Reliance Industries Ltd.

Paper Industry: The first paper mill was set up at Serampore, West Bengal in 1812. The important centres of paper industry in India are : Ballarpur and Sangli – Maharashtra, Sirpur (in Kagznagar) and Rajhamundry (A.P.), Rajkot and Vadodara in – Gujarat, Meerut, Modinagar and Muzzafarnagar - U.P., Baranagore and Titagarh - W. Bengal and Nepanagar (for newsprint) and Indore – M.P. The largest producer of paper in India is Maharashtra.

Match Industry: The first match mill was set up at Ahmedabad in 1921. Tamil nadu has more than two-thirds of the units in the unorganised sector (in Sivakasi, Kovilpatti and Sattur). West Bengal has the largest concentration of match industry in the organized sector.

Heavy Electrical Machinery Industry : The BHEL, set up in 1964, is one of the top power equipment manufacturers of the world. It's six units are located at Bhopal (M.P.) Bangalore (Karnataka), Tiruchirapalli (T. Nadu), Ramchandrapuram (Hyderabad, A.P.) Haridwar (Uttarakhand) and Jammu (J & K).

Salient Features of Census – 2011

By Dr. D B KUMAR

Introduction : The population of India at 0.00 hours on March 31, 2011 according to provisional population totals of census 2011 was 1,210,193,422 compared to 1,028737,436 in 2001. The absolute increase in 2001-2011 was 181 million, slightly lower than the population of Brazil. At present, a little more than one out of every 6 persons in the world is from India. China accounts for 19.4% of world population while India accounts for 17.5%. The share of other countries is USA - 4.5%, Indonesia-3.4%, Brazil - 2.8%, Pakistan - 2.7%, Bangladesh - 2.4%, Nigeria-2.3%, Russian Federation-2% and Japan-1.9%. The rest of the world accounts for 41.2% of world population. India with 2.4% of world's surface area accounts for 17.5% of world population.

Growth Rate of India's Population in 2001-2011. The average annual growth rate of India's population in 2001-2011 was 1.64% (It was 1.97% per anum in 1991-2001). The progressive growth rate over 1901 population is 407.64% in 2001-2011. Decadal Growth Rate of population (2001-2011).

The decadal growth of population in 2001-2011 over 2001 was 17.64% (compared to 21.54% in 1991-2001). The states of India with highest decadal growth are 1. Meghalaya (27.8%) 2. Arunachal (25.9%), 3. Bihar (25.1%), 4. Jammu and Kashmir (23.7%) 5. Mizoram (22.8%) 6. Chhattisgarh (22.6%) 7. Jharkhand (22.3%), 8. Rajasthan (21.4%) 9. M.P. (20.3%) and 10. U.P. (20.1%). The National Capital Territory of Delhi registered a decadal growth of 21%. The least decadal growth was recorded by Nagaland where it was minus 0.5%. Among the union territories, the highest decadal growth was shown by Dadra and Nagar Haveli while the least was recorded by Lakshadweep.

Average Annual Growth Rate of Population of States in 2001-2011: The average annual population growth rate of states as per census 2011 in the decade 2001-11 is as follows. The states with the highest growth rates are 1. Meghalaya (2.49% p.a.) 2. Arunachal Pradesh (2.33% p.a.) 3. Bihar (2.26% p.a.) 4. Jammu and Kashmir (2.15% p.a.) 5. Mizoram (2.07% p.a.) 6. Chhattisgarh

(2.06% p.a.) 7. Jharkhand (2.04% p.a.) 8. Rajasthan (1.96% p.a.) 9. M.P. (1.87% p.a.) and 10. Haryana (1.83% p.a.). The average annual growth rate of National Capital Territory of Delhi in 2001-11 was 1.92% p.a. The ranking of union territories is 1. Dadra and Nagar Haveli (4.51% p.a.) 2. Daman and Diu (4.38% p.a.) 3. Puducherry (2.48% p.a.) 4. Andaman and Nicobar (0.65% p.a.) 5. Lakshadweep (0.61% p.a.). The least growth rate was shown by Nagaland in the census-2001-11.

Share of States in India's population by census-2011: The most populated states of India by census-2011 are 1) U.P.-16.49%, 2) Maharashtra-9.29%, 3) Bihar-8.58%, 4) W.Bengal-7.55%, 5) A.P.-7.00%, 6) M.P.-6%, 7) T. Nadu-5.96%, 8) Rajasthan-5.67%, 9) Karnataka-5.05% and 10) Gujarat-4.99%. Sikkim is the least populated state. Among the union territories, the largest population size is in Puducherry and the smallest population size is in Lakshadweep. (The descending order of population size for union territories is Puducherry, Chandigarh, Andaman and Nicobar, Dadra and Nagar Haveli, Daman and Diu and Lakshadweep). The largest population among the Northeastern States is in Assam followed by Tripura, Meghalaya, Manipur, Nagaland, Arunachal Pradesh and Mizoram.

III Density of Population : The following terms are used in describing density in demography 1. Arithmetic Density – The overall inhabitants per square km 2. Agricultural Density – the agricultural population per unit area of arable farming land 3. Physiological Density – the overall population per unit area of arable land. The population density of India as per census 2011 is 364.9 people per square km. The states with the highest population density by census 2011 are 1. W. Bengal 2. Bihar 3. Kerala 4. U.P. The state with the least population density is Arunachal Pradesh (17 per square km). Among union territories, the most densely populated is Delhi (9340 persons per square km) followed by Chandigarh (9252 per sq. km) Puducherry (2598 per sq. km), Lakshadweep (2013 per sq. km.), Dadra and Nagar Haveli (491 per sq. km.) Daman and Diu (112 per sq. km.) and Andaman and Nicobar (46 per sq. km.) The density of population of India increased in every census decade except in 1911 – 1921 when it came down from 82 per sq. km in 1911 to 81 per sq. km in 1921

IV. Sex Ratio : The sex ratio as per 2011 census is 940 per 1000 males. The sex ratio improved marginally over that of 2001 census. The states with the highest sex ratio as per census 2011 are 1. Kerala (1084 per 1000 males) 2. T. Nadu (995 per 1000 males) 3. A.P. (992 per 1000 males) 4. Chhattisgarh (991 per 1000 males). The least sex ratio was in Haryana (877 per 1000 males). The states showing the least sex ratio as per census 2011 are 1. Haryana (877 per 1000 males) 2. Jammu and Kashmir (883 per 1000 males) 3. Sikkim (889 per 1000 males) 4. Punjab (893 per 1000 males). The sex ratio among the union territories as per census 2011 was highest in 1. Puducherry (1038 per 1000 males) 2. Lakshadweep (946 per 1000 males) 3. Delhi (866 per 1000 males) 4. Chandigarh (818 per 1000 males) 5. Dadra and Nagar Haveli (775 per 1000 males) 6. Daman and Diu (618 per 1000 males). The sex ratio declined in Dadra and Nagar Haveli, Daman and Diu and Lakshadweep over 2001 census but improved in rest of the union territories with the highest improvement recorded in National Capital Territory of Delhi followed by Chandigarh.

V. Literacy Rate : The literacy rate improved in the census decade 2001-2011 (from 64.8% in 2001 to 74.04% in 2011). A notable thing is the sharp increase in the female literacy rate in the decade 2001-2011. The states with the highest male literacy rates as per census 2011 were 1. Kerala (96%) 2. Mizoram (93.7%) 3. Goa (92.8%) 4. Tripura (92.2%). The least literacy rate was in Bihar (73.5%). Among the union territories, the highest literacy rate was shown by 1. Lakshadweep (96.1%) 2. Puducherry (92.1%) 3. Daman and Diu (91.5%) 4. Delhi (91%) 5. Andaman and Nicobar (90.1%) and 6. Dadra and Nagar Haveli (86.5%)

Female literacy rate was 65.46% in 2011. The highest female literacy rate among states was in 1. Kerala (92%) 2. Mizoram (89.4%) 3. Tripura (83.1%) 4. Goa (81.8%). The least female literacy rate among states was shown by 1. Lakshadweep (96.1%) 2. Puducherry (92.1%) 3. Daman and Diu (91.5%) 4. Delhi (91%) 5. Andaman and Nicobar (90.1%) and 6. Dadra and Nagar Haveli (86.5%). The least female literacy rate was shown by Rajasthan (52.7%) followed by Bihar (53.3%). Among union territories, the female literacy rate in descending order as per census 2011 is 1. Lakshadweep (88.2%) 2. Andaman and Nicobar (81.8%) 3. Chandigarh (81.4%) 4. Puducherry (81.2%) 5. Delhi (80.9%) 6. Daman and Diu (79.6%) and Dadra and Nagar Haveli (65.9%). The

General literacy rate for India was 74.04% while the male and female literacy rates for India were 82.14% and 65.46% respectively. The states with the highest literacy rates by census 2011 were 1. Kerala (93.9%) 2. Mizoram (91.6%) 3. Tripura (87.8%) and 4. Goa 87.4%).

Urbanisation : The census decade 2001-2011 saw an increase of 91 million people in the urban settlements of India. The population increase in 2001-2011 was 181.4 million people of which rural population increased by 90.4 million and urban population by 91 million. Thus, in census 2001-2011, more number of people were added in urban than rural areas. The growth in rural population is steadily declining since 1991. Four states recorded a decline in rural population in 2001-2011 which where Kerala (decline by 26%), Goa (decline by 19%), Nagaland (decline by 15%) and Sikkim (decline by 5%). However largest increase in rural population was recorded by Meghalaya (increase by 27%) in the census decade 2001-2011.

It may be noted that U.P. has the largest share in India's rural population – it accounts for 18% of India's rural population (excluding the union territories). Sikkim has the least share in India's rural population (a little less than 0.1% of India's rural population, excluding the union territories). Maharashtra has the largest share in India's urban population (13.5% of India's urban population, excluding the union territories) while Sikkim has the least share in India's urban population.

Urban population as a percent of state population is highest in 1. Goa (62.1%) 2. Mizoram (51.5%) 3. Tamil Nadu (48.4%) 4. Kerala (47.7%). The state with the least percent of urban population as part of its total population by Census 2011 was Himachal Pradesh (10.1%). However in terms of absolute size of urban population, it is Maharashtra (with 50.8 million urban people) followed by U.P. (44.4 million urban people), Tamil Nadu (34.9 million urban people) and W. Bengal (29.1 million urban people). The least size of urban population was in Sikkim (0.15 million people). Among the union territories – the share of urban population of total population is highest in Delhi (97.5%) followed by Chandigarh (97.2%), Lakshadweep (78%), Daman and Diu (75.1%) Dadra and Nagar Haveli (46.6%) and Andaman and Nicobar

(35.6%). In terms of absolute size of urban population among union territories the ranking is Delhi (16.3 million) followed by Chandigarh, Puducherry, Daman and Diu, Dadra and Nagar Haveli, Andaman and Nicobar and Lakshadweep.

ENVIRONMENT

By Dr. D B KUMAR

Wetlands: Wetlands in India are distributed in different geographical regions, ranging from the Himalaya to the Deccan plateau. The variability in climatic conditions and topography is responsible for significant diversity. Based on their origin, vegetation, nutrient status and thermal characteristics, they are classified into following different types:

Glaciatic Wetlands (e.g., Tso Moriri in Jammu and Kashmir, Chandertal in Himachal Pradesh). Tectonic Wetlands (e.g., Nilnag in Jammu and Kashmir, Khajjiar in Himachal Pradesh, and Nainital and Bhimtal in Uttarakhand). Oxbow Wetlands (e.g., Dal Lake, Wular Lake in Jammu and Kashmir and Loktak Lake in Manipur and some of the wetlands in the river plains of Brahmaputra and Indo-Gangetic regions. Deepor Beel in Assam, Kabar in Bihar, Surahtal in Uttar Pradesh). Lagoons (e.g., Chilka in Orissa). Crater Wetlands (Lonar lake in Maharashtra). Salt Water Wetlands (e.g., Pangong Tso in Jammu and Kashmir and Sambhar in Rajasthan). Urban Wetlands (e.g., Dal Lake in Jammu and Kashmir, Nainital in Uttarakhand and Bhoj in Madhya Pradesh). Ponds / Tanks, Man-made Wetlands (e.g., Harike in Punjab and Pong Dam in Himachal Pradesh). Reservoirs (e.g., Idukki, Hirakud dam, Bhakra Nangal dam). Mangroves (e.g., Bhitarkanika in Orissa). Coral reefs (e.g., Lakshadweep)

Ramsar Site: The Ramsar Convention (The Convention on Wetlands of International Importance especially as Waterfowl Habitat signed in Ramsar, Iraq in 1971) is an international treaty for the conservation and sustainable utilization of wetlands. Andhra Pradesh (Kolleru Lake), Assam (Deepor Beel), Himachal Pradesh (Pong Dam Lake, Renuka Wetland, Chandertal Wetland), Jammu & Kashmir (Wular Lake, Tso Moriri, Hokera Wetland, Surinsar – Mansar Lakes), Kerala (Ashtamudi Wetland, Sasthamkotta Lake, Vembanad – Kol), Madhya Pradesh (Bhoj Wetland), Manipur (Loktak Lake), Orissa (Chilika lake, Bhitarkanika Mangroves), Punjab (Harike Lake, Kanjli Lake, Ropar Lake), Rajasthan (Sambhar Lake, Keoladeo National Park), Tamilnadu (Point Calimere Wildlife and Bird Sanctuary), Tripura (Rudrasagar Lake), Uttar Pradesh (Upper Ganga River (Brijighat to Narora Stretch), West Bengal (East Kolkata Wetlands).

Biosphere Reserves: The programme of biosphere Reserve was initiated under the 'Man & Biosphere' (MAB) programme of UNESCO in1971. The purpose of the formation of the biosphere reserve is to conserve in-situ all forms of life, along with its support systems, in their totality, so that it could serve as a referral system for monitoring and evaluating changes in natural ecosystems. The first biosphere reserve of the world was established in 1979. Since then the network of biosphere reserves has increased to 531 in 105 countries across the world. Presently, there are 15 existing biosphere reserves in India. The biosphere reserves of India are : Achanakamar – Amarkantak (Chhattisgarh and M.P.), Agasthyamalai (Kerala), Dehang – Dibang (Arunachal Pradesh), Dibru – Saikhowa (Assam), Great Nicobar (Andaman and Nicobar), Gulf of Mannar, Khangchendzonga (Sikkim, Assam), Nanda Devi (Uttarakhand), Nilgiri (Tamil Nadu, Kerala and Karnataka), Nokrek (Meghalaya), Pachmarhi (M.P. & Chhattisgarh), Sunderbans (West Bengal), Kutch (Gujarat).

Tiger Protection: The Tiger Reserves in India are : Manas, Kaziranga, Nameri (Assam), Nagarjunasagar and the new one declared in 2012 i.e., in Adilabad (Andhra Pradesh), Namdapha, Pakke (Arunachal Pradesh), Valmiki (Bihar), Indravati, Undanti – Sitandadi, Achanakmar (Chhattisgarh), Palamu (Jharkhand), Periyar, Parambikulam (Kerala), Bandipur, Bhadra, Dandeli-Anshi, Nagarhole (Karnataka), Tadoba-Andhari, Pench, Melghat, Sahyadri (Maharashtra), Bandhavagarh, Kanha, Satpura, Panna, Sanjay-Dubri, Pench (Madhya Pradesh), Dampa (Mizoram), Satkosia, Simlipal (Orissa), Ranthambhore, Sariska (Rajasthan), Kalakad-Mundanthurai, Mudumalai, Annamalai (Tamil Nadu), Corbett (Uttarakhand), Dudhwa (Uttar Pradesh), Buxa, Sunderbans (West Bengal).

Mangrove Sites in India: West Bengal (Sunderbans), Orissa (Bhitarkanika, Mahanadi, Suvarnarekha, Devi-Kauda, Dhamra, Mangrove Genetic Resources Centre, Chilka), Andhra Pradesh (Coringa, East Godavari, Krishna), Tamil Nadu (Pichavaram, Muthupet, Ramnad, Pulicat, Kazhuveli), Andaman & Nicobar (North Andaman, Great Nicobar), Kerala (Vembanad, Kannur), Karnataka (Coondapur, Dakshin Kannad/Honnavar, Karwar), Goa (entire Coastal Goa), Maharashtra (Achra-Ratnagiri, Devgarh-Vijay Durg, Veldur, Kundalika-Revdanda, Mumbra-Diva, Vikroli, Shreevardhan, Vaitarna, Vasai-Manori, Malvan), Gujarat (Gulf of Kutch, Gulf of Khambhat, Dumas-Ubhrat).

Coral Reefs: The four major coral reef areas identified for intensive conservation and management are : 1. Gulf of Mannar, 2. Gulf of Kutch 3. Lakshadweep and 4. Andaman and Nicobar Islands.

SRIRAM'S IAS

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Indian Geography

Contents

1. STRUCTURE AND RELIEF OF HIMALAYAS

The Himalayas constitute a folded mountain complex and formed due to the closure of the Tethys ocean basin upon the convergence of the Indian and the Eurasian plates. The Himalayas run for a length of 2400 km and are widest in the west. At both of their extremeties in the northwest and the northeast, they show sharp bends which leads to an abrupt change in their direction. These bends are called the *syntaxial bends*. Since the relief and structural features of the Himalayas show a zonal arrangement, they are briefly discussed in terms of the respective zones.

A) **The Siwalik Zone** : These constitute the outermst belt and have an average elevation of 1500 metres. These are a system of continuous ranges. They are separated from the Lesser Himalayas in the north by the Main Boundary Fault, a group of factures. The siwaliks are called Jammu hills in J & K and Daffla, Miri Mishmi and Abhor hills in the northeast.

B) **The Lesser Himalayas:** Also called as Himachals, they show an average elevation of 3000 metres. Unlike the Siwaliks, they occur in the form of a series of discontinuous ranges. The Pir Panjal, the Dhauladhar and the Mussoorie Range are part of the Himachals. Kulu, Kangra Lahul and spiti are prominent valleys within the Himachals. Along the junction of the Himachals and Greater Himalayas, valleys filled with sediments, called the Doons occur.

c) **The Greater Himalayas** : These are also called the Himadris and are separated from the Himachals by the Main Central Thrust. Their average elevation is 6100 metres. The topography of the Himadris is very rugged and they boast of 14 of the 28 tallest peaks of the world. The four prominent peaks of the Greater Himalayas are Mt. Everest, Everest South Peak, Kanchenjunga-I and Lhotse-I. The Greater Himalayas are cut by some prominent passes like the Zojila pass (Kashmir), the Shipki pass (Himachal) and the Liphu Lekh Pass (Uttarakhand). Some very large glaciers are present within the Greater Himalayas like Zemu, Gangotri, Kanchenjunga and others.

D) **The Trans-Himalayas** : These lie north of te Greater Himalayas and are made up of the Karakoram, Ladakh and Zaskar Ranges, from north to south. *The Karokorams have the world's largest non-polar glacier i.e., the Siachen*. The Ladakh Ranges have the highest peak of India - the Ladakh Plateau. Towards the north, the Transe-Himalayas have the *Indus-Tsangpo Suture Zone* - where the Indian plate and the Euraslan plate are joined.

2. THE ORIGIN OF THE HIMALAYAS

The Himalayas represent a folded mountain belt. Folded mountain belts form due to compression of the earth's crust by the movement of lithospheric plates. According to the theory of *plate tectonics*, folded mountain belts form when two lithospheric plates made up of continental masses progressively converge upon each other and close an intervening ocean basin.

The Himalayas formed as a result of the convergence of the Indian plate with the Eurasian plate, thereby closing the Tethy's ocean between them. The Tethys ocean is postulated to be present between the Indian plate and the Eurasian plate. As the Indian plate moved northwards, the Tethy's Ocean began to be squeezed between the northward moving Indian plate and the Eurasian plate (lying north of the Tethys ocean). According to geographers, the Indian plate collided with the Eurasian plate around five times. Each of these collisions led to the progressive evolution of the Himalayan folded mountain complex. The collisions squeezed up the sediments lying on the floor of the Tethys as well as the oceanic crust of the Tethys. In the final phases of collision, even the leading portions of the Indian landmass got fractured and these sliced off portions were thrust up. The Greater Himalayas are said to represent a part of the Indian landmass. The various structural features within the Himalayas like the Main Central Thrust (which separates the Greater Himalayas from the Lesser Himalayas), the Main Boundary Fault (which separates the Lesser Himalayas from the Siwaliks) and the Indus Suture Zone are due to these collisions. The outermost belt of the Himalayas i.e., the Siwalik Ranges are said to have formed in the last phase of collision. The Indian plate is believed to be still moving north and thrusting against the Eurasian plate and hence leading to the continued rise of the Himalayas.

3. IMPACT OF HIMALAYAS ON INDIA's CLIMATE

The Himalayas are an important controlling factor in the climate of India. The Himalayas are responsible for splitting rapid upper airflows called jet streams into two branches. These jet streams influence the onset of monsoons over north Indian plains. *Secondly, though half of India lies in the tropics, the entire country has a tropical climate because of the Himalayas*. This is because of two effects of Himalayas. 1. The Himalayas insulate India from cold winds originating in Siberia / Manchuria by blocking them. These cold winds in winter could have brought very cold conditions to India i.e. temperate climatic conditions. 2. The landmass of India heats up in summer and this leads to northerly shift of the equator. But the excess heating up of the landmass of India is because of Himalayas blocking the entry of cold winds coming from the north. Both these factors associated with the Himalayas gives to India its tropical climate with a cold dry and hot wet season.

4. IMPORTANCE OF HIMALAYAS TO INDIA

The Himalayas are very important to India in terms of the resources they offer to India, their role in India's climate, and their strategic functions due to their location along the frontier.

A) **Resources From Himalayas**: The Himalayas are the birthplace for the Indus, Ganga and the Brahmaputa systems. These rivers have been responsible for the development of the fertile Indo-Gangetic plains which form the core agricultural regions of India. These rivers also provide water for agriculture, irrigation and municipal needs. In addition, the Himalayas have rich reserves of subtropical and temperate timber species. The coniferrous vegetation of the Himalayas is a source of rich reserves of softwood timber which finds use in a variety of industries. The Siwalik ranges of the Himalayas are rich in mineral resources like gypsum, limestone and good quality phosphate deposits.

B) **Ecological Importance**: The Himalayas are extremely rich in biodiversity and the Himalayan region of northeast India is considered to be one of the 12 major biodiversity rich zones of the world. Himalayas play a very prominant role in the ecology of the subcontinent. They maintain the regional hydrological balance and also the regional ecological balance through their rich forests. The Himalayas also influence the climate of India profoundly like for e.g., they prevent the northward migration of the monsoons away from India and also prevent cold Siberian winds from blowing over India in winter.

C) The Himalayas also offer exotic sites for recreation and tourism. The Himachal Ranges boast of a large number hill stations which are major tourist destinations in summer (like Ranikhet, Mussoorie, Dalhousie Point, Simla, Darjeeling and others).

D) The Himalayas also have a strategic value because they provide a natural frontier to India which forms a natural defensive border for India in the north and the northeast.

5. THE GREAT PLAINS OF INDIA

The Great Plains of India include the Indus Plains, the Ganga Plains and the Brahmaputra plains. These cover an area of 7.5 lakh sq kms. Except the Thar Plains and the Rann of Kutch, the Great plains are a result of deposition of alluvial sediments by the Indus, Ganga and the Brahmaputra systems. The Great Plains are widest in the west (in the Punjab - Rajasthan stretch) and narrow down towards the east. The Delhi Ridge of the Aravalli Ranges is the Indo-Gangetic Divide since it divides the Indus from the Brahmaputra plains. The different regions within the Great Plains are :

1. **Punjab-Haryana Plains** : These are made up of the floodplains and alluvial plains of the Ravi, Beas and Sutlej. They merge with the plains of Rajasthan in the south. Within the Punjab-Haryana plains, the Khadar plains (i.e., plains with newer alluvium) of Punjab are called *Bets* while *Chos* are parts of Punjab Plains with gullies and ravines.

2. **The Rajasthan Plains** : These include the Thar plains. The portion of Thar which is very arid is called Marusthali plain while *Bagar* constitute the *steppe land* immediately west of Aravallis. The narrow stretch of fertile plains near the foothills of the Aravallis are called *Rohi* plains. The Thar plains and portions of the Rann of Kutch are not due to deposition of river alluvium. Thee were originally part of the Arabian sea floor and were uplifted in the pleistocene epoch. Initially, this newly uplifted sea floor was marshy / swampy but later changed into a desert as it came under the influence of the sub-tropical high pressure belt and also because of the fact that the Aravallis do not obstruct the monsoon winds to induce rainfall in this region. Within the Thar plains and the Rajasthan Bagar, temporary saline lakes are called Ranns. The most important river draining the Thar plains is Luni.

3. **The Rann of Kutch :** The Great Rann represents a very large tidal marsh. Both the Great Rann and Little Rann represent the filling up of an arm of the Arabian sea by sand and silt deposits by wave and current action. Originally, the region which today makes up the Great Rann was made up of a few islands within an arm of the Arabian sea. These islands were joined to the Indian landmass by narrow strips of sediments. As waves and currents depsoited sediments, these islands grew and got joined to the Indian landmass completely. The Great Rann develops into a swampy region during the summer monsoon of India.

4. **The Ganga Plains** : These costitute the largest part of the Great plains by *area*. The Ganga plains include the upper Ganga, Middle Ganga and Lower Ganga Plains. The Upper Ganga plains lie between river Yamuna and Allahabad and include the Ganga-Yamuna doab, the Rohihkhand plains and Avadh Plains. In the northern parts (today lying primarily in Uttaranchal), the upper Ganga plains are made up of the *Bhabhar* and the *Terai* zones. The Bhabhar is a piedmont plain made up of coarse sediments. South of the Bhabhar lies the *Terai* which is a marshy/ swampy lowland. The Terai plains are made up of finer sediments. South of the Terai lie the Bangar and the Khadar plains. The *Bangar* is made up of older alluvial deposits and occurs on relatively higher land while the *Khadar* is made up of new alluvial and occurs as lowlands. The Yamuna, Ghaghara and the Ramganga are the most important rivers draining the upper Ganga Plains. The *Middle Ganga Plains* cover portions of eastern U.P. and northern Bihar. They are made up of the Ganga-Ghaghara doab, the

Mithila plains and the Kosi plains in the north and Magadh and Anga plains in the south. In their northern fringes, the Middle Ganga plains of Bihar have a long line of marshes called *Caur*. The Lower Ganga plains principally lie in W. Bengal and are mostly made up of the Ganga delta. The lower Ganga plains are divided into Barind Plains (in northern parts of W. Bengal), the Teesta plains (the Central to northern parts of W. Bengal), the Rarh Plains (in western parts of southern W. Bengal) and the Sunderbans delta.

The Brahmaputra Plains : These constitute the upper Brahmaputra plains lying within Assam. These are the floodplains along the upper course of Brahmaputra. They slope to the east and south and show a series of river terraces (i.e., a series of floodplains occurring at different elevations).

6. THE WEST COASTAL AND EAST COASTAL PLAINS

The West Coastal Plains : The west coastal plains extend for a length of 1400 kms between Diu and Kanyakumari and occur between 8^0 North to 20^0 north latitudes. The average width of the west coastal plains is 25-50 km. They are widest in the Konkan stretch. The west coastal plains off Maharashtra and Gujarat are the Konkan plains. The Sahyadris form steep west facing scarps along the Konkan coast. The Konkan coast is a submerged coast as shown by submerged forests and drowned rivers. The west coast off Karnataka is the Kanara coast. It is also a submerged coast. The west coastal plains become narrowest in the Kanara stretch. The west coast off Kerala is the Malabar coast. Three are a series of sand dunes in the Malabar coastal plains, locally called Teris. The sand dunes have given birth to a large number of backwaters called Kayals. Unlike the Konkan and the Kanara coasts which are submerged, the Malabar coast is an emerged coast. In general, the west coastal plains lack deltas.

The East coastal plains : These stretch for a length of 1100 kms between 8^0 north and 21^0 north. In general, the east coastal plains are referred to as the Coromandel coast. Again, the entire east coast is an emerged coast. The east coastal plains off Orissa are called the Utkal plains. The Utkal plains include lake Chilka, the largest saline lake of India. The east coastal plains off Andhra are called the Andhra plains. The East Coastal plains become widest in the Andhra plains. The Andhra plains contain lake Kolleru, the 2nd largest freshwater lake of India. The East coastal plains off Tamil Nadu are called the Madras coastal plains which include lake Pulicat. In general, compared to the west coastal plains, the east coastal plains are wider and are characterised by the presence of large deltas of Mahanadi, the Krishna-Godavari system and Cauvery.

7. DECCAN TRAPS

The phrase Deccan Trap refers to the structure shown by the Deccan plateau. The stepped surface of the Deccan plateau is called the Trap structure and hence the name Deccan Trap. The stepped appearance is a result of the solidification of lava flows after flowing for variable distances. The Deccan plateau is made up of solidified lava flows. The Deccan plateau is the largest plateau of India covering almost entire Maharashtra, Malwa and northern parts of Mysore and Telangana plateaus. The Kathiawar peninsula is also part of the Deccan plateau. The Sahyadris or the northern Western Ghats are edges of the Deccan plateau. The Deccan plateau is structurally composed of hundreds of individual layers of solidified lavas. The plateau slopes towards the east and attains its maximum thickness near Bombay. The lavas were poured out from linear fissures and hence deposited as layers. The Deccan plateau is covered by black soils which have been derived from the basaltic rocks that make up the plateau. There are a large number of ranges within the Deccan Plateau like Balaghat Range, Ajanta Range etc. The northern W. Ghats, which are part of the Deccan plateau are broken by the Bhor Ghat and the Thal Ghat passes. The highest peak of Sahyadris is Vavulmara. The prominent peaks of Sahyadris are Mahabaleshwar, Salher and Kalsubai.

8. THE CHOTANAGPUR PLATEAU

The Chotanagpur plateau includes Jharkhand and adjacent portions of W. Bengal, Orissa and Chattisgarh. It is between Rajmahal hills in the east and Maikala Ranges in the west. It is a continental plateau and is made up of very old igneous and metamorphic rocks that make up the peninsular landmass. The Chotanagpur plateau includes a series of smaller plateau-like features which are called *patlands*. These patlands are the Ranchi plateau, the Hazaribagh plateau, the Koderma plateau and others. The highest hills of the Chotanagpur plateau are the Parasavanath hills. Most of the plateau is covered with red soils which have been developed by the granitic rocks below. The Damodar and Suvarnarekha are the principal rivers of the Chotanagpur plateau. The plateau boasts of rich deciduous forests of sal and teak and is the richest mineralised zone for metallic deposits of India. It also includes some of the richest coalfields of India.

9. WESTERN GHATS & EASTERN GHATS

The Western Ghats : The Western Ghats constitute a system of narrow hill ranges extending for a length of 1600 kms between Diu and Kanyakumari. They lie close to the coast and hence the west coastal plain is only about 50 kms wide (the width increases towards the south). The Western Ghats north of Goa represent the plateau edges of the Deccan plateau and show the Ghat or *Trap* appearance. They are therefore made up of volcanic rocks. The Southern Western Ghats are made up of rounded hills of old igneous and metamorphic rocks and occur as the Nilgiri, Annamalai and Cardomom hills. These hills represent residual hills of the peninsular plateau. Unlike the northern W. Ghats, the Southern Western Ghats show a gentle relief. The Northern Western Ghats have some prominent peaks like Mahabaleshwar and Vavulmara. The Bhor Ghat and Thal Ghat passes are prominent breaks in the northern W. Ghats.

The Southern Western Ghats have some prominent peaks like Doddabetta (in Ooty hills of Nilgiris), Anaimudi Peak (in Annamalai hills), Brahmagiri and Kudremukh. The prominent breaks in the

Southern W. Ghats are Palghat Pass (between Annamalai and Nilgiri Hills) and the Shencottah Pass (between Annamalai and Cardomom hills).

The Eastern Ghats : The represent residual mountains and occur in the form of a series of discontinuous ranges / hills. The Eastern Ghats are made up of the very old igneous and metamorphic rocks that make up the peninsular plateau. Unlike the western ghats, the eastern ghats occur much in the interior and hence the east coastal plains are more wide. The E. Ghats extend for a length of 1100 kms between south of Chilka lake and Kanyakumari with an average elevation of 600 meters. The Eastern Ghats in A.P. occur as Nallamala ranges, in Tamil Nadu, they occur as Palani, Shevaroy and Javadi hills and in Orissa, they are called the Orissa hills. The tallest peak of the Eastern Ghats i.e., Mahendragiri peak occurs in the Eastern Ghats of Orissa. The Eastern and Western Ghats join in the Nilgiri Ranges.

10. HIMALAYAN AND PENINSULAR RIVERS

Himalayan rivers include the drainage basins of the Indus, Ganga and Brahmaputra. The Himalayan rivers originate in the snowfields and glaciers of the Himalayan ranges. They are perennial and have large basins and catchment areas. The Himalayan rivers are antecedent and are in their youthful stage and hence are actively eroding their valleys. Since they descend from great heights of the Himalayas, they create excellent heads for the generation of hydropower. These rivers have an extensive network of tributaries and show meandering courses in the Indo-Gangetic plains. They also shift their courses in the plains.

The peninsular rivers are born from natural springs and lakes of the hilly regions of peninsular India. Since they do not have sources in glacial fields and snow fields they are non-perennial. These rives have small basins and catchment areas and have cut their courses in hard rock strata. Their shallow and they have fewer tributaries. They show a superposed and a consequent drainage. The peninsular rivers are in their old age and hence their valley floors are almost at sea level. They descend from smaller heights and do not create many heads for hydropower generation. ∴ Only some of the peninsular rivers form deltas like Mahanadi, Godavari, and Cauvery.

11. THE MONSOONS OF INDIA

The monsoons are seasonal winds blowing over the Indian subcontinent. The monsoons comprise of the southwest or the summer monsoons blowing from June to September, the retreating monsoons blowing between September to December and the northeast monsoons blowing between December to February. The moonsoon winds show seasonal reversal of wind direction. The southwest monsoon is born due to the following factors.

1. **Shift in the Pressure belts of the world** : In the summer of the northern hemisphere, there is a global shift of pressure belts to the north. This leads to the northward migration of the Inter-Tropical Convergence Zone (i.e., the I.T.C.). As a result, the southeast trade winds, normally confined to the southern hemisphere, cross the equator (since they always blow towards the ITC) and approach the Indian landmass as southwesterly monsoon winds.

2. **The Monsoon Trough**: This is a well developed low pressure system stretching between Saudi Arabia and the coast of Orissa. This low pressure system which covers the northern Indian plains, is due to the intense summer heating of the landmasses of Asia and Arabia. The monsoon trough attracts the air from the Indian ocean as well as the southeast trade winds which have been modified into the southwesterly monsoons towards the northern plains. Thus the southwest or the summer monsoon is basically a modification of the southeast trade winds which have crossed the equator.

The Retreating Monsoons : The monsoon rains in summer cool the Indian landmass and hence air pressures over the northeern plains rise. However air pressure over the adjoining Indian Ocean is relatively low. This leads to the retreat of the monsoon winds which now blow from land to sea. The retreat begins on 1st

September in Rajasthan and is completed by 15th December. These monsoons bring some rain to parts of Rajasthan, the Andhra Coast and Tamil Nadu Coast.

The Northeast Monsoon: Beginning in December, the pressure belts of the world begin to shift southwards. As a result, the Indian landmass comes under the influence of the northeast trade winds which blow from northeast to southwest over India between December and February. These are called the northeast monsoons. They bring some rain to parts of the Tamil Nadu Coast and interior Kerala.

12. VARIABILITY OF RAINFALL IN INDIA

Around three fourths of the total annual rainfall in India is received during the summer monsoon season. Some regions of India receive rainfall during the retreating monsoon and northeast monsoon periods (like the Coromandel and Andhra coasts, interior Kerala and Tamil Nadu, parts of Punjab, Delhi, Haryana and Himachal Pradesh). Though the average monsoonal rainfall for India is anywhere between 88 cms to 100 cms, there is great spatial variability in the rainfall received in different parts of the country. The factors responsible for the spatial variability of rainfall in India are :

1. **Latitudinal Location** : Regions close to the Indian Ocean (including the Bay of Bengal and the Arabian sea) receive more rainfall since monsoon is an air current carrying moisture and hence the distant areas (like places in Jammu and Kashmir) far removed from the oceans receive lesser rainfall.

2. **Effect of Relief Features** : Spatial variability of rainfall is due to the profound effect of topography and relief. For example, Mumbai gets about 190 cms of rainfall during summer monsoon because of its windward location but Poona, which is just 160 kms away gets only 50 cms of rainfall because of its leeward location. Again, much of Rajasthan does not receive rainfall during the summer monsoon because the Aravalli Ranges are parallel to the southwest monsoon.

3. **Vagaries of the Monsoon** : Spatial variability of rainfall is also due to some characteristic of the monsoon winds themselves. These inherent characteristics include features such as late onset, early withdrawal and break monsoon conditions. For e.g., in some years, the monsoon does not advance according to the normal pattern and hence leads to variation in the amount of rainfall. For e.g., the monsoon current may reach the Punjab plains one week later than the normal onset date hence causing lesser rainfall. Similarly, the break monsoon conditions (i.e., the breaks in the spell of monsoonal rain) can cause variation in rainfall. In July and August, there are certain periods when monsoons become weak and rainfall ceases over the entire country outside the Himalayan region. This is known as the break in the monsoon.

4. **Role of Storms and other Weather Disturbances** : The east coast of India, the Middle and Lower Gangetic plains get heavy rainfall due to monsoon depressions which form in the Bay of Bengal between June and September. All these depressions enter the peninsular landmass along the deltas of Ganga, Mahanadi, Godavari and Krishna causing heavy rainfall. Cyclone activity in the Bay of Bengal in October and November also leads to heavy rainfall on the east coast. Weather disturbances originating in the Mediterranean (i.e., the Western Disturbances) bring rainfall to parts of Jammu and Kashmir, Himachal, Punjab, Haryana and Delhi in January and February.

13. WESTERN DISTURBANCES AFFECTING INDIA

Western Disturbances refer to the temperate cyclones that form in the Mid-latitudes and which in their course of travel to the east, reach the northern parts of the India. These cyclones originating in West Asia, the Mediterranean and sometimes even the Atlantic, reach the northern portions of India bringing winter rainfall to Punjab, Haryana, Chandigarh, Delhi, Himachal Pradesh and sometimes Rajasthan, and snowfall to Jammu and Kashmir. In the winter season, these cyclones move farthest to the south. By the time these western disturbances reach India, they are in the weakened stage and hence bring moderate rainfall/snowfall. Most of the western disturbances that affect India occur in the cool season (the retreating monsoon season). In the northeast monsoon season, most of the temperate cyclones do not pass over the subcontinent. However, some secondary temperate cyclones which form over the Nile Basin and the Red Sea move northeast and enter India.

14. TROPICAL CYCLONES OF INDIA

The tropical weather disturbances affecting India develop in three different periods i.e., the Southwest Monsoon period, the Retreating Monsoon Period and the Northeast Monsoon period. The weather disturbances that develop in the southwest monsoon season are the monsoon depressions. These form in the northern part of the Bay of Bengal. The rainfall of Bengal and Orissa and that of the northern Indian plains is to a large extent, determined by the frequency and intensity of these monsoon depressions. The tropical cyclones that develop in the Bay of Bengal form towards the open part of the Bay i.e., in a lower latitudinal belt. Nearly 50% of the tropical cyclones that develop in the Bay of Bengal actually develop in southwest Pacific and move west to reach the Bay. The tropical cyclones that form in the Bay of Bengal are maximum in the retreating monsoon season (the cool season). Around 55% of the storms of Bay of Bengal affect the Indian coast. Many cyclones that strike the Indian coast below 15^{0} north, move across the Peninsula and emerge into the Arabian sea. Here they reintensify into severe cyclones and strike Konkan, Gujarat and Malabar. Cyclonic activity in the Bay of Bengal is the least in the northeast monsoon season. These cyclones usually form in more southerly latitudes (i.e., between 5^{0} to 10^{0} North) and may strike the southern coast of Tamil Nadu. In general, it may be noted that more number of cyclones form in the Bay of Bengal than the Arabian sea. Of all the storms that develop in the Arabian sea, only 25% affect the Indian coast, with the rest moving west. It may also be noted that nearly 50% of the Arabian sea cyclones are storms of the Bay of Bengal i.e., they have developed out of the remnants of the Bay storms which have crossed over into the Arabian sea.

15. RAINFORESTS OF INDIA

Tropical rainforests of India have developed in areas receiving more than 100 cms of rainfall per year and where the yearly average temperature is between 25°C to 27° C. These regions have a short dry season. The tropical rainforests of India include:

1. **Tropical Evergreen Forests** - These have developed in regions with more than 250-300 cms of rainfall per year and constitute the typical rainforests. They are found in areas below a height of 900m on the windward slopes of W.Ghats, in Andaman and Nicobar and in Northeast India. The typical species are Rosewood, Ebony, Mahogony, Gurjan etc.

2. **The Tropical Semi-evergreen forests** - These have developed in regions getting rainfall between 250-200 cms per year. The forest is a mixture of evergreen and deciduous species. These occur in northern parts of W. Bengal, the Orissa Hills and parts of Andaman and Nicobar. Rosewood, Laurel are some species.

3. **Tropical moist deciduous forests** - These have developed in regions with 150-100 cms of rainfall. They occur in Northeast, eastern slopes of Himalayas and the Central plateaus.

4. **The Shola Forest** - This is a type of rainforest but is part of temperate broadleaf hill forest and is found in the Nilgiris.

16. VEGETATION OF HIMALAYAS

The Himalayan Vegetation shows vertical gradation of forest type due to vertical gradation in climate. In the eastern Himalayas, tropical evergreen and semi-evergreen forests occur upto 900 metrees. Between 900-1800 meters, the evergreen montanne forests with pine and oak dominate. Between 1800-2800 metres, the monsoon temperate forests of oak, chestnut and laurel are developed. Between 2800-4300 metres, the conifers with spruce, fir and other softwoods are developed. Above 4300 M, the alpine and arctic vegetation of grass and mosses and lichen are developed. The vegetation sequence in Western Himalayas is much the same except that the conifer zone starts at a much lower height.

17. SOILS OF INDIA

1. **Black Soils** : Derived from the basalts (the volcanic rocks) of the Deccan plateau. The black colour is due to the presence of titanium bearing iron and to a certain extent humus. Also called Regur soils, Black Cotton soils or Tropical Chernozem soils. The soils are **poor** in nitrogen, phosphorous but **rich** in humus, potassium, calcium, magnesium and lime. The soils are **fertile** because they contain water soluble salts and because they retain moisture. The **largest occurrence** of Black soils is in Maharashtra. They also occur in Malwa and Kathiawar. They soils of Bundhelkhand called **Mar** and those of lower Ganga basin called **Karail** are similar to black soils.

2. **Alluvial Soils** : The most dominant soils by volume. In the northern plains they show belts in the form of Bhabhar, Terai, Bangar and Khadar. They do not show any horizons and have a loamy texture. Poor in humus, nitrogen and phosphorous but rich in Potassium. Their fertility is due to **diversity of mineral species** within them and due to the rich subsurface water resources. **Usar soils are alluvial soils of Punjab with high concentration of sodium salts.**

3. **Red Soils :** These are made up of Red and Yellow soils. They have been developed from the very old **granitic** rocks of Peninsular India. They red colour is due to iron oxides. The yellow soils have a coating of **hydrated oxide of iron** which is yellow in colour. The Red soils are poor in nitrogen, phosphorous, humus and lime (calcium oxide) but are **rich** in iron and potassium. They red soils are the most widespread in Tamil Nadu and occur throughout peninsular India wherever the granitic rocks occur. They also occur in Shillong Plateau. In Telangana, the red soils are called **Chalkas**. The red soils are the **most widely** distributed soils of India.

4. **The Lateritic Soils** : These occur as **cappings** on hill tops/ plateau tops. They have developed due to intense chemical weathering of rocks (i.e., intense leaching) and hence have only iron and aluminium oxides (because every other element has been leached away). They show a **honey-comb** structure. They are very infertile. They are clayey and show a lumpy appearance. These soils are residual.

5. **The Desert Soils** : The desert soils of Rajasthan represent the sands of the continental shelf of the Arabian sea. They are light coloured and have a high percentage of water soluble salts. They are poor in nitrogen, humus and clay. They are rich in phosphorous, potassium, calcium and sodium. The desert soils of Thar are very rich in phosphates.

6. **Peaty and Organic Soils** : These have formed in situ under humid climate and poor drainage. These soils are acidic. Organic matter may make-up 40% to 50% of the soil. The peaty saline soils of **Kerala** are called **Kari**.

18. IRRIGATION

About 75% of the rainfall in India is by the southwest monsoons which bring rainfall for only three to four months in a year. It is also a fact that only 30% of the cultivated area receives 75 to 100 cm of annual rainfall. Hence around two-thirds of the cropped area needs irrigation to support agriculture. The need for irrigation in more specific terms is brought out by certain facts. These are a) about one-third of India's land area is drought-prone b) rainfall is unevenly distributed across different regions. c) Peninsular India's rivers are not only seasonal but also have uncertain flows during different periods d) Irrigation is necessary to increase productivity of dryland agricultural regions and e) Irrigation makes possible the application of modern inputs.

Irrigation potential of India is reasonably large due to the presence of perennial rivers in the northern plains, the rich reserves of underground water in some regions, the large volumes of water seasonally carried by the peninsular rivers and the abundant monsoon rainfall that India receives. In fact, many rivers of India carry large volumes of utilizable flows.

19. AGRICULTURAL SEASONS AND CROPPING PATTERN OF INDIA

Agricultural Seasons : The cropping pattern of India falls within three agricultural seasons- the kharif, the rabi and the zaid. Kharif season is agriculturally the most important because almost the entire arable land comes under crops. It starts with the onset of the southwest monsoon and continues till winter. Rice, maize, bajra, cotton, groundnut and some pulses crops dominate the kharif season. The rabi season starts in October or November and continues either till the end of winter or the beginning of summer in March. The rabi crops are mostly raised under irrigated conditions. The major crops are wheat, barley, jowar and some oilseeds like rapeseed mustard. Zaid is a short cropping season where crops are sown in summer and harvested in the rainy season. The important crops are fooder crops, fruits and vegetables and some rice, maize, groundnut and pulses.

Cropping Pattern : India's cropping pattern is dominated by foodcrops due to the huge population. The net sown area of India is 46% of the total land. The area under foodgrains is largest in UP followed by MP, Rajasthan and Maharashtra. The area under non-food crops is largest in Maharashtra followed by MP, AP and Gujarat. In the cropping pattern for food crops, rice dominates with around 24% of the gross cropped area devoted to it. The largest rice acreage is in U.P., W.Bengal, Bihar and M.P. Wheat is the dominant rabi food crop. The largest area under wheat is in U.P. followed by M.P., Punjab, and Rajasthan. The most important coarse cereals are jowar, bajra, maize and ragi and most of them are kharif. Jowar occupies the greatest area in coarse cereals and is a rabi crop. Most area under jowar is in Maharashtra. After jowar, bajra occupies the second largest area in coarse cereals. Rajasthan followed by Maharashtra have the largest areas under bajra.

Pulses account for 18% of India's cropped area and chick pea and pigeon pea account for half of pulses output. The leading growers of pulses are M.P., Maharashtra, Rajasthan and U.P. Oilseeds are raised in India as both kharif and rabi crops and oilseeds account for 13% of cropped area. Gujarat leads in Kharif oilseed output while U.P. leads in rabi oilseed output.

The most important cash crops dominating India's cropping pattern are cotton, sugarcane, jute, coffee and tea. Sugarcane is a kharif crop and the maximum area under cane is in U.P. India has the largest area under cotton and it is raised as a kharif crop.

Maharashtra has the largest area under cotton. India has the largest area under jute and is also the largest producer. The jute area is principally in W. Bengal. India is the largest producer of tea and the maximum area under tea plantation is in Assam. India is an important producer of coffee and nearly 75% of coffee area is in Karnataka.

20. CAUSES OF LOW AGRICULTURAL PRODUCTIVITY IN INDIA

Agricultural productivity is simply the output per unit area of land. Indian productivity is 2/3rd of world average productivity and about 60% of the productive potential in the farm sector is unutilised.

Causes for low agricultural productivity in India :

a) High pressure of population on land. Excess pressure results in disproportionate utilisation of land along with an unsatisfactory system of crop rotation and inadequate land reclamation.

b) **Institutional Factors :**

1] **Size of holdings** : The average size of holding in India is between 2 to 5 acres. Fragmented holdings impede the application of scientific cultivation and improved implements.

2] **Defective land tenure**: Inspite of abolition of intermediaries and tenancy reforms, the position of the tenants is precarious without any security of tenure hence their motivational levels are low.

c) **Technological Factors :**

1) **Inadequate irrigation facilities**: The net irrigated area as a percent of net sown area is 42% for all India as a whole. Lack of irrigation exposes India's agriculture to the vagaries of the monsoon and also does not permit application of modern inputs.

2) **Poor Techniques of Production**: The fertilizer and manure use intensity is quite low and the use of pesticides is also low. There is sub-optimal use of manure. Bad storage and poor post-harvest technology compounds the problem.

3] **Inadequate non-farm services**: Non-farm services like marketing, finance, transport are inadequate leading to rural indebtedness and distress sales. Inadequate development of the co-operative movement and inadequate storage facilities are other problems.

4] **Low output of farm research**: The farm research in India has only reached general conclusions. There is very poor transfer from lab to land and extension is confined to individual appropriate practices but no complete farming pattern has been evolved.

d) **Environmental factors :**

1. **Soil Degradation** : 50% of land area is affected by soil erosion and about 21% of land area is under severe stage of degradation. About 30 million hectare are affected by floods and 68 million hectares are affected by drought. All these have reduced the agricultural potential of Indian soils.

21. THE GREEN REVOLUTION IN INDIA

The phrase Green Revolution is used to denote the sharp increase in the output of foodgrains in India after the mid – 60's due to the implementation of a package of agricultural practices, use of modern technological inputs, along with provision of infrastructural and institutional support. The Green Revolution in India began with the implementation of the Intensive Agriculture Development Programme (IADP) in 1961 as a pilot project in 7 districts in 7 states. Due to its success, it was extended to other parts of the country. The main components of the IADP and hence the Green Revolution were use of HYV, artificial irrigation, intense use of chemicals as technological inputs, land reforms, agricultural R and D as institutional inputs and appropriate cropping pattern, scientific land, soil and water management practices, development of rural infrastructure in the form of rural roads, rural electricity and agricultural credit as infrastructural inputs.

The Green Revolution succeeded in increasing the output of foodgrains and also modernization of agriculture in regions with irrigation facilities. The most important food crops that benefited because of the green revolution were wheat, rice, bajra and the most important non-food crops which benefited due to it were sugarcane and cotton. The Green Revolution made India self-reliant in food grains and also sharply increased the value of India's agricultural economy. However, it also led to certain undersirable consequences in the form of imbalances in foodgrain agriculture, accentuation of regional disparities and ecological imbalances due to the intensive agricultural practices (which include intense irrigation, intense use of chemicals large scale use of HYV and so on).

22. JHUM CULTIVATION IN INDIA

Jhum cultivation refers to shifting cultivation. This is practiced by the primitive tribes of the hilly forested regions in the tropical regions of India. The tribes create agricultural land by clearing forests after felling the trees and burning the stumps. The arable land so created is cultivated for two to three years and abandoned for around 10-15 years due to decreased soil fertility. Jhum cultivation is characterised by primitive methods and there is complete absence of modern inputs. The main crops that are raised in the Jhum cultivated regions of India are dry paddy, maize, buck wheat, small millets and sometimes tobacco. Jhum cultivation occupies an area of nearly 5.5 m.ha. Jhum or shifting cultivation is known by different names in different regions of India like Jhum in northeast, Bewar in M.P. and Chhattisgarh, Podu in A.P., Ponam in Kerala and so on. It is widely practiced by the Garos, Nagas, Gonds, the Kurumbas, the Gerasias and other tribes on India.

23. DRYLAND AGRICULTURE

Of the total agricultural area of 162 million hectares (m.ha), Drylands occupy 105 m.ha, Dry farming zones are regions receiving annual rainfall ranging from 375 mm to 1125 mm. Drylands are therefore environments with a significant permanent, seasonal or periodic shortage of water. These drylands include the semi-arid regions of peninsular India and the hyper-arid regions of the northwest i.e., in Gujarat and Rajasthan. Dry farming refers to either crop production based entirely on rain water received during the crop growing season or crop production based on conserved soil moisture in areas of low rainfall. Agriculture in drylands is adversely affected by: inadequate and often erratic rainfall, soils of dryzones suffer from varying degrees of soil erosion and soil salinisation; fragmented agricultural holding; low socio-economic status of the farming communities and lack of adequate crop varieties suited to the agro-climatic conditions of these regions. The drylands account for nearly 42% of India's foodgrain output, around 10% of India's GDP and nearly 42% of India's population derives livelihood from these areas. The drylands account for 73% of all crops on the basis of the percentage of area under rainfed farming. Specifically, they account for nearly 60% of paddy area, more than 90% of the area under pulses, around 70% of area under cotton and around 90% of area under groundnut.

24. FISHERIES DEVELOPMENT

India is one of the 10 largest fishery countries in the world. Today half each of India fish output comes from marine and inland sectors. India has enormous fishery potential in both offshore and inland sectors. Marine fishery potential is around 20 to 25 million tonnes. This potential lies in the 6.68 lakh square kms of continental shelf area including the shelf area in India's EEZ, the 20.2 lakh square km area under India's EEZ and a 7500 km coastline. Within the marine sector, the inshore sector i.e., upto 8 kms from the coast, has 10 times more potential than the offshore sector. In the offshore sector, the Indian ocean is considered to be very rich in pelagic species like mackeral, sardine, tuna and others. In the offshore areas, the deep sea fishery potential mainly includes the demersals which live on the sea-floor. These include the crustaceans. The freshwater fishery potential of India is in the length of fishable orivers (which is 27,389 kms), the irrigation canals with a total length of 1,12,654 km, a 2.9 m.ha. area of reservoir / lakes and about 2.6 m.ha. of brackish water area. The fifth and sixth 5-year plans launched programmes for development of inland fisheries. These are Fish Farmer Development Agencies (FDDA) and National Programme for Fish Seed Development (

NPFSD). Around 5 lakh hectares have been brought under fish culture through the efforts of FFDDA. Many fish seed hatcheries have been set up under NPFSD. To promote marine fisheries, efforts include the setting up of 5 major fishing ports (Vizag, Kochi, Chennai, Roychowk, Paradwip and Sassoon Dock at Mumbai), setting up Brackish Water Fish Farmers Development Agencies and assistance to fishermen to motorise their craft.

25. DAIRY DEVELOPMENT

Efforts to develop the dairy sector in India began with the launch of the Anand Model in Gujarat. The Anand Model basically organized the milk producers into cooperatives and also included an efficient system of transport of milk and its supply to urban centres. Encouraged by the success of the Anand Model, India launched Operation Flood-I in 1970-71 under which a National Dairy Development Programme was launched in 10 states and milk supply to the four metros of Mumbai, Kolkata, Chennai and Delhi. Due to the huge success of Operation Flood-I, India launched Operation Flood-II in 1978 which aimed at organizing milk marketing in 144 cities other than the four metros and other features such as improvement of breeds, improving fodder supply to milch cattle and so on. Operation Flood-III was launched in 1987 with assistance from the World Bank and the E.U. Its immediate aim was to set up 170 milk centres to benefit 250 districts in 22 states. As a result of these programmes under operation Flood, milk production in India went up from 21 million tones before operation Flood-I to around 110 m.t. today. It also raised the per capita availability of milk in India. In addition, it has led to organization of nearly 8.4 million farmers into 65,000 dairy cooperatives. As more than 62% of the milk procurement under Operation Flood comes from marginal, small and landless, it has raised their incomes.

26. AGRO-CLIMATIC PLANNING

Agro-climate planning refers to planning based on the harmonious correlation between climatic factors and agricultural practices for the scientific utilisation of all available resources (natural and man-made) to boost produciton, income, employment and to reduce the imbalances in agricultural growth. The objectives of agro-climatic planning are : 1. Optimal utilisation of land and water sources 2. To bring down unemployment and poverty by suitable agricultural and livestock strategies. 3. To improve the income of farmers 4. Increase agricultural productivity 5. Preserve the eco-system

Strategy: The country is divided into several agro-climatic zones delineated on the basis of climatic factors, soil type, water resources besides taking into account demographic factors (like pressure of population on arable land), land and livestock resources, crop production and productivity, input use and environmental factors. After studying all these factors i.e. the assets and limitations in each region, appropriate agricultural and livestock strategies are formulated for the optimal utilisation of land, water, livestock and human resources in each region.

Measures Taken : 1. The country has been divided into 15 Agro-climatic regions based on soil type, rainfall, temperature characteristics etc. 2. An Agro-climatic Atlas for the entire country has been published in 1975. 3. Zonal planning teams have been set up for each region. 4. An Agro-climatic classification for regional crop planning has been made.

27. AGRO - METEOROLOGY

Agro-meteorology is an applied science blending problems of agriculture with meteorology. More specifically, it deals with the qualitative and quantitative relationships between weather conditions and agricultural operations.

The Need For Agro-Meteorology : 1. Weather conditions play an important role in affecting crop production. In fact, 50 per cent of variations in yield from year to year are due to climatic factors. 2. Weather-based agro-meteorological practices help in : selecting efficient crops for a region; appropriate schedules of sowing seeds and application of fertilisers; application of chemical inputs/sprays and irrigation inputs and appropriate harvesting and post-harvest operations. 3. The existing forecast system of 24 to 48 hours does not help farmers to take adequate steps for contingent action. 4. The present agro-advisory forecasts are for broad areas and of a general nature and hence do not indicate the steps the farmers should take in a specific place. 5. Agro-meteorology is also useful since it studies crop destructive meteorological phenomena like effects of drought, floods, dust storms on crop quality and yield.

Components of Services Provided Under Agro-meteorology : 1. Agro-meteorological information for crop planning. 2. Agro-meteorological forecasts with advisories for farming operations. 3. Demonstrating the usefulness of weather information for farming practices. 4. Carrying out R and D to understand crop-weather relationship.

Efforts made in India : 1. 131 Agro-meteorological observatories have been set up all over the country. 2. Around 17 Agro-meteorological services are operational in various states. 3. All-India Co-ordinated Project on Agro-meteorology has been launched in 1983 at the Central Institute for Dryland Agriculture (CRIDA), Hyderabad, with co-ordinating centres in Indian Agricultural Research Institute (IARI), New Delhi, Central Arid Zone Research Institute (CZARI) Jodhpur and North East Hill Complex, Shillong. 4. Training facilities at post-graduate level have been created in Punjab Agricultural University (Ludhiana), Haryana Agricultural University (Hissar), Gujarat Agricultural University (Anand) and Mahatma Phule Krishi Vidyapeeth (Pune).

28. OIL AND GAS RESOURCES OF INDIA

The oil and gas resources of India are confined to the sedimentary rocks belonging to mesozoic and cenozoic eras. A major part of peninsular India is considered to be geologically unfavourable for the occurrence of petroleum oil and natural gas since it is made up of very old igneous and metamorphic rocks. The total sedimentary cover of India distributed across 27 sedimentary basins is 1.72

million square kms. These sedimentary basins include offshore mesozoic and cenozoic rocks with an area of 2.5 lakh sq kms upto a depth of 100 metres and 0.7 lakh square kms between 100-200 metres. The sedimentary basins of India have prognosticated reserves of 21 billion tonnes of oil and oil equivalent of gas. Around 60% of these reserves are in the offshore areas. About half of this reserve is in Bombay High, the Cambay basin (offshore and onshore, Gujarat) and in Assam including other areas of the northeast. The promising areas with large potential are the deltaic areas (both offshore and onshore) of Krishna-Godavari, Mahanadi, and Cauvery, the Andaman sea, the Gulf of Mannar, the Ganga delta, the Thar desert and the valleys of Himachal.

29. COAL RESOURCES OF INDIA

India ranks 6th in the world reserve of coal. Coal reserves of India include the bituminous coal and lignite deposits. Much of India's bituminous coal occurs in the Gondwana rock formations which belong to the Paleozoic and Mesozoic eras. In fact, 80 coalfields of the 113 major coalfields of India belong to the Gondwana coal. The recoverable reserves of coal in India are around 52 billion tonnes (b.t.) of the total reserve of 248 b.t. The states with the largest reserves of coal are Jharkhand followed by Orissa, Chhattisgarh, W. Bengal. And M.P. Coalfields occur in the Damodar valley of Jharkhand (Giridih, Jharia, Bokaro, Karanpura) and W. Bengal (Ranigung coalfields), the Mahanadi valley coalfields of Orissa (Talcher and Sambalpur), Chhattisgarh (Korba coalfields) and M.P. (Sonepat), the Son valley coalfields of M.P. (Singrauli), Chhattisgarh (Sohagpur) and Jharkhand (Daltongung and Huttar), and the Godavari Valley coalfields of A.P. (Singareni fields) and Maharashtra (Kamptee and Ballarshah).

In India Lignite deposits occur in younger rock formations of Tertiary period. The largest reserves are in Tamil Nadu (Neyveli) followed by Gujarat (Kutch and Bharuch) and Rajasthan (Palana in Bikanner).

30. GEMSTONE DEPOSITS OF INDIA

Gemstone deposits of India include diamonds, sapphires and rubies, and emeralds. The diamond deposits of India occur in the Kimberlitic rocks. The main reserves are in Majhgawan (Panna in M.P.), Raipur in Chhattisgarh and Vajrakarur in Anantapur, in A.P., Sapphires and rubies mainly occur in Madurai (T. Nadu), Hassan (Karnataka) and Kishtawar (J&K). Emerald deposits mainly occur in Ajmer and Udaipur (Rajasthan) and Kulu in Himachal.

31. ATOMIC MINERALS OF INDIA

The nuclear or the atomic minerals of India are Monazite, Uraninite, Pitchblende, Zircon, Ilmenite and Thorianite. The Black sands of Malabar contain large reserves of monazite, Zircon and Ilmenite. Large deposits of Pitcblende occur in Singhbhum district of Jharkhand (in Jaduguda, Dhantupa and Narwa Pahar). The Black sands of the east coast off Vishakapatanam contain Ilmenite, monazite and zircon. Uraninite deposits occur in Jhunjhunu, Udaipur and Alwar districts of Rajasthan. Mineral monazite occurs in Gaya in Bihar and also in the Black sands off the coast of Orissa in Ganjam and Cuttack.

32. MAJOR PORTS OF INDIA

The major ports of India have been guided in their location by a series of factors like availability of natural harbours, strategic value of a site, proximity to international sea routes, the need to decongest some ports and so on. On the eve of planning, there were 5 major ports handling around 19 m.t. of cargo. These have risen to 12 major ports landling close to 550 m.t. of cargo. The major ports of India handle 95% of India's trade by volume and around 40% by value. These ports are fundamental in India's foreign trade for export and import of bulk and heavy commodities and sustain a large number of industrial, infrastructural and mining sectors which are involved in these sectors. They directly sustain India's shipping industry and also provide direct employment to around one lakh forty thousand people besides providing indirect employment to workers in infrastructure, industry and mining which are linked to India's foreign trade. They serve large hinterlands along the west and the east coasts and also contribute significantly to the non-tax revenue of the centre.

33. INLAND WATER TRANSPORT

India has 14,352 kms of navigable waterways, of which only 5200 km are navigable by mechanised craft. The potential for inland water transport is in the navigable stretches of the Himalayan rivers in the Indo-Gangetic plains with the intense industrial and agricultural activity. Most peninsular rivers are also navigable in their lower reaches. The potential is also present in the long network of canals for irrigation, with their total length of 1,12,654 kms. In addition, the backwaters of Kerala are also navigable. The inland water transport sector with its advantage of being cost-effective over the road and rail sectors, can be developed if appropriate steps are taken. These would be dredging the river channels and canals, developing navigational aids along them and promoting industrialisation near these waterways. Efforts to develop the inland water transport sector began in 1952 with the establishment of the Ganga Water Transport Board for promoting water transport along Ganga. A Directorate of Inland Water Transport under the Ministry of Surface Transport was set up in 1967 to supervise all matters pertaining to inland water transport. The National Waterways Act was enacted in 1982 to develop national waterways under which three waterways i.e., Allahabad - Haldia, Sadia-Dhubri and Kothapuram-Kollam have been declared as National Waterways. The Inland Waterways Authority was set up in 1986 as the apex administrative agency to oversee all matters pertaining to national waterways.

34. RACIAL GROUPS OF INDIA

The people of India belong to the following racial groups:

A) Negritos : The Negritos are characterized by short stature, dark skin, woolly hair, a bulbuous forehead and slightly protruding jaws. The Negritos were the first to arrive in India. The Negritos are represented by the people of Andaman and Nicobar, the Uralis of Nilgiris, the Badgis of the Rajmahal hills in Jharkhand and so on.

B) The Proto-Australoids : This racial stock followed the Negritos into India. Their physical appearance is close to that of the Negritos but they do not have woolly hair. Today they constitute the bulk of population in many isolated and semi-isolated parts of central and southern India. The Irulas, the Veddahs and the Malavedahs of S. India are the true representatives of this race. However, the Bhils, the Kols, the Mundas of central India and the Chenchus and Kurumbas of S. India may be taken to represent the proto-Australoids.

C) The Mongoloids : The people of this race have a round and a broad head, high check bones, a hairless skin and a long flat nose. The mongoloids of India belong to the a) Paleo – Mongoloids who are represented by the tribes of Himalayan fringes in Assam and Myanmar border and b) The Tibeto-Mongoloids who are represented by the people of Sikkim, Ladakh and Baltistan.

D) The mediterraneans : These people are of medium stature, a dark skin and a long head. The Paleo-mediterraneans, a sub-type of this race, constitute a bulk of India's population in the north and the south.

E) The Brachycephals: They have broad heads and came from Central Asia. The Brachycephals are made up of the Alpinoids, the Dinarics and the Armenoids. They are represented by the Coorgis and the Parsis.

F) The Nordics : These were the last to come to India. These are the Indo-Aryans with long head, fair skin, a strong and well built body. They are represented by the people of Punjab, Haryana and Rajasthan.

35.THE LANGUAGES OF INDIA

The languages of India fall into the following categories :

A) **The Indo-European Family** - These are the Aryan languages. About 73% of the Indian population speak the languages of the Aryan family. The Aryan languages are sub-divided into Dardic Aryan and Indo-Aryan languages. The Dardic Aryan languages are spoken by some mountain communities of Kashmir and include languages like Shina, Kashmiri and Kohistani. The Indo Aryan languages include Bengali, Punjabi, Hindi, Rajasthani, Gujarati, Sindi, Marathi, Oriya Sanskrit, Assamese and Urdu.

B) **The Dravidian languages -** These are older than the Aryan languages and include: a) North Dravidian languages like Telugu, and dialects like Gondi, Oraon, Parji, Kolami and others b) The South Dravidian languages which include Tamil, Malayalam, and Kannada.

C) **The Austric languages of India** are subdivided into a) Munda (or Kol) which are the largest of the Austric group and principally include tribal languages like the Kherwari group which includes Santhali, Mundari, Korwa and others and b) the Mon-Khmer languages which includes Khasi and Nicobarese.

D) **The Sino-Tibetan languages of India** include the Tibeto-Himalayan group which includes Chamba, Kannauri, Bhatia group (Balti, Ladakhi and others), the North Assam languages (like Aka, Daffla, Miri, Mishing and others) and the Assam – Myanmari languages (which include Bodo, Naga, Manipuri, Garo and others).

36. DEMOGRAPHY OF RELIGION

The Hindus account for 81.4% of India's population according to the 2001 census. They constitute the majority community in most states and union territories except in Jammu and Kahsmir, Punjab, Meghalaya, Mizoram, Nagaland and Lakshadweep. Hindus account for 95.4% of the population in Himachal, 94.7% in Chhattisgarh, 94.4% in Orissa and 91.1% in M.P. In terms of absolute size, UP has the largest number of Hindus followed by Maharashtra, Bihar and A.P. 9 states of India (including the 4 above and Tamil Nadu, Rajasthan, Karnataka, W.Bengal and MP) account for three-fourths of the Hindu population. The Muslims, the second largest religious community and the largest minority community of India, account for 12.4% of India's population according to the 2001 census. Spatially, pockets of Muslim concentration are the Kashmir valley, Malappuram in Kerala, the Rohilkhand region of U.P., Upper Ganga Plain of Uttarkhand and Lakshadweep. Jammu and Kashmir has 67% of its population as Muslim, followed by Assam (31%), W. Bengal (25.2%) and Kerala (24.7%). In terms of absolute size, Muslim population is the largest in U.P. followed by W.Bengal, Bihar and Maharashtra. The Christians account for 2.3% of India's population according to the 2001 census. The Northeast is a major region with high concentration of Christians. Christians account for 90% of the population in Nagaland followed by Mizoram (87%) Meghalaya (70.3%) and Manipur (34%). Christian population is also large in Kerala (19%) of its population) and Goa (26.7% of its population). Kerala has the largest size of Christian population with high concentration in Kottayam and Ernakulam. After Kerala, Christian population is largest in Tamil Nadu, Arunachal Pradesh and Meghalaya. The Sikhs constitute 1.9% of the total population according to the 2001 census. The areas with large concentration of Sikhs are Punjab, Haryana, Delhi, the Terai of Uttarkhand and Alwar and Ganganagar in Rajasthan. Sikh population as a percent of state population is highest in Punjab followed by Haryana, Uttaranchal and Jammu and Kashmir. Buddhists constitute 0.8% of India's population according to the 2001 census. Maharashtra has the largest Buddhist population (around 73% of India's Buddhist population). Buddhist population as a percent of state population is highest in Sikkim followed by Arunachal, Maharashtra and Himachal Pradesh. Spatially pockets of concentration of Buddhists are in Ladakh, Arunachal, Himachal, Maharashtra and Karnataka. Jain population constitutes 0.4% of India's population according to the 2001 census. Spatially Jain population shows high concentration in western India i.e., in M.P., Rajasthan, Maharashtra, Gujarat and U.P.

Jain population as a percent of state population is highest in Maharashtra followed by Rajasthan, Gujarat and M.P.

37. DEMOGRAPHY OF TRIBAL POPULATION

The spatial distribution of tribal population in India shows a striking tendency of clustering and concentration in pockets. This is primarily because of isolation and due to the dependence of the tribes on forests. The ST's account for 8.2% of India's population according to the 2001 census. According to the 2001 census, 94.5% of the total population is tribal in Mizoram and Lakshadweep, followed by Nagaland (89.1%), Meghalaya (85.9%) and Arunachal Pradesh (64.2%). In terms of absolute size, the largest number of ST's are in M.P., followed by Maharashtra, Orissa and Gujarat. Among the 15 major states of India, ST population as a percent of state population is highest in Orissa, followed by M.P., Gujarat and Rajasthan. If all the states are taken together, the ST population as a percent of state population is highest in Mizoram, followed by Nagaland, Meghalaya and Manipur. About one third of ST population of India lives in the three states of M.P., Maharashtra and Orissa. Around 57 districts of India (about 10% of the total districts) have more than 60% of their population as tribal. These districts lie in the Northeastern states, in the border between Rajasthan, Gujarat and M.P., in the Chotanagpur plateau, in parts of Himachal, Jammu and Kashmir and Chhattisgarh. Thus the spatial distribution of tribal population shows a high concentration in the Northeast, the central Indian Highlands between Aravallis, the Vindhyans and the Sahyadris and the belt between the Orissa hills and Chotanagpur plateau.

38. DEMOGRAPHY OF SCHEDULED CASTE POPULATION

The scheduled castes numbering around 542, constitute 16.2% of India's population according to the 2001 census. Unlike the ST's who have a tendency to concentrate in the remote and hilly areas, the SC's do not show this tendency for clustering. The SC population shows a very high concentration in the Indo-Gangetic plains and the coastal plains. According to the 2001 census, UP has the largest number of SC's followed by W.Bengal, Bihar and A.P. The two states of U.P. and W. Bengal alone account for nearly one-third of India's SC population. SC population as a percent of state population is highest in Punjab followed by Himachal W. Bengal and U.P. About 13 states and union territories of India have 15 to 20% of their population as SC. It may also be noted that around 61 districts of India (i.e., over 10% of the total districts) have over one fourth of their total population as SC's. Most of these districts are in the northern plains of India.

39.FLOODS IN INDIA

Floods occur when the capacity of a river channel is exceeded. Floods bring about increased discharges, high average velocities, high sediment discharges, inundation of floodplains, erosion of river channel and damage to farm land / property.

Causes of Floods in India: 1) Heavy precipitation, often exceeding 15 Cms day, causing flash floods and heavy concentration of silt. 2) Cyclones and depressions in the Bay of Bengal lead to strong winds and often widespread rainfall. The damage is caused by both gusty winds and floods. These are typical to coastal areas of A.P., Orissa, W. Bengal and Tamil Nadu. 3) Siltation of river beds and hence spilling of rivers over river banks. 4) Inadequate drainage arrangements to tackle excess discharges of water. 5) Indiscriminate deforestation in the catchments areas in upper reaches of river basins – especially in the Siwalik basin, Assam Himalayas and Chotanagpur plateau. 6) Jhum cultivation in the Northeast leading to deforestation and flooding in Brahmaputra plains. 7) Obstruction of free drainage due to developmental projects like dams and hydel power projects.

Flood Prone Zones in India: Almost all the rivers in India cause floods in one or more of their lower reaches. Areas which are subjected to severe floods are in the Northern Plains of India. In general, the major groups of regions that are recognized are: 1) River basin areas of Ganga – Indus and Brahmaputra and their tributaries. 2) River basins of the Northwest covering parts of Punjab, Western U.P., Haryana where the Jhelum, Sutlej, Ravi, Beas and Chenab flow. 3) East coastal tracts are exposed to floods due to cyclones depressions. 4) Peninsular river basins covering parts of Maharastra, Orissa, A.P., M.P. where Narmada, Tapti, Godavari and Cauvery flow. 5) Windward slope regions of Gujarat plains and Konkan plains.

National Flood Control Policy (1954): This policy suggested short-term measures to tackle the flood problem. **A) Short-term measures:** Include improvement of surface drainage, establishment of proper flood warning systems, shifting or raising of villages over flood-level, building, channel diversions and construction of raised platforms. **B) Long-term measures:** Include construction of dams or storage reservoirs for flood protection and soil conservation in catchment areas of various rivers, building detention basins and digging larger channel diversions.

40 .DROUGHT IN INDIA

Droughts are basically related to weather conditions but their affects can be intensified due to some socio-economic factors. Meteorological drought is related to deficiency of rainfall. Hydrological drought is related to water flows into rivers, lakes, ponds, tanks, wells etc. Agricultural drought is related to weather, soil, crop and cropping pattern and management practices. Meteorological and agricultural droughts are related to on-site weather conditions that affect rainfed farming while hydrological drought also includes the weather conditions in catchment areas.

Causes of Drought in India: 1) Variability of annual rainfall. Areas of medium and low rainfall have high rainfall variabilities leading to crop failures and drought. 2) Delay in onset of monsoon and early withdrawal of monsoon may lead to failure of crops / reduced yields. 3) Breaks in monsoon – long breaks in monsoon rains causes considerable damage to standing crops. 4) Areal differences in persistence of monsoon leads to disturbance of agricultural practices / crop failures. 5) Inadequate irrigation facilities in dryland regions leads to rain water going waste and drought. 6) Inadequacies in farm practices like faulty cropping pattern, lack of soil/water conservation, poor management of traditional resources of irrigation (like tanks, ponds, wells), neglect of water-harvesting structures etc. 7) Environmental factors such as soil erosion, soil salinity / alkalinity (due to canal irrigation) deforestation of catchment areas etc.

Drought Prone Regions of India: One-third of India's geographic area is vulnerable to drought. These areas receive rainfall of less than 60 cms per year and they also do not have adequate irrigation facilities. The main drought-prone regions of India are: 1) Low rainfall regions on the lee side of W. Ghats getting less than 60 cms of rainfall. The region stretches in a north-south fashion covering parts of Maharashtra, Karnataka and A.P. 2) Arid and semi-arid regions in northwest parts of India covering most parts of Rajasthan, Gujarat (especially Saurashtra region) and parts of adjoining states. 3) Isolated areas such as southern districts of Tamil Nadu, southwestern districts of U.P. (like Varanasi), the rain shadow regions of Palamu and Singhbhum districts of Jharkhand, rain shadow/low rainfall regions of South Chotanagpur plateau and Keonjhar, Phulbani, Kalahandi, Bolangir and Koraput districts of Orissa.

41. DESERTIFICATION IN INDIA

As per the UNEP, land degradation in arid, semi-arid and dry sub-humid areas resulting from adverse effects of human impact is termed desertification. The march of the sand dunes is only a small part of desertification. In India, the arid zone of the dryland regions making up more than 100 million hectares including the truly arid zones (like the Thar Desert) are exposed to the problem of desertification. The truly arid zones like the Thar account for 12% of India's total land area.

Causes: 1) Climatic: The climatic factors give birth to the truly arid zones like the Thar. These zones are located within the sub-tropical belts of high pressure on western margins of continents where warm/dry offshore winds blow throughout the year bringing no rainfall. 2) Topographic factors: The lee regions of mountainous areas get scanty rainfall and are perennially drought prone like the lee regions of W. Ghats in Karnataka and Telangana in A.P. 3) Lack of orographic barriers to cause rainfall like the Aravallis which lie parallel to South-West monsoon currents. 4) Siltation due to flooding leading to soil erosion. 5) Mining / quarrying as in Aravallis, Kumaon/Garhwal (Uttarakhand) and limestone quarrying in Himalayan foot hills. 6) Deforestation due to expansion of urban areas and building of developmental projects, jhum cultivation and indiscriminate tree felling by timber mafias lead to march of sand dunes. 7) Overgrazing in fragile eco-systems leading to intensification of arid formation. India has the world's larges livestock population but has only 13 million hectares of pasture land i.e., about 4% of total land area leading to overgrazing and land degradation. For e.g., the Thar region supports a huge cattle population leading to high pressure on grazing land which is the primary factor for speeding up of aridification of Thar.

Steps Taken : 1) Afforestation programme including social forestry. 2) Desert Development Programme launched in 1977-78 which includes measures to halt march of deserts, restore ecological balance in desert/arid regions, pasture development and development of land/water resources in these regions. The DDP covers 3.62 lakh square kms. 3) Drought Prone Areas Programme was launched in 1973 as a long term integrated area development programme for restoration land/water/livestock/human resources. 4) A Wasteland Development Programme was launched in 1985

42. WASTELANDS IN INDIA

Wastelands Defined : All vacant lands lying unused for having become unproductive as a result of topsoil erosion due to causes like soil erosion, deforestation and development of soil toxicity are referred to as wastelands.

Extent of Wasteland in India: About 130 million hectares (m.ha.) in India's total land area of 329 m.ha. is classified as wasteland. This also includes 94 m.ha. of non-forest wasteland. Of the 94 m.ha. of non-forest wasteland, nearly 74 m.ha. have been rendered waste due to water and wind erosion, and spread of saline/alkaline soils. Statewise, Rajasthan leads with maximum area as wasteland followed by Madhya Pradesh and Maharashtra. The rest of wastelands are spread over Gujarat, Orissa, Bihar, West Bengal and Sikkim.

Causes : All factors which lead to topsoil erosion constitute causes for the development of wastelands. These include deforestation (about 1.5 m.ha. of forestry cover is lost annually due to which 12,000 million tones (m.t.) of topsoil is last annually), soil erosion due to floods, drought and wind action (about 50% of India's land area is affected by soil erosion, about 30 m.ha. are affected by floods annually, about 68 m.ha. are affected by drought annually). In fact, 21% of India's land area is in a severe state of degradation. Overgrazing due to limited availablility of pasture land is a major cause.

Measures Taken: The National Wasteland Board was set up in 1985 with a mandate of reclaiming 5 m.ha. of wastelands every year primarily through afforestation. The Department of Wasteland

Development has launched several scheme and measures for reclamation of wastelands. 1) It has initated a comprehensive plan for the development of 94 m.ha. non-forest wasteland which include the following programme components. a) Integrated land-use planning b) Preparation of village level action plans c) Creation of sectoral linkages at implementation level planning on a watershed basis. c) Provide financial support to non-government organizations (NGO's) with an additional programme to build on work done by existing NGO's. 2) The Department of Wasteland Development has launched 5 schemes a) Integrated wasteland development programme b) Production of fuelwood and timber c) Grants-in-aid to NGO's and voluntary organizations d) Raising nurseries for afforestation e) Programmes for realizing margin money from wastelands developed. 3) The Department has also identified 147 districts for reclamation of wasteland. The 147 districts have 15% of area as wasteland. Microplans have been prepared for 45 most affected districts. 4) It has also initiated an experiment to revegetate the saline lands of India (about 7 m.ha. of land in 14 states of India suffer from high salinity and alkalinity). The experiment will involve technology evolved by Australia for wasteland reclamation which basically involves vegetating with salt tolerant species like a triplex.

Other General Measures : 1) Revision of forest policy in 1988 to prevent conversion of forestland to non-forest use, promote afforestation and protect existing forests. 2) Centre has proposed to give major thrust to wasteland development of linking it with Jawahar Rozgar Yojana and other such rural development programmes. 3) About 330 voluntary agencies are engaged in the task of wasteland\s development in India. 4) The centre has embarked upon a programme of identifying committed voluntary agencies which will be given the task of motivating and organizing communities for protection, afforestation and development of wastelands, especially in vicinity of habitations.

Objectives of Wasteland Development in India: The overall objectives of Wasteland Development in India are: 1) Improvement and stabilization of soil and water regime to an optimum level. 2) Planting suitable trees/legumes/grasses for the production of fuel, fodder, small timber and also meet other requirements of people. 3) Prevent further expansion / extension of wastelands.

43. SOCIAL FORESTRY

Background: 1) Large scale deforestation i.e., forest cover is being lost at the rate of 1.5 million hectares per annum 2) Acute scarcity of fuelwood in rural areas. 3) Loss of farmland manure to soil because of its use in rural energy requirements. Based on a comprehensive review of the state of forestry in the country, the National Commission on Agriculture recommended three programmes in 1976 for implementation. 1) Afforestation of degraded forest land. 2) Development of productive forests to meet commercial wood and timber requirements. 3) Development of social forestry to meet the fuelwood, fodder, timber requirement of the rural population. Forming one of the important components of the 20-Point Programme, the social forestry scheme was launched in 1980-81 in 101 districts as a centrally sponsored programme. The scheme includes, "A tree for every child" and Rural Fuel wood Plantations. The basic philosophy of the social forestry programme is to prevent the diversion of agricultural land to non-agricultural use and for maintaining environment conducive to living.

The three main components of social forestry programme are: **1) Farm Forestry:** This is with the objective of encouraging farmers to plant and raise trees through subsidized and free supply of seedlings. **2) Rural Forestry:** This is for the benefit of the rural community as a whole through massive plantations and along roads, canal banks, tanks and in fallow uncultivable waste. **3) Community Woodlots:** These are planted by particular communities themselves on their own lands and the benefits are shared equally by them.

Specific Components of Social Forestry: 1) Village woodlands on community and government lands. 2) Block plantation in tank beds and foreshore lands. 3) Agro-forestry on marginal and sub-marginal lands 4) Tree planting along homesteads and field boundaries. 5) Development of pasture and silvipasture 6) Afforestation of degraded areas 7) Tree plantation in industrial and urban areas to combat noise and water pollution 8) Control of water and wind \erosion by tree and shrub planting which will act as shelter belts and noise protection belts. 9) Strip plantation along canal, rail and roadsides.

Importance of Social Forestry:

1. **Fuelwood:** This contributes or accounts for 36% of the total energy consumed in the rural areas. Hence planting trees like

Acacia, Eucalyptus and Leucalina, the fuelwood requirements of the rural populace can be met.

2. **Food:** Tree species like Magnifera Indica, Aegle Marmelos, Syzygum Cumini are important sources of food for rural and tribal people. The trees also produce protein rich seeds and fruits.

3. **Fodder:** The grazing lands will be provided by social forestry with fodder species like Acacia, Arabica, Terminolia Arjuna etc.

4. **Rural Cottage Industry :** The social forestry plantations provide raw material for rural cottage industry like gum, lac, metal rope, resin, silk, soap etc.

5. **Employment:** Unskilled labour can be gainfully employed in preparation of beds, weeding, watering, fencing and planting. It is estimated that in the primary and secondary sectors forestry activities generate approximately 240 million man days of employment per annum

6. **Environment:** In maintaining and regeneration of ecological balance.

Thus, social forestry is a harmonious programme integrating human beings, animals, trees i.e., it combines idle labour, idle land and water resources for optium production of firewood, fodder, food, manure and small timber.

44. BIOSPHERE RESERVES IN INDIA

A biosphere reserve consists of totality of plant, animal and micro-organisms as an interdependent system. Biosphere reserves being set up all over the world are part of the Man and Bio-sphere Programme of the UNESCO- initiated in 1971. The objectives of the Man and Biosphere Programme are: 1) Conserve the ecosystem b) Promote sustainable management of the living resources of a reserve c) Promote international co-operation in conserving / managing biosphere reserves. d) Conserve genetic diversity e) Facilitate basic and applied research in genetic diversity.

What is a biosphere reserve: Basically, a biosphere is an ecology containing plant/animal/micro-organic life as an interdependent system. In a biosphere reserve therefore, endemic species inhabiting a particular geographic area co-exist true to their nature and hence the food chain is undisturbed. In other words a biosphere reserve offers an endemic species a biorhythm familiar to it.

Aims of Biosphere Reserves: 1. The need for conserving eco-systems of a larger size to ensure self-perpetuation and unhindered evolution of living organisms. 2. In-situ conservation of plants/animals and micro-organisms not in isolation but in their totality as part of a wider eco-system. 3. Conserve biodiversity 4. Promote research on ecological conservation and other environmental aspects. 5. Provide facilities for education, awareness and training.

How are biosphere reserves different from wildlife sanctuaries and national parks:

1. Unlike in wildlife sanctuaries and national parks, tourism is not permitted in biosphere reserves.
2. Boundaries of biosphere reserves are delimited by acts of legislature unlike the boundaries of wildlife sanctuaries and national parks.
3. National parks are habitat oriented and wildlife sanctuaries are species oriented but biosphere reserves are ecology oriented.
4. There is no biotic interference in biosphere reserves as in the case of parks / sanctuaries.
5. Research and Management is poor in most parks and sanctuaries.

45. MANGROVE FORESTS IN INDIA

Mangroves are salt-resistant and salt-tolerant forest eco-systems found mainly in the tropical, subtropical and inter-tidal regions.

Uses: 1) The organic detritus from mangrove leaves/litter forms the basis of food chains which nourish a wide variety of marine and estuarine fauna including crabs and oysters, prawns and fishes. 2) Mangrove forests along the coasts stabilize the shoreline and check coastal erosion by sea. 3) The network of anchored and breathing roots of mangroves trap sediments and thus build up land. It is believed that mangroves march into the sea at the rate of as much as

100 metres a year leaving behind built up land for other uses. 4) Mangroves are important wildlife habitats holding rich potential for recreation, sports and nature study. They are excellent reservoirs for wide variety of organisms. 5) Like wetlands, mangrove vegetation minimizes the impact of storms/cyclones thereby minimizing loss of life and property. 6) Mangroves have their economic utility as they provide a wide variety of materials including food, fodder, wood salt, honey, oil wax, dyes, tannins, medicinal products and fibre.

Mangroves in India: In India mangroves cover an area of 6,700 square kms. The major mangroves are North Andaman and Nicobar, Sunderbans (W. Bengal), Bhitarkanika (Orissa), Coringa (A.P.), Mahanadi Delta (Orissa), Godavari delta (A.P), Gult of Cutch (Gujarat), Coondapur (Karnataka), Achra Ratnagiri (Maharashtra), Lake Vembanad (Kerala), Point Calimere (Tamil Nadu) and Krishna Estuary (A.P). The National Wetlands Management Committee has been expanded to cover mangroves and coral reefs for conservation and management. The following areas are listed in management action plan – setting up biosphere reserves (Ram of Kutch, Gulf of Mannar, Sunderbans, Andaman) declaring National parks and rehabilitation of tribals.

46. WETLANDS OF INDIA

Wetlands Defined: Wetlands are transitional areas between truly aquatic and truly terrestrial ecosystems where the water-table is usually at or near the surface of land. The wetlands are usually covered with shallow water. Examples of wetlands include marshes, bogs, swamps, floodplains, peatlands, tidal marshes, littoral zones of large water bodies and deltaic areas. The three key attributes of wetlands are hydrology (refers to the degree of flooding or soil saturation with water), hydrophytes (the wetland vegetation like water-hyacinth) and hydric soils.

Ramsar Convention: An international convention was held in Ramsar (Iran) in 1971 to provide a framework for International Co-operation for the Conservation and Management of wetland habitats. India acceded to the Ramsar convention in 1982 and six wetlands in India have been declared as wetlands of international importance viz. Chilka, Harike, Loktak, Sambhar Wular and Kaladeo.

Uses of Wetlands:

1. Wetlands are one of the most productive ecosystems. Their water-logged conditions produce a rich collection of plants providing food, fodder and timber. The water-logged conditions are also ideal for cultivation of rice and potential sites for aquaculture.

2. Wetlands support a wide variety of bird and animal life. Many wetlands serve as winter resorts for a variety of birds. For e.g., the Bharatpur bird sanctuary offers habitat for exotic migrants from China, Siberia and Afghanistan. In fact, many rare and endangered species live in and around wetlands as for e.g., the Royal Bengal Tiger in Sunderbans wetland complex. Wetlands are breeding grounds for water fowl.

3. Wetlands can be thought of as nature's kidneys since they absorb toxic chemicals and detoxify/denitrify polluted water. In fact the water-hyacinth abundantly available in wetlands acts as a pollution filter.

4. Wetlands are sinks for carbon. The wetland vegetation is responsible for great intake of atmospheric carbon-dioxide. For e.g., it is estimated that the marshy areas of Salt Lake Town (east or Calcutta) once generated 99,000 litres of oxygen per minute. But ever since the area has been converted into a residential site, the oxygen release went down to 12,000 litres per minute.

5. Wetlands naturally serve in flood control and prevent coastal erosion by intercepting and absorbing run-off waters due to storms. For e.g., the Sunderbans wetland complex prevents storm waters from entering Calcutta.

Wetlands in India: India has a wetland areas measuring 4.1 million hectares. Indian wetlands can be classified into Himalayan. Indo-genetic and Coastal. Indian wetlands are directly or indirectly linked to the river systems.

Measures Taken: The Union Ministry of Forests and Environment has constituted a "National Committee" on Wetlands, Mangroves and Coral Reefs. The committee is expected advise the government on policy guidelines for conservation management and research of wetlands, mangroves, coral reefs and related ecosystems. Earlier, the National Wetlands Management Committee (NWLMC) was constituted to advise the government on policy guidelines for implementing the programme of conservation, management and research. The NWLMC has identified 16 wetlands in the country for conservation and management on a priority basis. These are Kolleru Lake (A.P.), Wular Lake (J & K), Chilka Lake (Orissa), Loktak Lake (Manipur), Harike Lake (Punjab) Bhuj Lake (M.P.) Lake Sambhar (Rajasthan), Lake Pichola (Rajasthan), Lake Ujni (Maharashtra), Kaladeo National Park (Rajasthan), Kanjli Lake (Punjab), Renuka Lake (Punjab) Sunderbans (W. Bengal) etc. The NWLMC has formulated an action plan for conservation and management of wetlands which includes the following components: a) Survey / demarcation b) Weed and siltation control c) Pollution abatement d) Development of fisheries e) Promotion of environmental awareness for rational use of wetlands. To implement the action plan, state level "Sterring Committee" have been constituted for some wetlands like Wular, Harike, Renuka and Kanjli. The state level steering committees are responsible for survey, notification, weed/siltation control, pollution abatement etc in their respective districts.

47. RENEWABLE ENERGY

The renewable energy resources of India include solar energy, wind energy, hydropower, biomass based power, tidal energy, wave energy and ocean salinity based OTEC power. India receives 5000 trillion KWh of solar energy per year. The Jodhpur-Jaisalmer stretch of Thar desert has been declared as a solar energy enterprise zone for solar energy development. The government has announced a national solar power mission to develop 20,000 mw by 2020. India has a wind energy potential of 45,000 mw and has installed around 10,000 mw capacity. India also has biomass based power potential of 1800 mw and has developed around 700 mw form this potential. India has around 84000 mw of hydro power potential and has installed a capacity of around 37,000 mw. Small hydropower potential of India is around 15,000 mw of which around 2500 mw has been developed. The coasts of India have a tidal energy potential of 8000 mw and pilot plants for tidal power development have been set up at Thangassery (Kerala), Vizhingam (Kerala) and Car Nicobar. The wave energy potential of India's coasts is around 40,000 mw and a pilot plant at Kovalam (Kerala) has been commissioned. Ocean Energy Thermal Conversion (OTEC) which makes use of temperature differences between surface and deep waters has a potential of 50,000 mw and a pilot plant is being set up at Kulashekarapatnam, Tamil Nadu.

48. Anthropogenic Causes For Floods In India

The anthropogenic factors responsible for floods in India are

1. Intense developmental activity in the floodplains of rivers has interfered with the natural flow regimes of rivers in addition to reduction in area of surface runoff. This has exposed new areas to flooding, often unpredictable.
2. The development of canal irrigation in the northern plains has raised the water tables which has restricted downward infiltration of excess runoff during times of heavy rain.
3. Faulty location and faulty designs of bridges, rail routes and roads particularly in hilly and forested regions has led to drainage congestion in river channels hence leading to floods.
4. Indiscriminate deforestation in catchment areas in upper reaches of river courses especially in the Siwalik basin, Assam Himalayas,

Chotanagpur region and shifting cultivation in the northeast has led to accelerated rates of runoff and also excessive siltation of river beds and reservoirs leading to floods.

That human factors have intensified flooding in India is supported by the finding of the National Commission on Floods which declared that the flood prone area in India increased from around 7 million hectars in 1950s to around 30 m.ha today.

49. THE SPATIAL AND THE TEMPORAL CHARACTERISTICS OF SUMMER MONSOONS OF INDIA

The Southwest Monsoon of India has its normal onset on 1st June each year on mainland India having covered Andaman and Nicobar by 25th May. By 5th June, the summer monsoon covers entire southern peninsular India and the Northwest. By 1st July it covers entire landmass of India except northern Kutch and Thar plains and by 15th July it covers entire landmass of India. The landmass of India gets about 78% of rainfall by the summer monsoon. Spatially, the summer monsoon is made up of the Arabian Sea and the Bay of Bengal branches. There are three streams of the Arabian Sea branch which bring rainfall to a major part of Peninsular India and Northwest India except the Aravalli region. The Bay of Bengal branch is made up of two streams which deliver rain to the Northeast and the middle and lower Ganga plains. The Tamil Nadu coast is the rain shadow region for the summer monsoon in addition to a 225 km wide rain shadow region on the eastern side of the Western Ghats.

The two branches of the summer monsoon have their confluence over the Chotanagpur plateau. The summer monsoon begins to retreat on 1st September and the retreat is completed by 15th December. The retreating monsoon brings rain to the Tamil Nadu coast, the Krishna-Godavari delta, to Northeast India and to the region immediately west of the Aravallis.

50. THE GEOGRAPHIC OCCURRENCE OF NUCLEAR MINES IN INDIA

The nuclear minerals of India include pitchblende (uranium oxide), uraninite (for uranium and thorium), monazite (for thorium and uranium) and zircon (for some uranium). These occur in a) black sands of Malabar coast which mainly contain monazite b) the black sands of the eastcoast along Vishakapatanam and Cuttack which have monazite and zircon c) Jaduguda, Dantupa, Narwa Pahar, Bhatin- all in the Singhbhum district of Jharkhand which contain pitchblende for uranium d) new deposits of uranium having discovered in Nalgonda district of Andhra Pradesh, Kylleng-Martabah region of Meghayala. It may be noted that India has the largest reserves of thorium. Small deposits of uranium also occur in Ajmer/Udaipur, Rajasthan and Monghyr /Gaya, Bihar. The black sands along the coast of Ganjam in Orissa have significant deposits of mineral monazite. Monazite also occurs in Jhansi/Lalitpur, Uttar Pradesh and in Madurai in Tamil Nadu.

51. THE GEOGRAPHIC POTENTIAL OF INDIA IN OIL AND GAS RESERVES

About 40% of India's landmass is made up of sedimentary rocks in 17 sedimentary basins which can be potentially hydro-carbon bearing. Another 10 sedimentary basins are in offshore areas which have an extremely large potential for the occurrence of hydrocarbons. The prognosticated reserves in these 27 sedimentary basins are around 28 billion tonnes of which around 7 billion tonnes have been established as in place reserves. About 70% of reserves are in the form of oil and rest in natural gas. The potential for oil and gas is in the deltaic areas of Krishna, Godavari, Cauveri, Ganga and Mahanadi, particularly offshore deltaic regions, in the Thar plains because they represent a former continental shelf, the Indo-Gangetic plains which are young alluvial sediments could also contain hydrocarbon and the Andaman Sea region. The potential in these regions has been validated by the discovery of oil in Andaman Sea, of oil and gas in Barmer and Jaisalmer in Rajasthan in 2004, in Mahanandi offshore areas in 2009 and the established oil and gas deposits in the Cambay basin of Gujarat, the Krishna – Godavari and Cauvery basin and in the Assam basin of North East India.

52. THE IMPORTANCE OF COASTAL SHIPPING IN INDIA'S TRANSPORT SECTOR

Coastal shipping is the movement of goods/people within the territorial waters of India extending upto 12 nautical miles from the coastline. The major and intermediate ports of India on the east and the west coasts serve more than 50 districts which holds enormous opportunities for development of coastal shipping. The importance of coastal shipping in India lies in the following:

a. India's coastline is suited for long distance feeder coastal services for both passenger and freight movement.

b. It is cost-effective and an environment friendly alternative to rail and.road. For example, it is 10 times more efficient than roads for the same diesel used and is only $1/8^{th}$ of the cost of road transport.

c. It will lead to the development of an integrated multimodal transport system with an alternative to move cargo, currently being moved uneconomically by road/rail.

d. It boosts coastal trade

e. It will offer the growing number of port based SEZs a cost-effective and efficient alternative mode of transport.

53. THE COMPONENTS AND IMPORTANCE OF COMMAND AREA DEVELOPMENT STRATEGY

Command areas are areas served by irrigation projects. The command area development strategy is to bridge the gap between irrigation potential created and the actual irrigated area due to factors such as inadequate development of on-farm irrigation infrastructure, inability of farmers to change their agronomic practices to suit wet agriculture, inadequate farm extension services in irrigation commands. The components of the strategy are:

a. On-farm development works like land development, development of field irrigation systems along with equitable supply of water to all farmers in the command

b. Development and adoption of an appropriate cropping pattern suited to wet agriculture

c. Development of rural physical infrastructure in the neighbourhood of commands to support a productive agriculture

d. Maintenance and modernization of irrigation systems close to the farms.

The importance of command area strategy lies in :

1. It permits the full exploitation of the productive potential of the farm sector based on irrigation
2. It will lead to efficient cropping systems
3. It will make agriculture productive due to use of modern inputs
4. It will ensure efficiency/equity in use of the water resources
5. It will lead to development of rural infrastructure

54. THE CHIEF POINTS IN THE INTERNAL MIGRATION PATTERNS OF INDIA.

In general, the people of India have low levels of mobility internally. The following are the chief points in the pattern of internal migrations in India:

1. The smaller states have a larger proportion of inter-state migrants compared to the larger states
2. The most dominant class in the internal migration process is rural to urban migration in which female migrants dominate over the males, usually due to relocation following marriage.
3. The second important form of internal migration is rural to urban because of both push and pull factors in which male migrants

dominate over female migrants.

4. The urban to urban form of migration is the 3rd dominant form which involves migrations from towns to cities.

5. The urban to rural migration is the least dominant and where female migrants dominate over males and it is usually due to marriage. The recent focus on rural development, particularly the Mahatma Gandhi Rural Employment Programme has partly slowed down the process of rural to urban migration.

55. AGRO-FORESTRY AND ITS IMPORTANCE IN INDIA

It is a label for a series of land-use patterns on farm lands where permanent trees are grown on farm land with crops and or animals in some planned form of spatial arrangement or temporal arrangement which is mutually beneficial. In Agro-forestry, there is a significant interaction between the woody and the non-woody components on a piece of agricultural land where the interaction can be ecological or economical or both. Sustainable use of land, conservation of resources and increase in productivity of resources are the aims of agro-forestry. Agro forestry includes strategies like agri-silviculture (tree and crop association) or silvi-pastoral system (growing pasture crops with trees) or slivi-agri-sericulture (association of crops with trees that can host silk warms) etc. Agro-forestry assumes importance in India due to continued large scale deforestation, growing demand for timber wood/fuel-wood, increasing livestock population and continued large scale soil erosion. Hence well planned agro-forestry strategies can mitigate these problems.

56. THE MAJOR FACTORS IN THE DEVELOPMENT OF INDIA'S SOUTHWEST MONSOONS

The Southwest or summer monsoon develops due to:

1. The global shift of pressure belts to the north in the summer of the northern hemisphere including the shift of the inter-tropical convergence induces the development of monsoonal circulation. The shift of the ITC is very pronounced in the vicinity of the Indian subcontinent where it is located in the northern plains. This forces the southeast trades to cross the equator and blow over northern Indian Ocean and the Indian landmass as southwesterly winds.

2. The offshore monsoons along the Somali coast lead to upwelling of cold waters and development of the Mascarene high pressure area. The Somali jet stream blows from the Mascarene high towards the West Coast of India strengthening the monsoonal circulation.

3. The heating of Tibetan surface in the summer generates warm air currents which descend into the Indian Ocean to form the Easterly Jet which blows west to join the monsoon winds.

4. The disintegration of the westerly jet over the Himalayan foothills and the adjacent plains by the high Himalayas when the jet moves north in phase with the onset of the monsoon over the northern plains.

5. The tropical easterly jet born close to Sumatra adds to the monsoon winds as it blows towards the coast of Africa.

57. THE CHIEF CHARACTERISTICS OF INDIAN BIODIVERSITY HOT SPOTS

Biodiversity are regions which are unusually rich in species, most of which are endemic to the regions, and under constant threat of being overexploited. India has two of the world's eighteen biodiversity hot spots- The Eastern Himalayas and The Western Ghats. The Eastern Himalayas include Nepal , Bhutan , Parts of China and Northeast India. The region has 9000 plant species with 40% being endemic to the region. It is recognized as rich source of primitive flowery plants and wild relatives of economically important plants. More than 50% of the land mammals are from this region and is also rich in bird species.

The Western Ghat region is one of the richest biodiversity regions and is rich centre of endemism. There atre 1500 endemic species of dicotyledon plants and 315 species of vertebrates. The rare animals of Western Ghat are Lion Tailed Macaque, Nilgiri Longue and Malabar Gray Hornbill.

58. THE CHIEF CHARACTERISTICS OF INDIA'S DESERT REGIONS

I. b) Indian landmass include three kinds of deserts- the hot tropicalThar desert, the salt desert of Gujarat and the cold desert of Ladakh and adajacent portions of Himachal. Thar desert is a typical hot tropical desert within the sub-tropical high pressure belt with vast areas of sand dunes. This desert includes rich reserves of oil-gas , Phosphate ,Gypsum etc. The Thar is drained by the seasonal Luni and is home to around 1200 species of animals. The soils are red desert soil with rich concentration of water soluble salts. The cold desert of Ladakh and Himachal are intermontanne high altitude desert with gray desert soils. In ladakh , the desert has a rugged topography with high altitude plateau and gray desert soils. The Ladakh cold desert include large saline water bodies which are important wetlands Illa Tso Moriri and pongong Tso. The great Salt desert of Gujarat include the great Rann of Kutch which is a marshy region with Mangrove forests, The soils are rich in salt deposits. The region includes the rare species like Asiatic wild ASS and is also nesting ground for Flamingoes.

59. DROUGHTS IN INDIA

Drought is a condition of inadequate availability of water for man, animal and crop. Meteorologically, a condition of drought is said to arise if monsoonal rainfall falls short by 15% of the long period average in a given Meteorological subdivision. While it is true that only one-third of India's land mass gets adequate rain fall , it is also true that the heavy monsoonal rainfall is inadequately captured and stored. To a significant extent, droughts in India are man made in the context of heavy monsoonal rainfall over India and its large number of rivers. The problem of drought is intensified due to

1. Actual irrigated area is around 90 million hectare of the total of 105 million hectare irrigation potential created

2. India's storage capacity of rainwater is equal to 30 days of rainfall in a river basin, very less compared to world standard.

3.Inadequate watershed management and poor rainwater harvesting has led to increase of drought prone atrea.

4. Faulty cropping pattern in different agro-climatic regions inappropriate to their agro-climatic condition has led to frequent crop failures intensifying droughts.

60. THE CHIEF STEPS TO INCREASE INDIA'S ENERGY SECURITY

1) The share of renewable energy in India which is around 9% should be increased with focus on development of solar and wind energy.

2) India should increase exploitation of its hydropower potential which is about 150 GW

3) India should exploit her huge Thorium reserves which if exploited by the breeder reactor route can add 5 Lakh MW of capacity.

4) Indian companies should be encouraged to acquire oil/ gas and coal blocks abroad. The acquisition of coal blocks by NTPC in Madagascar is a step in this direction.

5) India should promote the use of CNG as its operating cost is cheaper by 2/3rd compared to petrol and 1/3rd cheaper than diesel.

6) The exploratory efforts of India for oil / gas should increase as the 27 sedimentary basins of India are inadequately exploited.

7) India should intensify R&D to exploit new sources of energy like coal ded Methane and gas hydrates.

61.THE DIFFERENCES BETWEEN THE COALFIELDS OF PENINSULAR INDIA AND COALFIELDS OF NORTHEAST INDIA

The coalfields of peninsular India belong to the Gondwana rocks of the parozoic era. These are part of Damodar, Godavari , Mahanadi, and Son Valleys..These Gondwana fields contain the principal deposits of bituminous coal of India with some coking coal as in Jharia coalfields. the reserves are large, the coal seams are thick and Gondwana coal has relatively lower ash , Sulphur and volatiles. The coalfields of Northeast India are contained in younger geographical formations of Tertiary age. Hence these are low grade coals of sub-bituminous quality with a high content of ash , volatiles and Sulphur. These Tertiary coal deposits have small reserves and thin seams. The Tertiary coal deposits are mainly in Mikil/ Maibum fields of Assam and Namchilk fields of Arunachal Pradesh.

62. THE GLOBAL BASIS OF INDIA'S SUMMER MONSOON

The Summer Monsoon has a global basis in its origin and mechanism. These are briefly:

1) The global shift of pressure belts brings the I.T.C over the Northern Plains. This induces the Southeast Trades to cross into the northern hemisphere and change into Southwest Monsoons.

2) Global shift in temperature belts to the north in summer of the northern hemisphere leads to heating of Tibetan Plateau, also due to its great height. This triggers the Tibet Easterly Jet which rises in Tibet and sinks over equatorial Indian Ocean to strengthen monsoon circulation.

3) Shift of temperature belts to north in summer of northern hemisphere leads to intense heating of Asia hence giving birth to the seasonal Tropical Easterly Jet which blows from Sumatra towards Arabian Sea, hence strengthening monsoon circulation

4) Heating and cooling of equatorial Pacific can give birth to EL Nino and La Nina conditions which may affect the monsoon.

63. THE POTENTIAL AND IMPORTANCE OF ECO – TOURISM IN INDIA

The climate and geographic diversity of India with diverse ecosystems with their rich ecology gives to it a rich eco – tourist potential. This includes cold and hot desert ecosystems of Ladakh and Thar, the mangrove regions, the biosphere reserves with rich ecology, the coral reef regions of Palk Strait and Lakhshadweep, the ecology rich backwaters of Kerala, the eco – rich zones of the Himalayas etc. The potential also lies in the hospitable climate of India which permits access to these ecosystems throughout the year. Affordability and tourist friendly local communities add to this potential. The importance lies in:

1) Regulated eco – tourism improves the socio – economic well being of local communities.

2) Strengthens conservation efforts and properly planned eco – tourism is one of the most effective tools for long tern conservation of biodiversity

3) Can revitalise traditional arts and crafts of indigenous communities

4) Generates large revenues for local communities hence becomes effective in dealing with poverty/unemployment

64. THE CHIEF CHARACTERISTICS OF GLOBALLY IMPORTANT AGRICULTURE HERITAGE SYSTEMS (GIAHS)

The chief characteristics of GIAH like Koraput would include:

1) A diverse agricultural system with species diversity

2) These have globally significant agricultural biodiversity which not only provide food security to local communities but have implications for global food security. That is, the crop strains in such agricultural systems have the genetic make – up to help develop improved crop varieties for world agriculture.

3) The agricultural systems are compatible with the physical, biological and cultural environment and hence include sustainable conservation practices

4) These systems have communities with a rich reservoir of knowledge of sustainable farming systems, which can provide models of sustainable farming to the world

5) Since they represent co – evolution of Man and Nature, they include practices which can inspire sustainable development practices relevant to the world.

6) They are major centres of origin of important species of crops.

7) They provide useful information on development of mixed farming systems.

65. THE CURRENT POSITION OF INDIA IN DEMOGRAPHIC TRANSITION

India's demographic trends beginning in the census decade of 1991 – 2001 and continuing into 2001 – 2011 shows a clear tendency towards a demographic transition. For example in census decade 1991 – 2001, demographic trends indicated a slowing down of population growth decisively for the first time, unlike in the period between 1951 – 1981 when India was locked up in population explosion stage. In 1991- 2001, states like Tamil Nadu, Karnataka and A.P showed trends of rapid decline in population growth while Kerala and Puducheri had already made the demographic transition i.e., stable and low population growth. In 2001 – 2011 census decade, expect a few states like Bihar, U.P, Rajasthan, M.P and Jharkhand, the trend in other states was a definite slowdown in population growth. That the country is trending towards completion of demographic transition is also indicated by a gradual decline in the Total Fertility Rate (TFR) and a sharp decline in birth rates and infant mortality rates noticed in 2001 – 2011.

66. THE VIABILITY OF THE SCHEME OF INTERLINKING THE INDIAN RIVERS

The scheme of interlinking of rivers conceived in two components, Himalayan and Peninsular, is to add 35 million hectares as additional irrigation potential, add 34 GW of additional power capacity, control floods / drought and improve dryland agriculture. The main issues in the viability are:

1) Interlinking includes construction of some large dams, world experience including India's experience with large dams has clearly demonstrated that
   a) They are not effective in flood control
   b) By promoting flood irrigation, can cause water logging / soil salinisation and hence may negate gains of irrigation led agriculture
   c) Big dams undergo rapid siltation of their reservoirs hence do not last their planned life, hence do not justify cost – benefit analysis

2) Inter – basin transfer is the most expensive method to transfer water and improve agriculture as demonstrated by such schemes which failed in Turkey and USA

3) Will have the potential to create serious adverse ecological imbalances like deforestation, water logging

4) The estimate of surpluses in India's river basins are only rough approximations as run – off of rivers varies seasonally and hence the surpluses may not be surpluses after all

5) There is no clear quantitative estimate of the amount of water to be transferred from one basin to another, hence the infrastructure created to utilise surpluses may not be fully utilised

67. THE FACTORS RESPONSIBLE FOR CLOUDBURSTS IN INDIA

A cloudburst is an episode of heavy rainfall delivered in a short spell, usually amounting to more than 100 mm of rain per day. The mechanisms involved in cloudbursts in India are:

1) Intense convection in summer due to intense heating of the landmass promotes the development of thunderstorms in May and June in the Northern Plains and portions of peninsular India leading to heavy rainfall and flash floods.

2) In the hilly forested regions of India, particularly in summer months, convective activity is intensified due to high water availability in these regions. This can lead to cloudbursts like the Ladakh cloudburst in 2010.

3) Depressions and tropical cyclones of the Bay Bengal in late summer months of September to November can bring sudden stormy conditions leading to cloudbursts in east coastal regions

4) The heating of landmass, particularly in the Northern Plains during the monsoon season can trigger convection cells which can intensify the monsoon rainfall leading to heavy rainfall like heavy monsoon rain in Mumbai in 2005 (which recorded around 37 Cms of rain in a single day in the monsoon season)

5) The abrupt onset of monsoon winds as part of their onset in different regions can lead to sudden spells of heavy downpour as in Kerala

68. THE CHIEF CHARACTERISTICS OF INDIA'S BIO – GEOGRAPHIC ZONES

India's 15 Bio – geographic zones, accounting for 8 % of global biodiversity include the following characteristics:

1) They include tropical, temperate and desert ecosystems
2) They represent elements from Afro – Tropical, Indo – Malaysian and Paleo – Arctic bio -geographic realms
3) These have a high degree of endemism of species

4) The Bio – geographic zones of India include two of the 18 biodiversity hot spots of the world (the Western Ghats and Eastern Himalayas. The Western Ghats have been recognised as one of the 8 hottest of the biodiversity hot spots with large species diversity and high degree of endemism of species.
5) The Thar desert Bio – geographic zone has nearly 1200 animal species
6) The Bio- geographic zones include special ecosystems like coral reefs, the salt marshes of Kutch, the mangroves like Sunderbans.

69. REGIONS OF INDIA ARE EXPOSED TO THE THREAT OF DESERTIFICATION

A 8) Desertification is land degradation in semi – arid to arid tropical regions due to both natural and anthropogenic factors. The threat of desertification is serious in:

1) The areas in the vicinity of Aravallis which is primarily due to mining of phosphate and gypsum besides overgrazing by livestock in this fragile ecosystem

2) Large areas in the Rann of Kutch are exposed to this hazard due to expansion of agriculture (i.e., animal husbandry and some hardy crop agriculture) and salt mining

3) The Badlands of Chambal basin are exposed to intense ravine and gully erosion which has already turned them into wastelands which could easily turn into a desert

4) The forested regions on the fringes of Aravallis are exposed to desertification due to deforestation.

5) The fragile ecosystems of the rainshadow regions of peninsular India (like the region east of Western Ghats in A.P and Karnataka) face this threat due to intense agricultural activity

The Vidharba region of Deccan Plateau is exposed to this hazard due to intensive agricultural activity

SRIRAM'S IAS

SHORT NOTES

Glacial Lake Outburst Flood: These develop due to rapid melting of glaciers, attributed to global warming, which develops rapidly growing lakes from the meltwaters which abruptly move downslope causing floods

Footloose Migrants in India: Footloose migrants are unskilled labour who do not have a definite region for in – migration and move haphazardly in search of livelihood, mostly made up of people from rural areas which have suffered agricultural collapse.

McMahon Line: Henry McMahon Line is the border between India (in Arunachal Pradesh and Sikkim) with Tibet of China, which was agreed to between India, China and Dalai Lama of Tibet in the 1913 – 1914 Shimla conference.

Tidal characteristics of India's West and East Coast: Tidal amplitudes systematically increase from lower to higher latitudes along both the West and the East coasts, leading to highest tidal amplitudes at Kandla and Kolkata compared to Tuticorin. The tidal amplitudes are higher along the west coast as Arabian Sea is a true ocean unlike the partially enclosed character of the Bay of Bengal

Badlands of India: These are in the Chambal basin of the Malwa plateau which have developed gullies and ravines due to intense soil erosion in this semi – arid climate region. These Badlands have been rendered into wastelands.

Intensive and extensive agriculture: Intensive agriculture is irrigated agriculture with widespread use of chemicals and high yielding varieties of seeds. It also has either no fallow or small fallow period and usually the land is under multicropping . Extensive agricultureis more environment friendly with reasonably long period of fallow , lesser intensity of cropping , irrigation to only supplement rainwater and low intensity in use of chemicals and high yielding variety. Extensive agriculture does no hazards like water logging, soil salinisation and soil toxicity

Earthquakes and tectonic plates: Plate tectonics theory declares that the earth's lithosphere occurs in the form of tectonic plates and that the motions of such plates are responsible for the world pattern of earthquake and volcanic activity. The motions of the tectonic plates are also responsible for development of fold mountains. The motions of tectonic plates create plate boundaries which are either convergent, divergent or neutral. Along all these boundaries two adjacent plates move relative to each in convergent, divergent or slip motion. These plate motions cause earthquake and volcanic activity along the plate boundaries. Hence volcanic and earthquake belts follow plate boundaries

Soil horizons: soil horizons are the distinct horizontal layers within the soil. These horizons differ from each other in colour , content of humus and plant nutrients, the soil particle size and relative age. The horizons develop from rock and mineral fragments over a long period of geographical time. The collection of all the soil horizons makes up the soil profile. The typical horizons are 'O' or the organic horizons , 'A'-the top soil horizon , 'B'- sub-soil horizon , C- which is rock fragments or sometimes bedrock

Causes of ocean tides: The alternate global rise and fall in the level of the sea is the ocean tide. The ocean tide are due to gravitational pull of the Sun and Moon on earth and also due to the centrifugal force due to earth's rotation. The tides are semi-diurnal i.e. , two high tides and two low tides in some locations or diurnal i.e., one high and one low tide in other locations. The ocean tides have well defined temporal and spatial pattern. The tides create tidal flats in coastal plains which in turn become excellent sites for mangroves and also help man in certain areas like ship navigation and tidal energy based electric power.

New uranium mines of India: The new deposits and mines of Uranium in India are parts of Dharwar rocks. These include the Banduhuraang mines in Jharkhand, the Tumullapalli mines in Kadapa (AP) , the Peddagattu mines in Nalagonda(AP) , the Domiasiat and Mawtabah mines of Meghalaya and some small new mining areas in karnatka.The new Uranium mines based on recent discoveries have increased India's reserves of uranium enormously and making India one of the world's leading countries in uranium reserves.

Indian Ocean Dipole: The Indian Ocean Dipole is the Indian Ocean component of the El Nino of the Pacific Ocean which has been discovered by Japanese scientists. The Indian Ocean Dipole plays an important role in influencing the summer monsoons of the India during El Nino years.

Truck farming: Truck farming is a variety of agriculture that evolved in Western Europe. In truck farming, perishable agro items like fruits and vegetables are grown within a <u>truckable distance</u> of a large city i.e. , the distance over which trucks can easily transport the perishable to the major urban markets. Truck farming is well developed in Western Europe and North America and today involves not only the cultivation of fruits and vegetables but also dairying.

Ria coasts of India: Ria coasts are varieties of submerged highland coasts. In such coasts, mountain and their valleys are partly submerged under sea water and are also perpendicular to the shore line. The Ria coasts therefore develop deep inlets of sea into land. India has the Ria coast type of coast in portions of the Konkan coast , particularly the Konkan coast off Goa. Hence the Western Ghats i.e., the Sahayadris are perpendicular to the coastline and at places are also partly submerged under sea water

Run-off- the-river project : Run-of-the-river project is a hydro power dam making use of the natural flow of the river and its drop in height to produce electric power

Biodiversity Hotspot: A bio-diversity hot sport is a region rich in biodiversity where the biodiversity is endangered either directly or indirectly due to Man's activities. The Sahyadris and the northeastern Himalayas are two biodiversity hotspots.

Tabletop Airports: A Tabletop airport is an airport with the runway located on a hilltop or a plateau top which descend abruptly along their sides, like the Mangalore airport

Green water : This is water held in the different layers of the soil profile i.e. water held in the A, B and C horizons of the soil layer.

Coral Triangle: A region of Pacific Ocean which has a rich collection of coral reefs, the region is surrounded by Indonesia, Malaysia, the Philippines and New Guinea.

Ecological Footprint : Refers to the human demand for natural resources in a given region, larger the footprint more endangered are the natural resources.

Shale Gas : Methane gas contained in the sedimentary rocks called Shales, which is extracted via the fractures in these rocks as a source of commercial natural gas.

Arctic Oscillation: Fluctuation in atmospheric circulation in the arctic, when it is positive a ring of strong winds circle north pole which act as a barrier to contain winds in polar areas, if negative the cold winds spread to lower latitudes.

Strawberry belt of India: India's biggest region for the cultivation of strawberries and is in the Mahabaleswar region of Maharashtra.

Cartagena Protocol : : is on biosafety, evolved in 2003, to monitor the movement of genetically modified organisms.

Desert National Park of India : is part of the Thar desert of Jodhpur, home to the Great Indian Bustard and is tentatively in the UNESCO world heritage list.

Mention two Austric languages of India: The two largest groups within the Austric language family are the Munda group of languages (Santhali, Mundali) and the Mon-khmer languages which includes Khasi and Nicobarese

Badlands of India: These are regions with a large number of gullies/ravines cut by short streams in a semi-arid climate with thick soil and represent severe soil erosion. Are found in Chambal badlands of Malwa.

Cherry Blossoms: These are the pre-monsoon showers of Karnataka which are due to intense heating of the landmass throughout summer and hence leading to convectional rain

Green GDP: Is a tabulation of the natural resources consumed for a given output of GDP and hence represents the environmental cost of economic growth

Dandakaranya region: A tribal forested region in parts of Orissa (Kalahandi, Bolangir) and Chhattisgarh (Bastar and Bailadilla) inhabited by the Adivasis and which is also mineral rich

Indus Suture zone: is in Ladakh, represents the region where the Indian plate has fused with the Eurasian plate and is marked on the surface by the presence of volcanic rocks

NPK ratio: This is the ratio of nitrogen (N), phosphorus (P), and potassium (K) in fertilizers, which are the three major plant nutrients and the ideal NPK ratio is 4:2:1.

Agro forestry: This is scientific integration of agriculture with horticulture, silviculture, pisciculture and sericulture which is mutually beneficial to the crops and these activities.

Duars : These are the valleys across the Darjeeling hills of West Bengal and are the gateways of India to Bhutan.

Gas hydrates: These are ice-like crystals of methane found on the sea floor and are considered to be a major future source of methane gas as a commercial fuel.

SRIRAM'S IAS

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General Studies

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Contents

1. MATTER

Matter

Matter is anything made of atoms and molecules. Matter is anything that has a **mass**. Matter is also related to light and electromagnetic radiation. Even though matter can be found all over the universe, you usually find it in just a few forms. As of 1995, scientists have identified five **states of matter**. They are **solids, liquids, gases, plasmas, and a new one called Bose-Einstein condensates.** The first four have been around a long time. The scientists who worked with the **Bose-Einstein condensate received a Nobel Prize for their work in 1995.** But what makes a state of matter? It's about the physical state of molecules and atoms.

STATES OF MATTER

There are **five** main states of matter. **Solids, liquids, gases, plasmas, and Bose-Einstein condensates** are all different states of matter. Each of these states is also known as a phase. Elements and compounds can move from one phase to another phase when special **physical forces** are present. **One example** of those forces **is temperature**. The phase or state of matter can change when the temperature changes. Generally, as the temperature rises, matter moves to a more active state.

PLASMA

Plasmas are a lot like gases, but the atoms are different because they are made up of free electrons and ions of the element. If you have ever heard of the Northern Lights or ball lightning, you might know that those are types of plasmas. It takes a very special environment to keep plasmas going. They are different and unique from the other states of matter.

FINDING A PLASMA

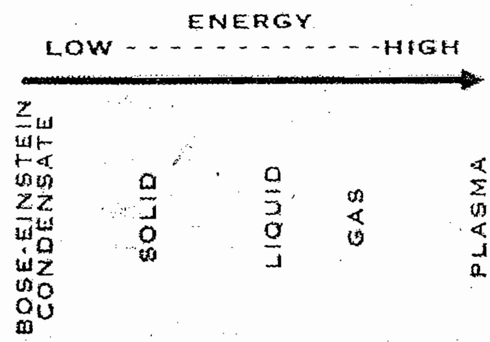
I. Fluorescent light bulb. They are not like regular light bulbs. Inside the long tube is a gas. Electricity flows through the tube when the light is turned on. The electricity acts as that special energy and charges up the gas. This charging and exciting of the atoms creates glowing plasma inside the bulb.

II. Another example of plasma is a neon sign. Just like a fluorescent light, neon signs are glass tubes filled with gas. When the light is turned on, the electricity flows through the tube. The electricity charges the gas, possibly neon, and creates plasma inside of the tube. The plasma glows a special color depending on what kind of gas is inside.

III. **Stars** are big balls of gases at really high temperatures. The high temperatures charge up the atoms and create plasma. Stars are another good example of how the temperature of plasmas can be very different.

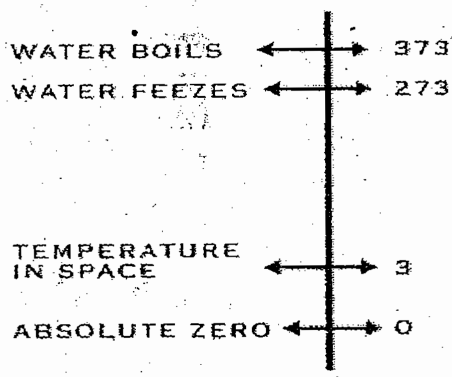
BOSE-EINSTEIN BASICS

If plasmas are super hot and super excited atoms, the atoms in a Bose-Einstein condensate (BEC) are total opposites. They are super-unexcited and super-cold atoms.



ABOUT CONDENSATION

Let's explain **condensation** first. Condensation happens when several gas molecules come together and form a liquid. It all happens because of a loss of energy. Gases are really excited atoms. When they lose energy, they slow down and begin to collect. They can collect into one drop. Water condenses on the lid of your pot when you boil water. It cools on the metal and becomes a liquid again. You would then have a condensate.



The BEC happens at super low temperatures. We have talked about temperature scales and Kelvin. At zero Kelvin all molecular motion stops. Scientists have figured out a way to get a temperature only a few billionths of a degree above **absolute zero**. When temperatures get that low, you can create a BEC with a few special elements. Cornell and Weiman did it with Rubidium.

CLUMPING

A cold ice cube is still a solid. When you get to a temperature near absolute zero something special happens. Atoms begin to clump. The whole process happens at temperatures within a few billionths of a degree so you won't see this at home. The result of this **clumping** is the BEC. A group of atoms takes up the same place, creating a "super atom." There are no longer thousands of separate atoms. They all take on the same qualities and for our purposes become one blob.

SOLUTIONS AND MIXTURES

Solutions are groups of molecules that are mixed up in a completely even distribution. Scientists say that solutions are **homogenous** systems. Other types of mixtures can have a little higher concentration on one side of the liquid when compared to the other side. Solutions have an even concentration throughout the system. An example: Sugar in water vs. Sand in water. Sugar dissolves and is spread throughout the glass of water. The sand sinks to the bottom. The sugar-water could be considered a solution. The sand-water is a mixture.

A simple solution is basically two substances that are going to be combined. One of them is called the **solute**. A solute is the substance to be dissolved (sugar). The other is a **solvent**. The solvent is the one doing the dissolving (water). As a rule of thumb, there is usually more solvent than solute.

FACTORS AFFECTING SOLUTIONS

All sorts of things can change the concentrations of substances in solution.. Solubility is the ability of the solvent (water) to dissolve the solute (sugar). Usually when you **heat** up a solvent, it can dissolve more solid materials (sugar) and less gas (carbon dioxide). **Next** on the list of factors is **pressure**. When you increase the surrounding pressure, you can usually dissolve more gases in the liquid. Think about your soda can. They are able to keep the fizz inside because the contents of the can are under higher pressure. Last is the **structure** of the substances. Some things dissolve easier in one kind of substance than another. Sugar dissolves easily in water; oil does not. Water has a low solubility when it comes to oil.

AMALGAMS

Amalgams are a special type of alloy. We like them because we think mercury (Hg) is a cool element. You might know **mercury** as "quicksilver" or the metal that is liquid at room temperature. Anyway, **amalgams are alloys** that combine mercury and other metals in the periodic table. The most obvious place you may have seen amalgams is in old dental work. The fillings in the mouths of your grandparents may have been amalgams. We already talked about mercury's being a liquid at room temperature. That physical trait was used when they made fillings. Let's say you have an amalgam of mercury (Hg) and silver (Ag). When it is created, it is very soft. As time passes, the mercury leaves the amalgam and the silver remains. The silver that is left is very hard.

NOTE: Mercury (Hg) is very poisonous. You shouldn't even touch it because it will seep into your skin. Dentists don't usually use amalgams with mercury anymore because it may have slowly poisoned people and gotten them sick.

EMULSIONS

Let's finish up with a little information on emulsions. These special **colloids** (another type of mixture) have a mixture of oils and waters. Think about a bottle of salad dressing. Before you mix it, there are two separate layers of liquids. When you shake the bottle, you create an emulsion. As time passes, the oil and water will separate to their original states.

ISOTOPES

We have already learned that ions are atoms that are either missing or have extra electrons. Let's say an atom is missing a neutron or has an extra **neutron**. That type of atom is called an **isotope**. An atom is still the same element if it is missing

an electron. The same goes for isotopes. They are still the same element. They are just a little different from every other atom of the same element.
There are a lot of carbon atoms in the universe. The normal ones are carbon-12. Those atoms have 6 neutrons. There are a few straggler atoms that don't have 6. Those odd ones may have 7 or even 8 neutrons. Carbon-14 actually has 8 neutrons (2 extra). C-14 is considered an isotope of the element carbon.

ATOMIC MASS

Atomic masses are calculated by figuring out how many atoms of each type are out there in the universe. For carbon, there are a lot of C-12, a couple C-13, and a few C-14 atoms. When you average out all of the masses, you get a number that is a little bit higher than 12 (the weight of a C-12 atom). The mass for element is actually 12.011. Since you never really know which C atom you are using in calculations, you should use the mass of an average C atom.

RETURNING TO NORMAL

If we look at the C-14 atom one more time we can see that C-14 does not last forever. There is a point where **it loses those extra neutrons** and becomes C-12. That loss of the neutrons is called **radioactive decay**. That decay happens regularly like a clock. For carbon, the decay happens in a couple of thousand years.

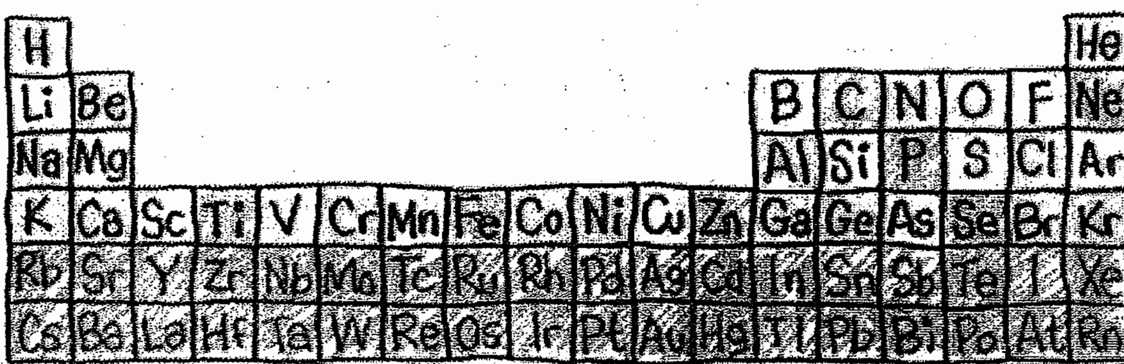
NEUTRONS

Neutrons are the particles on an atom that have a neutral charge. So if an atom has equal numbers of electrons and protons, the charges cancel each other out and the atom has a neutral charge. You could add a thousand neutrons into the mix and the charge will not change. However, if you add a thousand neutrons you will be creating one super-**radioactive** atom. Neutrons play a major role in the mass and radioactive properties of atoms. You may have just read about isotopes. **Isotopes** are created when you change the normal number of neutrons in an atom. You know that neutrons are found in the nucleus of an atom. During **radioactive decay**, they may be knocked out of there. But under normal conditions, protons and neutrons stick together in the nucleus. Their numbers are able to change the mass of atoms because they weigh about as much as a proton and electron together.

ONE SPECIAL ELEMENTA normal hydrogen (H) atom does not have any neutrons in its tiny nucleus. You can take away the electron and make an ion, but you can't take away any neutrons

SRIRAM'S IAS

2. Periodic Table and the Elements



Up to this point in time we have discovered/created over 100. While there may be more out there to discover, the basic elements remain the same. Iron (Fe) atoms found on Earth are identical to iron atoms found on meteorites. The iron atoms on Mars that make the soil red are the same too.

Elements as Building Blocks

The **periodic table** is organized like a big grid. The **elements** are placed in specific places because of the way they look and act. If you have ever looked at a grid, you know that there are rows (left to right) and columns (up and down). The periodic table has rows and columns, too, and they each mean something different.

Periods

Even though they skip some squares in between, all of the rows go left to right. When you look at a periodic table, each of the rows is considered to be a different **period**. In the periodic table, elements have something in common if they are in the same row. All of the elements in a period have the same number of atomic orbitals. Every element in the top row (the first period) has one orbital for its electrons. All of the elements in the second row (the second period) have two orbitals for their electrons. It goes down the periodic table like that. At this time, the maximum number of electron orbitals or electron shells for any element is seven.

Groups

When a column goes from top to bottom, it's called a **group**. The elements in a group have the same number of electrons in their outer orbital. Every element in the first column (group one) has one electron in its outer shell. Every element on the second column (group two) has two electrons in the outer shell. As you keep counting the columns, you'll know how many electrons are in the outer shell. There are some exceptions to the order when you look at the transition elements.

Two at the Top

Hydrogen (H) and helium (He) are special elements. Hydrogen can have the talents and electrons of two groups, one and seven. To scientists, hydrogen is sometimes missing an electron, and sometimes it has an extra. Helium is different from all of the other elements. It can only have two electrons in its outer shell. Even though it only has two, it is still grouped with elements that have eight (inert gases).

The elements in the center section are called transition elements. They have special electron rules.

HALOGENS ON THE RIGHT

In the second column from the right side of the periodic table, you will find Group Seventeen (Group XVII). This column is the home of the **halogen** family of elements. Who is in this family? The elements included are Fluorine (F), Chlorine (Cl), Bromine (Br), Iodine (I), and Astatine (At).

WHAT MAKES THEM SIMILAR?

When you look at our descriptions of the elements fluorine (F) and chlorine (Cl) you will see that they both have seven electrons in their outer shell. That seven-electron idea applies to all of the halogens. They are all just one electron shy of having full shells. Because they are so close to being happy, they have the trait of combining with many different elements. You will often find them bonding with metals and elements from Group One of the periodic table.

Not all halogens react with the same intensity. Fluorine is actually the most reactive and combines all of the time. As you move down the column, reactivity decreases.

HALIDE

The elements we are talking about in this section are called halogens. When a halogen combines with another element, the resulting compound is called a **halide**. One of the best examples of a halide is sodium chloride (NaCl). Don't think that the halogens always make ionic compounds. Many halides of the world are made with covalent compounds.

THE NOBLE INERT GASES

We love the inert gases. Some scientists used to call them the **noble gases**. These gases are another family of elements, and all of them are located in the far right column of the periodic table. The far right is also known as Group Zero (Group 0) or Group Eighteen (Group XVIII). This family has the happiest elements of all.

Using the **Bohr** description of electron shells, happy atoms have full shells. All of the inert gases have full outer shells with eight electrons. That's not totally correct.

At the top of the inert gases is little helium (He) with a shell that is full with two electrons. The fact that their outer shells are full means they are quite happy not reacting with other elements. In fact, they rarely combine with other elements. That nonreactivity is why they are called inert.

All of the elements in Group Zero are inert gases. The list includes Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr), Xenon (Xe), and Radon (Rn). Don't think that because these elements don't like to react, we don't use them. You will find inert gases all over our world. **Neon** is used in **advertising signs. Argon** is used in **light bulbs. Helium** is used to **cool things and in balloons. Xenon** is used in **headlights for new cars.** When you move down the periodic table, as the atomic numbers increase, the elements become rarer. They are not just rare in nature but rare as useful elements, too.

As of about 40 years ago, scientists have been able to make some compounds with inert gases. Some have been used in compounds to make **explosives** and other just form compounds in a lab. **The thing to remember is that they were forced.** When going about their natural lives, you will never (never say never because there may be an exception) find the inert gases bonded with other elements.

METAL BASICS

We will have an overview of **metals.** Almost 75% of all elements are classified as metals. They are not all like silver (Ag), gold (Au), or platinum (Pt). Those are the very cool and shiny ones. There are other metals like potassium (K) and iridium (Ir) that you might not think about right away.

MANY KINDS OF METALS:

Actinide Metals, Lanthanide Metals, Alkali Metals, Alkaline-Earth Metals, Noble Metals, Rare Metals, Rare-Earth Metals, and Transition Metals. Lucky for you the periodic table is excellent at organizing elements, and you will find each of these groups in specific areas of the periodic table.

IDENTIFICATION of METAL

Conduction: Metals are good at conducting electricity. Silver (Ag) and copper (Cu) are some of the most efficient metals and are often used in electronics.
Reactivity: Metals are very reactive, some more than others, but most form compounds with other elements quite easily. Sodium (Na) and potassium (K) are some of the most reactive metals.
Chemical: Metals usually make positive ions when the compounds are dissolved in solution. Also, their metallic oxides make hydroxides (bases) (OH-) and not acids when in solution. Think about this example. Sodium chloride (NaCl), when dissolved in water, breaks apart into sodium (Na+) and chlorine (Cl-). See that

sodium is the positive ion? Sodium is the metal. It works that way for other metals. Potassium chlorine (KCl) works the same way.
Alloys: Metals are easily combined. Mixtures of many elements are called alloys. Examples of alloys are steel and bronze.

ALKALI METALS TO THE LEFT

Let's start on the left side of the periodic table. When looking for families, the first one you will find is the **alkali metal** family of elements. They are also known as the alkaline metals. You should remember that there is a separate group called the alkaline earth metals in Group Two. They are a very different family even though they have a similar name. That far left column is Group One (Group I). When we talk about the groups of the periodic table, scientists use Roman numerals when they write them out.

A FAMILY PORTRAIT

Who's in the family? Starting at the top we find hydrogen (H). But wait. That element is NOT in the family. When we told you about families, we said that they were groups of elements that react in similar ways. Hydrogen is a very special element of the periodic table and doesn't belong to any family. While hydrogen sits in Group I, it is NOT an alkali metal

FAMILY BONDING

Now that we've covered that exception, the members of the family include: Lithium (Li), Sodium (Na), Potassium (K), Rubidium (Rb), Cesium (Cs) and Francium (Fr). As with all families, these elements share traits. They are very **reactive**. Why? They all have one electron in their outer shell. That's one electron away from being happy (full shells). When you are that close to having a full shell, you want to bond with other elements and lose that electron. An increased desire to bond means you are more reactive. In fact, when you put some of these pure elements in water, they will cause huge explosions. The alkali metals are also metals. That seems obvious from the name. Often, in chemistry, characteristics are assigned by the way elements look. You will find that the alkali group is shiny and light in weight. Their light weight and physical properties separate them from other metals.

GROUP TWO

The **alkaline earth metals** is in Group II. This is the second most **reactive** family of elements in the periodic table. **Did you know why they are called alkaline? When these compounds are mixed in solutions, they are likely to form solutions with a pH greater than 7. Those pH levels are defined as 'basic' or 'alkaline' solutions.**

Who's in the family?

The members of the alkaline earth metals include: beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba) and radium (Ra). As with all families, these elements share traits. While not as reactive as the alkali metals, this family knows how to make bonds very easily. Each of them has two electrons in their outer shells. They are ready to give up those two electrons in **electrovalent bonds**. Sometimes you will see them with two halogen atoms (BeF_2) and sometimes they might form a double bond (CaO). It's all about giving up those electrons to have a full outer shell.
As you get to the bottom of the list, you will find the radioactive radium (Ra). While radium is not found around your house anymore, **it used to be used in glow-in-the-dark paints**. The other elements are found in many items including **fireworks, batteries, flashbulbs, and special alloys**. The lighter alkaline earth metals such as magnesium and calcium are very important in animal and plant **physiology**. We all know that calcium helps build our bones.

TRANSITION METALS
Lets start off by telling you that there are a lot of elements that are considered **transition metals**.

Which metals are the transition metals?
21 (Scandium) through 29 (Copper)
39 (Yttrium) through 47 (Silver)
57 (Lanthanum) through 79 (Gold)
89 (Actinium) and all higher numbers.

WHAT MAKES THEM SO SPECIAL?
It all has to do with their shells/**orbitals**.. Transition metals are good examples of advanced shell ideas. They have a lot of electrons and distribute them in different ways.
Transition metals are able to put more than eight **electrons** in the shell that is one in from the outermost shell. Think about argon (Ar). It has 18 electrons set up in a 2-8-8 order. Scandium is only 3 spots away with 21 electrons, but it has a configuration of 2-8-9-2. This is where it starts. This is the point in the periodic table where you can place more than 8 electrons in a shell.
The transition metals are able to put up to 32 electrons in their second to last shell. Something like gold (Au) has an organization of 2-8-18-32-18-1. Of course, there are still some rules. No shell can have more than 32 electrons. It's usually 18 or 32 for the maximum number of electrons.

ONE MORE THING......
Most elements can only use electrons from their outer orbital to bond with other elements. Transition metals can use the two outermost shells/orbitals to bond with

other elements. It's a chemical trait that allows them to bond with many elements in a variety of shapes. Why can they do that?
As you learn more, you will discover that most transition elements actually have two shells that are not happy. Whenever you have a shell that is not happy, its electrons can bond with other elements. Example: Molybdenum (Mo) with 42 electrons. The configuration is 2-8-18-13-1. The shells with 13 and 1 are not happy. Those two orbitals can use the electrons to bond with other atoms.

LANTHANIDE SERIES OF METALS

When you look at the periodic table you will see two rows that kind of sit off to the bottom. One of those rows is called the Lanthanide series. There are a bunch of names that you may hear that describe these 15 elements. Some say Lanthanide, some say **rare-earth** and some say **inner-transition** elements. No matter what you choose everyone will know what you mean if you say Lanthanide.

THE FAMILY

Fifteen elements that start with lanthanum (La) at atomic number 57 and finishing up with lutetium (Lu) at number 71.

ACTINIDE SERIES OF METALS

There are two rows under the table. The Lanthanide and Actinide series. The Lanthanide series can be found naturally on Earth. Only one element in the series is **radioactive**. The Actinide series is much different. They are all radioactive and some are not found in nature. Some of the elements with higher atomic numbers have only been made in labs. There are special laboratories across the world that specialize in experimenting on elements. Some of these **particle accelerators** have pounded atomic particles into elements with lower atomic numbers. The buildup of additional parts creates short-lived elements.

THE FAMILY

Fifteen elements that start with actinium (Ac) at atomic number 89 and finishing up with lawrencium (Lr) at number 103.

3. SOME COMMON ELEMENTS

HYDROGEN

Hydrogen is the first element in the **periodic table** and the most basic and common of all elements in the universe. Over ninety percent of all the atoms in the universe are hydrogen atoms and they are the lightest of all **elements**.

where we find hydrogen :

I. **THE SUN**

II. **WELDING AND BLOWTORCHES**

III. **PLANTS AND SUGARS**
Hydrogen is in all plants. There are sugars all throughout plants and there is hydrogen in sugar. That's why animals eat plants... For the sugar and the energy.

IV. **CRYOGENICS**
Hydrogen is used in something called cryogenics. Cryogenics is a process when scientists freeze things. When hydrogen is in a liquid form it is very, very cold. Scientists use this cold hydrogen to freeze things very quickly.

HELIUM

Named after the **Sun** and the Latin word "helios". Even when first discovered and identified, scientists knew there were large amounts of helium in the Sun.

Similar to hydrogen, helium is usually found as a gas and has no color or smell. Helium is found everywhere in the universe and is the **second** most common element, just like hydrogen.

we find it in :

I. **BALLOONS** t.

II. **THE SUN**
Helium is in the Sun. If you were to look at everything in the sun you would discover large amounts of helium. The Sun is a really big ball of gases and all those gases are on fire. One of the results of that fire is helium.

III. **COMPRESSED AIR TANKS**
Whenever you see a SCUBA diver in the water, you should know that he has some helium in his air tank. Divers combine helium and regular air in

those tanks at very high pressures. When they go deep in the water the helium makes it easier for them to breathe.

IV. **LASERS**
Sometimes helium is used in lasers. It's a good element to use **because it is non-reactive**. Even at really high temperatures helium will not bond with other elements.

V. **COOLANTS**
Nuclear Reactors use helium as coolant. When helium is in a liquid form it is a very low temperature. Because a reactor can be very hot, scientists need something very cool to keep everything under control.

VI. **ROCKET FUEL**
A rocket into space is using helium. When we launch rockets into space, they sometimes use helium to cool the engines.

VII. **BLIMPS**
When you go to a football game you might see a blimp. That blimp is using helium to stay up in the air. Helium is lighter than regular air so it helps things float. A blimp is filled with helium and floats for a very long time. They use propellers to move around.

LITHIUM

This is the first **metal** encountered in the periodic table and it is a silvery colored solid when purified. One thing to remember is that lithium is never found alone in nature. It is always bonded to other elements.

We find it in :

I. **BATTERIES**

II. **MEDICINE**
When you take lithium it acts on nerves in your brain and changes the way you act.

III. **ROCKS AND SOIL**

IV. **HOT SPRINGS**

V. **NUCLEAR REACTORS**
Lithium is a very important element in Nuclear Reactors. It is a very light element which makes it important to scientists. It is used in many chemical reactions and processes.

VI. AIR CONDITIONERS

BERYLLIUM

Purified beryllium is a grey, hard, steel-like **metal** that is very poisonous. Another of its characteristics is its non-magnetic quality. Non-magnetic metals are very useful in electronics.. You can never find beryllium alone. It is always combined with other **elements** when found on Earth.

We find it in :

I. **NUCLEAR REACTORS**

II. **EMERALDS AND GEMS**
Beryllium is in emeralds. It is also in another gem called aquamarine. Beryllium is only one of many elements inside an emerald

III. **MACHINE PARTS AND SPRINGS**
Beryllium is a very light metal. It is also used with other metals to make strong pieces for machines. Beryllium is often used in springs. With beryllium the springs become lighter and stronger.

IV. **SATELLITES**
Scientists use beryllium in satellites because it is so light. Satellites need to be light in weight because it is easier to get them into space.

V. **SPACECRAFT**

BORON

It's a tough **element** to isolate because it is never found alone in nature. Boron is always part of larger compounds in the real world. When you do find it... It will either be in a brown powder or a crystal. As more tests were completed, it was discovered that boron was also a very **poor conductor** of electricity.

USED IN

I. CERAMICS

II. SOAPS

III. GLASS MANUFACTURING

IV. FLARE GUNS

V. FIBERGLASS
and cars instead of metal. Next time you see speedboats racing or someone surfing you will know that those things are made out of fiberglass.

CARBON

This is the magic **element** for everything on Earth. All life on Earth depends on carbon. It is in nearly every biological compound that makes up our bodies, systems, organs, cells, and organelles. When you breathe out, it's carbon combined with oxygen. Carbon has been known and used for thousands of years.
Carbon is the sixth element in the **periodic table**. Located between boron and nitrogen, it is a very stable element. Because it is stable, it can be found in many naturally occurring compounds and by itself. Scientists describe the three states of carbon as **diamond, amorphous,** and **graphite**.
It was never really discovered. Ancient people knew of the black soot left over after a fire. That was carbon.

OCCURANCE:

I. **PLANTS**
II. **DIAMONDS**
III. **CHARCOAL**
IV. **GRAPHITE**
V. **PETROLEUM PRODUCTS**
VI. **PLASTICS**

NITROGEN

The second of the big three elements in row two is nitrogen. Nitrogen is the seventh element of the **periodic table** located between carbon and oxygen. Along with carbon and oxygen, it is essential in most of the compounds that allow life to exist. Eighty percent of Earth's **atmosphere** is made of nitrogen gas.
Nitrogen is a clear gas that has no smell when it is in its pure form. It is not very reactive when it is in a pure molecule, but it can create very **reactive** compounds when combined with other elements including hydrogen (ammonia).

USED IN :

I. **AMMONIA**
Nitrogen is in something called ammonia. Ammonia is used as a disinfectant because it kills bacteria and fungus. It is very poisonous.
II. **STEEL MANUFACTURING**
Nitrogen is used in the processes to make steel. Many other elements are

also used to make steel. It is not an easy thing to do. Scientists use nitrogen in many difficult processes.

III. **COOLANT**

Nitrogen is used as a refrigerant. When it is in a liquid form nitrogen is very cold. Scientists use that cold nitrogen to keep things frozen.

IV. **OIL AND PETROLEUM REFINERIES**

Nitrogen is used to refine oil. Scientists get oil out of the ground but it can't be made into gasoline without nitrogen

V. **SOIL NUTRIENTS.**

OXYGEN

oxygen makes over twenty percent of the Earth's **atmosphere**. We are the only planet in the solar system with enough oxygen available to let us survive. Oxygen is the eighth element of the **periodic table** and found in the second row (period). Alone, oxygen is a colorless and odorless compound that is a gas at room temperature. Oxygen molecules are not the only form of oxygen in the atmosphere; you will also find oxygen as **ozone** and **carbon dioxide**.

Find it in:

I. OZONE LAYER

II. PLASTICS

Oxygen is inside things made out of plastic

III. BREATHABLE AIR.

IV. ROCKS AND SOILS

V. WATER

FLUORINE

Located in the second period of the table (row 2), fluorine is the first **element** in the family of **halogen** gases. Fluorine is a yellowish gas at room temperature and is very dangerous. Fluorine is both poisonous and very **reactive** with other elements. It can combine with nearly any element on Earth.

Find it in:

I. **ROCKET FUEL.**

II. **URANIUM PURIFICATION**

III. **REFRIGERATION FLUIDS**

There is something that helps your refrigerator work. It's called **Freon** One of the main elements in Freon is fluorine.

IV. **TOOTHPASTE**

V. **ETCHING SOLUTIONS**

Artists use fluorine when they etch glass

NEON

Neon is one of the fun elements. The first thing most people think of is a big neon sign. The gas is placed in glass tubes and an electric **current** is sent through the gas. When excited, neon enters a plasma state and glows red. Neon is the tenth element of the **periodic table** and the second of the **inert** or **noble** gases. The element is incredibly **non-reactive** because of its electron configuration.
When you find it, neon is a clear, odorless gas that isn't very exciting without **electricity**.

Find it in:

TV TUBES

I. CRYOGENICS
Scientists use neon in something called cryogenics. **Cryogenics is when scientists freeze things very quickly..**

II. SIGNS
Neon is a gas. Scientists take neon and pump it into glass tubes.

III. LASERS
Neon is also used in lasers. Right now lasers aren't in guns to blow things up. Scientists use those lasers in experiments. Doctors also use them to do surgery. When you see a doctor using a red light on someone... It might be a laser!

SODIUM

Being in the first column, sodium is a member of the **alkali metal** family with potassium and lithium.
When you purify sodium, you actually wind up with a silvery bright metal that is quite soft and malleable. Sodium is one of the few metals that will float when it is placed in water. Its **atomic mass** is less that water's atomic mass.
Find it in:

I. GLASS MANUFACTURING

II. PAPER MANUFACTURING

III. TABLE SALT

IV. DEVELOPING SOLUTION
When your send their pictures to be developed the company uses different liquids to make the pictures appear. Sodium is in some of those solutions.

V. FERTILIZER

MAGNESIUM

As we move across the third row of the **periodic table**, we find magnesium in the number two position. Humans have used magnesium, like many other simple **elements**, for hundreds of years.
Located in the second column of the periodic table, magnesium is in the family of **alkali earth metals** with calcium and beryllium. When purified, magnesium is a very light and silvery metal. Its lightness makes it perfect for use in many other metal alloys to increase strength without increasing the weight of the structure. Magnesium is also an important element in our diet. Both we and plants need magnesium to live and be healthy. It is called a **trace metal.**

Find it in:

I. **MEDICINE**
Scientist use magnesium in medicine.

II. **CHLOROPHYLL MOLECULES**

III. **CAMERA FLASH BULBS**

ALUMINUM

The metal is a silvery white color and very **reflective.** Another great trait of aluminum is that it is not toxic.
The thirteenth element in the **periodic table** has many other uses. When aluminum is combined with other metals it becomes very strong. It is so strong that engineers use it to build planes and ships

Find it in:

I. **SERVING UTENSILS**

II. **RUBIES AND GEMS**
There is a very special stone called a ruby. It is found in all sorts of jewelry. It has a very deep red color. There are aluminum atoms inside of all rubies.

III. **ALUMINUM FOIL**

IV. **POWER TRANSMISSION LINES**

V. **AIRPLANES AND HELICOPTERS**

VI. **SAPPHIRES**
Aluminum is in a lot of gem stones.

VII. **CANS AND PACKAGING**

SILICON

The periodic table's close relative of carbon is silicon. Silicon is found everywhere in the universe, but is not found by itself in nature. You will always find silicon bound to other elements (usually oxygen). The **rocks** with silicon and oxygen are called **silicates**.
You will find silicon just below carbon in the third row (period) of the **periodic table**. Silicon has a similar makeup to carbon in the way its electrons are arranged. **When purified, it is a metallic looking and grayish crystal. While it might be shiny like a metal, it is not a metal.**

Find it in:

I. CONSTRUCTION MATERIALS
   there is silicon inside all of those sidewalks and brick houses!
II. CERAMICS
III. COMPUTER CHIPS
IV. GLASS
V. SKELETAL SYSTEM
   You might not know that there is an element called calcium which is the main ingredient of your skeleton. Silicon is also inside your skeleton. Silicon keeps your skeleton strong and healthy.

PHOSPHORUS

It is very **reactive.** When isolated and pure, phosphorus is clear and almost transparent. There are four common forms used today: white, black, red, and violet. It's easy to spot phosphorus on the **periodic table** just under nitrogen at position number fifteen.
Find it in:

I. BAKING POWDER
   Scientists use phosphorus to make baking powder. You will find it as the compound calcium phosphate. It's even in some of your cheeses.
II. CHINA AND PLATES
   Phosphorus is also used to make dishes. Fine china is very expensive because a lot of special procedures go into making it. Phosphorus is one of the special elements that are used to make that fine china.
III. FIREWORKS
   You can find lots of phosphorus in fireworks. When phosphorus gets hot it

burns really brightly. The bright sparks and flashes are usually because of that phosphorus.

IV. **FERTILIZER**
Phosphorus is a very important element in fertilizers. Plants need small amounts of phosphorus to grow up healthy. People also need phosphorus and they get it by eating plants.

V. **GLASS**
Scientists use phosphorus when they make glass.

SULPHUR

It is bright yellow in color and it has a really bad smell (like rotten eggs). Beyond the obvious physical traits of sulphur, man has been using this element for thousands of years.. Sulphur is often found near **volcanoes** and hot springs. Sulfur is even mentioned in the bible where it is called **brimstone**.
It's just under oxygen at position sixteen. Naturally occuring sulfur is a yellowish color and often found as a crystal. At normal temperatures, sulfur is **non-reactive**.

Find it in:

I. **FERTILIZER**

II. **MEDICINE**
Sulfur is an important element in medicines. If you have bronchitis and are coughing all the time, sometimes doctors give you sulfa-drugs. This medicine is made with sulfur and helps kill the bacteria making you sick.

III. **VOLCANOES**
If you ever get close enough to a volcano you'll be able to smell the sulfur. It smells like rotten eggs.

IV. **FIREWORKS**
Fireworks are also a good place to find sulfur. Fireworks and firecrackers are filled with gunpowder. One of the main ingredients of gunpowder is sulfur.

V. **MATCHES**
Just like fireworks, there is sulfur in matches that sparks and starts the flames.

CHLORINE

Chlorine is the second member of the **halogen** family. It's is right there in the **periodic table** with other elements like bromine and iodine. Being a halogen, chlorine is found in many salts that are formed with both alkali metals and alkali earth metals (groups I and II).

Find it in:

I. **SWIMMING POOLS**
People put chlorine in the pool to kill bacteria and disease. That addition makes the pool clean for you so you won't get sick

II. **MAKING PAPER**
Scientists use chlorine to make paper white. It bleaches the paper of all color.

III. **BLEACH**
Chlorine in bleach makes your white clothes really white. It also takes the color out of your darker clothes.

IV. **WATER PURIFICATION**
The next time you get a glass of water you should thank chlorine. Chlorine is use to clean the water that comes to your house.

V. **SALT**
The salt on your table is made with chlorine.

VI. **PLASTICS**

VII. It is a special plastic called PVC. That's poly-vinyl-chloride. Chloride is the element chlorine.

ARGON

Argon makes up a little over one percent of our **atmosphere**. Once isolated, argon was not that special. It has no smell and not color. It wound up as the last **element** in period three at position number eighteen. As usual, the last element in the row is an **inert gas**. Argon is in the same family as helium and neon. For a long time, scientists thought that Argon did not combine with any other **elements**. They were wrong.

Find it in:

I. **WELDING**
If you see someone welding you should know that sometimes they use argon. Argon is non-reactive so it is a good element when you use really high temperatures. It makes things safer.

II. **GROWING CRYSTALS**
Argon is used to grow silicon crystals. When scientists grow silicon crystals it must be done in a pure environment. There can be no other elements that might combine with the silicon. Argon is used because it will not react with the silicon.

III. **LIGHT BULBS**
When you look in a light bulb it looks like there's nothing there. But there is! Argon is a gas that scientists put in light bulbs to help them work better.

IV. **VACUUM TUBES**
Many years ago, radios used to be much larger and had big glass tubes inside. Those radio tubes were filled with argon gas.

4. ACIDS AND BASES

Scientists use something called the **pH scale** to measure how acidic or basic a liquid is. Although there may be many types of ions in a solution, pH focuses on concentrations of hydrogen ions (H+) and hydroxide ions (OH-). The scale goes from values very close to 0 through 14. Distilled water is 7 (right in the middle). Acids are found between a number very close to 0 and 7. Bases are from 7 to 14. Most of the liquids you find every day have a pH near 7. They are either a little below or a little above that mark. When you start looking at the pH of chemicals, the numbers go to the extremes. If you ever go into a chemistry lab, you could find solutions with a pH of 1 and others with a pH of 14. There are also very stong acids with pH values below one such as battery acid. Bases with pH values near 14 include drain cleaner and sodium hydroxide (NaOH). Those chemicals are very dangerous.

NAMES TO KNOW
Here are a couple of definitions
Acid: A solution that has an excess of H+ ions. It comes from the Latin word acidus that means "sharp" or "sour".
Base: A solution that has an excess of OH- ions. Another word for base is alkali.
Aqueous: A solution that is mainly water. Think about the word aquarium. AQUA means water.
Strong Acid: An acid that has a very low pH (0-4).
Strong Base: A base that has a very high pH (10-14).

Weak Acid: An acid that only partially ionizes in an aqueous solution. That means not every molecule breaks apart. They usually have a pH close to 7 (3-6).
Weak Base: A base that only partially ionizes in an aqueous solution. That means not every molecule breaks apart. They usually have a pH close to 7 (8-10).
Neutral: A solution that has a pH of 7. It is neither acidic nor basic.

Acids are compounds that break into hydrogen (H+) ions and another compound when placed in an aqueous solution. Bases are compounds that break up into hydroxide (OH-) ions and another compound when placed in an aqueous solution.

If you have an ionic compound and you put it in water, it will break apart into two ions. If one of those ions is H+, the solution is acidic. If one of the ions is OH-, the solution is basic.

That pH scale we talked about is actually a measure of the number of H+ ions in a solution. If there are a lot of H+ ions, the pH is very low. If there are a lot of OH- ions, that means the number of H+ ions is very low, so the pH is high.

Catalysts

A catalyst is a substance that will change the rate of a reaction. A catalyst is often used to make a reaction go faster. The catalyst itself does not take part in the reaction as a reactant. It is not changed by the reaction, it is not used up during the reaction. It is still there in the same form when the reaction is complete. A catalyst is usually a transition metal, a transition metal oxide or an enzyme in living cells. An exception is aluminium oxide, used in the cracking of hydrocarbons. A substance which works well as a catalyst for one reaction might not work well as a catalyst for a different reaction.

How does a catalyst work?

A catalyst works by providing a convenient surface for the reaction to occur. The reacting particles gather on the catalyst surface and
1) collide more frequently with each other
2) more of the collisions result in a reaction between particles because the catalyst can lower the activation energy for the reaction.

A catalyst is often used as a powder, so that it has a bigger surface area per gram.

5. DEFINITIONS OF OXIDATION AND REDUCTION (REDOX)

Oxidation and reduction in terms of oxygen transfer

Definitions

- Oxidation is gain of oxygen.
- Reduction is loss of oxygen.

For example, in the extraction of iron from its ore:

reduction

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$

oxidation

Because both ***red***uction and ***ox***idation are going on side-by-side, this is known as a ***redox*** reaction.

Oxidising and reducing agents

An oxidising agent is substance which oxidises something else. In the above example, the iron(III) oxide is the oxidising agent.

A reducing agent reduces something else. In the equation, the carbon monoxide is the reducing agent.

- Oxidising agents give oxygen to another substance.
- Reducing agents remove oxygen from another substance.

Oxidation and reduction in terms of hydrogen transfer

These are old definitions which aren't used very much nowadays. The most likely place you will come across them is in organic chemistry.

Definitions

- Oxidation is loss of hydrogen.
- Reduction is gain of hydrogen.

Notice that these are exactly the opposite of the oxygen definitions.

For example, ethanol can be oxidised to ethanal:

$$CH_3CH_2OH \longrightarrow CH_3CHO$$

oxidation by loss of hydrogen

You would need to use an oxidising agent to remove the hydrogen from the ethanol. A commonly used oxidising agent is potassium dichromate(VI) solution acidified with dilute sulphuric acid.

Ethanal can also be reduced back to ethanol again by adding hydrogen to it. A possible reducing agent is sodium tetrahydridoborate, $NaBH_4$. Again the equation is too complicated to be worth bothering about at this point.

reduction by gain of hydrogen

$$CH_3CHO \longrightarrow CH_3CH_2OH$$

An update on oxidising and reducing agents

- Oxidising agents give oxygen to another substance or remove hydrogen from it.
- Reducing agents remove oxygen from another substance or give hydrogen to it.

Oxidation and reduction in terms of electron transfer: This is easily the most important use of the terms oxidation and reduction at A' level.

Definitions

- ***Oxidation is loss of electrons.***
- ***Reduction is gain of electrons.***

It is essential that you remember these definitions. There is a very easy way to do this. As long as you remember that you are talking about electron transfer:

OIL RIG

oxidation is loss   reduction is gain

6. Electrolytes and Electrolysis

In any chemical reaction, the existing chemical bonds are broken and new chemical bonds are formed. Hence, all chemical reactions are fundamentally electrical in nature since electrons are involved in some way or the other in all types of chemical bonding. Many chemical reactions utilize electrical energy, whereas others can be used to produce electrical energy. As electrical energy involves the flow of electrons, these reactions are concerned with the transfer of electrons from one substance to the other.

Examples of Electrolytes

Strong electrolyte	Weak electrolyte	Non-electrolyte
Sea water	Tap water	Chemically pure water
Hydrochloric acid	Carbonic acid	Alcohol
Sulphuric acid	Acetic acid	Kerosene
Aqueous copper sulphate	Ammonium hydroxide	Aqueous sugar solution
Molten lead bromide	Citric acid	Carbon disulphide
Aqueous sodium chloride	Oxalic acid	
Nitric acid		
Aqueous potassium hydroxide		

"Electrolysis is the electrolytic dissociation and decomposition of an electrolyte (electrovalent substance), by the passage of a direct current or electricity through its aqueous or molten form

Electrolyte

A compound (mostly an ionic compound) that conducts electricity in molten (fused) or aqueous (solution) state, and which simultaneously undergoes decomposition with the passage of electric current through it is known as an electrolyte.

Electrodes

The two metallic conductors in the form of rods dipped in the electrolyte and connected to the two terminals of the battery are called electrodes.

The anode is the electrode connected to the positive terminal of the battery.

The cathode is the electrode connected to the negative terminal of the battery.

Anions

The negatively charged atoms or group of atoms, which under the influence of an electric field migrate towards the anode (or positive electrode) are called anions.

Cations

The positively charged atoms or group of atoms, which under the influence of an electric field migrate towards the cathode (or negative electrode) are called cations.

Electrolytic cell

The container or a vessel consisting of the cathode, anode and the electrolyte is called an electrolytic cell. It is also known as a voltameter.

Battery or cell

For a current to flow through a conductor, a difference in charge should be maintained between the two ends of the conductor. To ensure this, a cell or a battery is used. The cell or a battery converts its chemical energy into electrical energy thus maintaining a constant difference of charge between any two points.

Simple Voltaic Cell

In a simple voltaic cell a zinc plate and a copper plate are immersed in a very dilute solution of sulphuric acid, taken in a glass vessel. These two metal plates are called electrodes and the solution is called the electrolyte. The copper plate and the zinc plate are externally connected to a bulb as shown in the figure

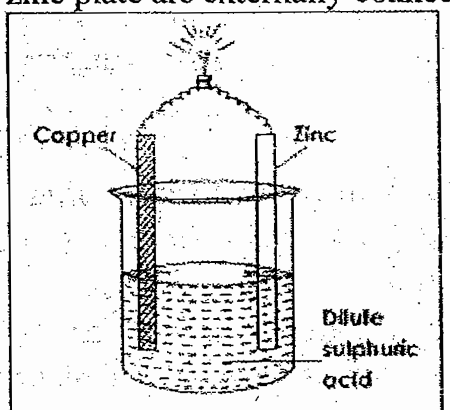


Fig. 4.7. Simple voltaic cell

Zinc loses electrons more readily than copper, as it is more electropositive than copper. Each zinc atom loses two free electrons and hence gains two units of positive charge.

$$Zn \longrightarrow Zn^{2+} + 2e^-$$

As copper is lower in the metal activity series, it does not undergo a similar reaction and hence remains a region of deficiency of electrons. So, when the zinc plate and the copper plate are connected by means of a metal wire, free electrons from the zinc plate flow to the copper plate and the bulb connected externally starts glowing.
Some of these electrons get added to hydrogen ions of the sulphuric acid of the electrolyte, to form free hydrogen.

$$H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{2-}$$

$$[H^+ + 1e^- \longrightarrow H] \times 2 \rightarrow H_2$$

It may be noted that in a voltaic cell, that the direction the flow of electrons is not affected if the position of the two metals is reversed.

As zinc metal is oxidised to zinc ions, oxidation occurs here. The electrons given up by zinc leave the cell from this electrode and travel the external circuit to copper electrode. Here, the electrons enter the cell and bring about the reduction of the hydrogen ions of the sulphuric acid. Thus an electric current is delivered as a result of a spontaneous oxidation reduction reaction.

Applications of Electrolysis
Electrolysis has various applications. Some of them are mentioned below:
a) Electroplating or coating of metals.
b) Electrorefining or purification of metals.
c) Electrometallurgy or extraction of metals from metallic ores.
Electroplating
Electroplating is a process of depositing a thin layer of a fine and superior metal (like chromium, zinc, nickel, gold etc.) over the article of a baser and cheaper metal (like iron, copper, brass), with the help of electric current.

Uses

Electroplating is very useful because of the following reasons:

- Surface protection e.g. nickel plating of iron to prevent corrosion.
- Makes the article attractive e.g., electroplating of silver or gold on brass etc.
- Repair of finer machine parts.

Process

The process of electroplating involves the following steps:

- Before electroplating the metal surface is cleaned thoroughly. Firstly, an alkaline solution is used to remove grease and then it is treated with acid to remove any oxide layer. It is then washed with water.
- The article to be electroplated is made cathode since metallic ions are positive and thus get deposited on the cathode.
- The anode is made of pure metal, which is to be coated on the article.
- The electrolyte is the salt of the metal to be coated on the article.
- A direct (D.C.) current is passed through the electrolyte. The anode dissolves, depositing the metal ions from the solution on the article in the form of a metallic coating. The passage of low current is continued for a long time to ensure an even coating.
- To obtain a thin, coherent and bright deposit, the conditions of low current density, optimum temperature and low metal ion concentration are found to be helpful.
- The choice of electrolyte for use in the electroplating bath is very important. A good electrolyte should have the following characteristics.
- It should be highly soluble in water.
- Its solution should be a reasonably good conductor of electricity.
- Its solution should be stable towards oxidation, reduction and hydrolysis.
- It should be reasonably priced.

a) Electroplating with Nickel

Electrolyte - Aqueous solution of nickel sulphate

Reaction at Cathode (Reduction)	Reaction at Anode (Oxidation)
Ions at cathode: Ni^{2+}, H^+	**Ions at anode:** SO_4^{2-}, OH^-
Preferential discharge of Ni^{2+} ions takes place.	None of the above ions discharge at anode; instead Ni atoms of the anode lose electrons to form Ni^{2+} ions.
$Ni^{2+}(aq) + 2e^- \longrightarrow Ni^0(s)$	$Ni^0(s) - 2e^- \longrightarrow Ni^{2+}(aq)$
Nickel metal deposits on the article, i.e., nail.	Ni^{2+} ions are formed at anode.

b) Electroplating with Silver

Electrolyte - Aqueous solution of sodium argento cyanide $Na[Ag(CN)_2]$.

Reaction at Cathode (Article to be plated)	Reaction at Anode (Silver Block)
Ions at cathode: Ag^+, Na^+, H^+	**Ions at anode:** OH^-, CN^-
Preferential discharge of Ag^+ ions takes place (Reduction).	Neither of the anions discharge, instead silver atoms lose electrons and become Ag^+ ions (Oxidation).
$Ag^+(aq) + e^- \longrightarrow Ag^0(s)$ Silver deposits on the article i.e., spoon	$Ag^0(s) - e^- \longrightarrow Ag^+$ Silver ions enter the solution at anode

7. The Reactivity Series of Metals

K	Potassium	Most reactive
Na	Sodium	
Ca	Calcium	
Mg	Magnesium	
Al	Aluminium	
C	Carbon	
Zn	Zinc	
Fe	Iron	
Sn	Tin	
Pb	Lead	
H	Hydrogen	
Cu	Copper	Least reactive
Ag	Silver	
Au	Gold	
Pt	Platinum	

C H *added for comparison*

- The higher the metal in the series, the more reactive it is i.e., its reaction is fast and more exothermic.
- This also implies that the reverse reaction becomes more difficult i.e., the more reactive a metal, the more difficult it is to extract from its ore. The metal is also more susceptible to corrosion with oxygen and water.
- The reactivity series can be established by observation of the reaction of metals with water, oxygen or acids.
- A metal in the series, can displace any metal below it in the series, from the oxide, chloride or sulphate of the less reactive metal.

Iron + Copper (II) sulphate $\longrightarrow$ Iron (II) sulphate + copper

$$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$$

Copper (II) sulphate solution is blue, iron sulphate solution is almost colourless when dilute. During the displacement, the blue solution loses its colour, and the iron metal is seen to turn pink-brown as the displaced copper becomes deposited on it.

On heating the mixture of magnesium powder and black copper(II) oxide, white magnesium oxide is formed with brown bits of copper:

$$Mg + CuO \xrightarrow{\Delta} MgO + Cu$$

Adding magnesium to blue copper(II) sulphate solution, the blue colour fades as colourless magnesium sulphate is formed and brown bits of copper metal form a precipitate:

$Mg + CuSO_4 \Rightarrow MgSO_4 + Cu$

- Hydrochloric acid makes a metal chloride
- Sulphuric acid makes a metal sulphate
- Reactions with nitric acid are complex, the nitrate is formed but the gas is rarely hydrogen, and more often, an oxide of nitrogen.
- Within the general reactivity or activity series there are some periodic table trends:

Two non-metals, carbon and hydrogen are important chemical reference points with regard to the method of metal extraction and reactivity towards acids. Metals above carbon cannot be extracted by carbon reduction and are usually extracted by electrolysis. Metals below hydrogen will not displace hydrogen from acids:

Metals	Reactivity and Reactions
Potassium K	Very reactive, very rapid with cold water forming the alkali potassium hydroxide and hydrogen gas (which is ignited). $2K + 2H_2O_{(l)} \Rightarrow 2KOH_{(aq)} + H_{2(g)}$
Sodium Na	◻ Fast reaction with cold water forming the alkali sodium hydroxide and hydrogen gas. $2Na_{(s)} + 2H_2O_{(l)} \Rightarrow 2NaOH_{(aq)} + H_{2(g)}$ ◻ The reaction of sodium with water - the sodium melts to a silvery ball and fizzes as it spins over the water. The rapid exothermic reaction produces a colourless gas - gives a squeaky pop! with a lit splint - hydrogen. Universal indicator will turn from green to purple/violet - the strong alkali sodium hydroxide is formed. The sodium floats because it is less dense than water.
Calcium Ca	◻ Quite reactive with cold water forming the moderately soluble alkali calcium hydroxide and hydrogen gas. $Ca_{(s)} + 2H_2O_{(l)} \Rightarrow Ca(OH)_{2(aq/s)} + H_{2(g)}$ ◻ Very reactive with dilute hydrochloric acid forming the colourless soluble salt calcium chloride and hydrogen gas. $Ca_{(2)} + 2HCl_{(gq)} \Rightarrow CaCl_{2(aq)} + H_{2(g)}$ ◻ Not very reactive with dilute sulphuric acid because the colourless calcium sulphate formed is not very soluble and coats the metal inhibiting the reaction. $Ca_{(s)} + H_2SO_{4(aq)} \Rightarrow CaSO_{4(s)} + H_{2(g)}$

Magnesium Mg	▫ Slow reaction with water forming the slightly soluble alkali magnesium hydroxide and hydrogen gas. $Mg_{(s)} + 2H_2O_l \Rightarrow Mg(OH)_{2\,(aq/s)} + H_{2\,(g)}$ ▫ With steam, the reaction is faster with heated magnesium and the white powder magnesium oxide is formed with the hydrogen. Magnesium will burn with a bright white flame in steam, if previously ignited in air! $Mg_{(s)} + H_2O_{(g)} \Rightarrow MgO_{(s)} + H_{2(g)}$ ▫ In fact it will even burn in carbon dioxide forming black specks of carbon! $2Mg_{(s)} + CO_{2(g)} \Rightarrow 2MgO_{(s)} + C_{(s)}$ ▫ Very reactive with dilute hydrochloric acid forming the colourless soluble salt magnesium chloride and hydrogen gas. $Mg_{(s)} + 2HCl_{(aq)} \Rightarrow MgCl_{2(aq)} + H_{2(g)}$ ▫ Very reactive with dilute sulphuric acid forming colourless soluble magnesium sulphate and hydrogen. $Mg_{(s)} + H_2SO_{4(aq)} \Rightarrow CaSO_{4(s)} + H_{2(g)}$
Aluminium Al	▫ Aluminium has no reaction with water or steam due to a protective aluminium oxide layer of Al_2O_3. ▫ Slow reaction with dilute hydrochloric acid to form the colourless soluble salt aluminium chloride and hydrogen gas. $2Al_{(s)} + 6HCl_{(aq)} \Rightarrow 2AlCl_{3(aq)} + 3H_{2\,(g)}$ ▫ The reaction with dilute sulphuric acid is extremely slow to form colourless aluminium sulphate and hydrogen. $2Al_{(s)} + 3H_2SO_{4\,(aq)} \Rightarrow Al_2(SO_4)_{3\,(aq)} + 3H_{2(g)}$
(Carbon C, a non-metal)	▫ Elements higher than carbon ie aluminium or more reactive, must be extracted by electrolysis (or displacing it with an even more reactive metal). Metals below it, ie zinc or a less reactive, can be extracted by reducing the hot metal oxide with carbon

Zinc Zn	◘ No reaction with cold water. ◘ When the metal is heated in steam zinc oxide and hydrogen are formed. $Zn_{(s)} + H_2O_{(g)} \Rightarrow ZnO_{(s)} + H_{2(g)}$ ◘ Quite reactive with dilute hydrochloric acid forming the colourless soluble salt zinc chloride and hydrogen gas. $Zn_{(s)} + 2HCl_{(aq)} \Rightarrow ZnCl_{2(aq)} + H_{2(g)}$ ◘ Quite reactive with dilute sulphuric acid forming the colourless soluble salt zinc sulphate and hydrogen gas. $Zn_{(s)} + H_2SO_{4(g)} \Rightarrow ZnSO_{4(s)} + H_{2(g)}$ (this reaction is catalysed by adding a trace of copper sulphate solution) ◘ Zinc can be extracted by reducing the hot metal oxide on heating with carbon $2ZnO_{(s)} + C_{(s)} \Rightarrow 2Zn_{(s)} + CO_{2(g)}$ ◘ A zinc coating (galvanising) is used to protect iron from rusting.
Iron Fe	◘ No reaction with cold water (rusting is a joint reaction with oxygen). ◘ When the metal is heated in steam an iron oxide (unusual formula) and hydrogen are formed. This oxide is 'technically' Iron (III,II) oxide!!!! $3Fe_{(s)} + 4H_2O_{(g)} \Rightarrow Fe_3O_{4(s)} + 4H_{2(g)}$ ◘ Slow reaction with dilute hydrochloric acid forming the soluble pale green salt iron(II) chloride and hydrogen gas. $Fe_{(s)} + 2HCl_{(aq)} \Rightarrow FeCl_{2(aq)} + H_{2(g)}$ ◘ Slow reaction with dilute sulphuric acid forming the soluble pale green salt iron(II) sulphate and hydrogen gas. $Fe_{(s)} + H_2SO_{4(g)} \Rightarrow FeSO_{4(s)} + H_{2(g)}$ ◘ Iron can be extracted by reducing the hot metal oxide on heating with carbon monoxide formed from carbon in the blast furnace eg $Fe_2O_{3(s)} + 3CO_{(g)} \Rightarrow 2Fe_{(s)} + 3CO_{2(g)}$ $Fe_3O_{4(s)} + 4CO_{(g)} \Rightarrow 3Fe_{(s)} + 4CO_{2(g)}$
(Hydrogen H non-metal	◘ None of the metals below hydrogen can react with acids to form hydrogen gas. They are least easily corroded metals and partly accounts for their value and uses in jewellery, electrical contacts etc.
Copper Cu	◘ No reaction with cold water or when heated in steam. ◘ No reaction with dilute hydrochloric acid or dilute sulphuric acid. ◘ Copper can be extracted by reducing the hot black metal oxide on heating with carbon $2CuO_{(s)} + C_{(s)} \Rightarrow 2Cu_{(s)} + CO_{2(g)}$

Silver Ag	◻ No reaction with cold water or when heated in steam. ◻ No reaction with dilute hydrochloric acid or dilute sulphuric acid. ◻ Silver can be extracted by reduction but can be found 'native' as the element
Gold Au	◻ No reaction with cold water or when heated in steam. ◻ No reaction with dilute hydrochloric acid or dilute sulphuric acid. ◻ Gold can be readily extracted from its ores easily by reduction but it is usually found 'native' . Pure gold is 24 carat
Platinum Pt	◻ No reaction with cold water or when heated in steam. ◻ No reaction with dilute hydrochloric acid or dilute sulphuric acid. ◻ Like gold, it is a very rare metal . It is used in expensive jewellery, laboratory ware (inert crucible container) and catalytic converters in car exhausts.

8.Minerals and Ores

Metals and their compounds are found in earth as natural elements known as minerals. Ores are minerals from which metals are extracted at low cost with minimum effort. Ores contains metal compounds with a percentage of impurities. All the ores are minerals, but all the minerals are not ores.

Metals and their Ores

Oxides	Carbonates	Halides	Sulphides	Sulphates
Zincite(ZnO)	Marble or Lime stone ($CaCO_3$)	Flurospar (CaF_2)	Zinc blende (ZnS) Galena (PbS)	Anglesite ($PbSO_4$)
Haematite ($Fe_2O_3.xH_2O$) Magnitite (Fe_3O_4)	Calamine ($ZnCO_3$)	Cryolite (Na_3AlF_6)	Iron pyrites (FeS_2)	Baryle ($BaSO_4$)
Bauxite ($Al_2O_32H_2O$)	Siderite ($FeCO_3$)	Horn Silver ($AgCl$)	Cinnabar (HgS)	Gypsum ($CaSO_4$ $2H_2O$)
Cuprite (Cu_2O)	Magnesite (Mg CO_3)	Rock salt ($NaCl$)		Epsom Salt ($MgSO_4.7H_2O$)

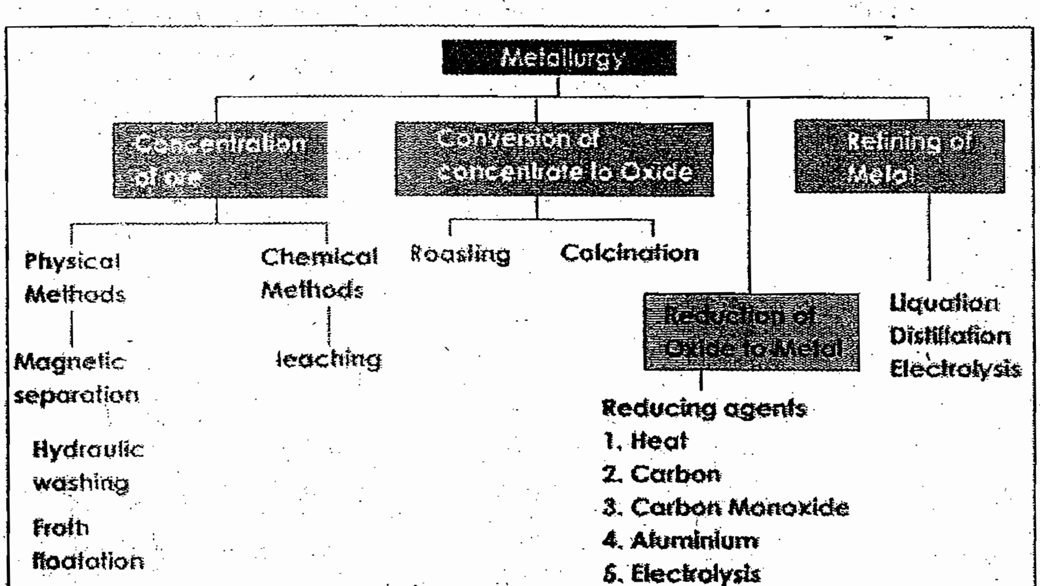
Occurrence of Metals

- Metals like gold and platinum occur in the free metallic form not acted upon by air or water
- The rest of the metals occur in the combined form as compounds. Copper is one of the metals which occur in free as well as combined state
- Aluminium is the most abundant metal in the earth's crust
- The second most abundant metal in the earth is iron and the third one is calcium

Metallurgy

It is a study of the physical and chemical behavior of metallic elements and their mixtures, called alloys. Metallurgists study the microscopic mechanisms that cause a metal or alloy to behave in the way that it does, the changes that occur at the atomic level, that affect the metal's (or alloy's) macroscopic properties. The various processes involved in the extraction of metals from their ores and refining are known as metallurgy. The compounds of various metals mixed with impurities and found in nature are called minerals. The naturally occurring metals from which metal can be extracted profitably and conveniently are called ores.

Processes Involved during Metallurgy



Zone Refining

This method is used for obtaining ultra pure metals like germanium, silicon and gallium.

Van Arkel's Method

This method is used for obtaining ultra pure titanium

Metal Corrosion and the Rusting of Iron

Iron (or steel) corrodes more quickly than most other transition metals and readily does so in the presence of both oxygen (in air) and water to form an iron oxide. Rusting is speeded up in the presence of salt solution.

Rusting is $Fe_{(s)} + O_{2(g)} + H_2O_{(l)}$ □ $Fe_2O_3 . x H_2O_{(s)}$ i.e., rust is hydrated iron (III) oxide (the equation is not meant to be balanced and the amount of water x is variable, from dry to soggy). Rusting is oxidation because it involved iron gaining or iron atoms losing electrons .

The rusting of iron is a major problem in its use as a structural material.

Iron and steel (alloy of iron) are most easily protected by paint which provides a barrier between the metal and air/water. Moving parts on machines can be protected by a water repellent oil or grease layer.

This 'rusting' can be prevented by connecting iron to a more reactive metal (e.g., zinc or magnesium). This is referred to as sacrificial protection or sacrificial corrosion, because the more reactive protecting metal is preferentially oxidised away, leaving the protected metal intact. Iron or steel can also be protected by mixing in other metals (e.g., chromium) to make non-rusting alloys called stainless steel. The chromium, like aluminium, forms a protective oxide layer.

Coating iron or steel with a thin **zinc layer** is called **'galvanizing'**. The layer is produced by electrolytic deposition by making the iron/steel the negative cathode or dipping the iron/steel object in molten zinc. The zinc preferentially corrodes or oxidises to form a zinc oxide layer that doesnot flake off like iron oxide rust. Also, if the surface is scratched, the exposed zinc again corrodes before the iron and continues to protect it.

Steel cans are protected by relatively unreacted tin and works well as long as the thin tin layer is complete.

Aluminium does not oxidise (corrode) as quickly as its reactivity would suggest. Once a thin oxide layer of (Al_2O_3) has formed on the surface, it forms a barrier to oxygen and water and so prevents further corrosion of the aluminium.

Aluminium is a useful structural metal. It can be made harder, stronger and stiffer by mixing it with small amounts of other metals (e.g magnesium) to make alloys.

Copper and lead are both used in roofing situations because neither are very reactive. The compounds formed do not flake away as easily as rust does from iron. Lead corrodes to a white lead oxide or carbonate and copper corrodes to form a basic green carbonate (combination of the hydroxide $Cu(OH)_2$ and carbonate $CuCO_3$).

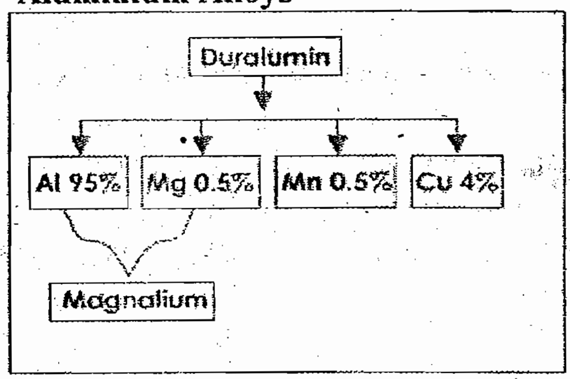
Both metals have been used for piping but these days lead is considered too toxic. Copper is usually used as the stronger, but equally unreactive alloy brass.

The Group 1 Alkali Metals rapidly corrode in air and need to be stored under oil.

9.Alloys

An alloy is a mixture of two or more metals fused together in molten state. Metals when melted tend to dissolve in one another forming alloys. The various properties of a metal like malleability, ductility, strength, hardness, resistance to corrosion and appearance can be improved by mixing with other metals. Alloys have properties different from its constituents.

Aluminium Alloys



Al – Alloy	Property/ Reason for alloying	Uses
Duralumin (Al,Mg,Mn,Cu)	Light, strong, resistant to corrosion	Aircraft, tools, pressure cooker
Magnalium (Al, Mg)	Light, hard, tough, corrosion resistant	Aircrafts, scientific instruments

Copper Allloys

	Cu	Zn	Sn	Pb	Ni
Brass	60-80%	40-20%			
Bronze	80%	2%	18%		
Gun metal	90%		10%		
German Silver	50%	30%			20%
Bell metal	80%		20%		

Cu – Alloy	Property/ Reason for alloying	Uses
Brass	Lustrous, easily cast, Alloy is Malleable, ductile, harder than Cu	Electrical fittings. Medals, hardware
Bronze	Hard, brittle, takes up polish	Statues, medals, coins
Bell metal	Hard, brittle, sonorous Alloy is more sonorous than Cu or Sn	Bells, gongs
Gun metal	Hard, brittle, easily cast	Barrels, cannon
German silver	Hard, silvery, takes up polish	Decorative articles

Steel Alloys

Steel – Alloy	Property/ Reason for alloying	uses
Stainless steel (Fe, C, Ni, Cr)	Lustrous, resistant to corrosion, high tensile strength Alloy: Acquires brilliant silvery shine on alloying with Ni, Cr	Utensils, cutlery, automobile parts

Nickel Steel (Fe,C,Ni)	Hard, corrosion resistant, elastic Light, hard, tough, corrosion resistant	Cables, aircraft parts and propeller shafts
Tungsten steel	Very hard Corrosion resistant Alloy: Acquires hardness on alloying with tungsten (W)	High speed machine parts

Alloying of Gold

From the first discoveries of gold in ancient times, its beauty and the ease with which it could be worked inspired craftsmen to create it into ornaments, not just for adornment, but as symbols of wealth and power

Pure gold is used in those parts of the world where jewellery is purchased as much for in- vestment as it is for adornment, but it tends to be vulnerable to scratching. Elsewhere, it is usually mixed, or alloyed, with other metals. Not only do they harden it, but influence the colour; white shades are achieved by alloying gold with silver, nickel or palladium; red alloys contain mainly copper. A harder alloy is made by adding nickel or a tiny percentage of titanium.

The proportion of gold in jewellery is measured on the carat (or karat) scale. The word carat comes from the **carob seed, which was originally used to balance scales in Oriental bazaars**. Pure gold is designated 24 carat, which compares with the "fineness" by which bar gold is defined.

Pure Gold alloys

Caratage	Fineness	% Gold
24	1000	100
22	916.7	91.67
18	750	75
14	583.3	58.3
10	416.7	41.67
9	375	37.5

The most widely used alloys for jewellery in Europe are 18 and 14 carat, although 9 carat is popular in Britain. Portugal has a unique designation of 19.2 carats. In the United States 14 carat predominates, with some 10 carat. In the Middle East, India and South East Asia, jewellery is traditionally 22 carat (sometimes even 23 carat). In China, Hong Kong and some other parts of Asia, "chuk kam" or pure gold jewellery of 990 fineness (almost 24 carat) is popular. In many countries the law requires that every item of gold jewellery is clearly stamped with its caratage. This is often controlled through hallmarking, a system which originated in London at Goldsmiths' Hall in the 14th century. Today it is compulsory in such countries as Britain, France, the Netherlands, Morocco, Egypt, and Bahrain. Where there is no compulsory marking manufacturers themselves usually stamp the jewellery both with their own individual identifying mark and the caratage or fineness.

Some common alloys and what we use them for

There are zillions of different alloys used for zillions of different purposes. We've listed 20 of the more common (or otherwise interesting) ones in the table below. There are lots of different variations on most alloys and the precise mixture can vary widely, so the percentage figures you see quoted in different books will often not agree exactly.

Alloy	Components	Typical uses
Alnico	Iron (50%+), aluminum (8-12%), nickel (15-25%), cobalt (5-40%), plus other metals such as copper and titanium.	Magnets in loudspeakers and pickups in electric guitars.

Amalgam	Mercury (45-55%), plus silver, tin, copper, and zinc.	Dental fillings.
Babbitt metal ("white metal")	Tin (90%), antimony (7-15%), copper (4-10%).	Friction-reducing coating in machine bearings.
Brass	Copper (65-90%), zinc (10-35%).	Door locks and bolts, brass musical instruments, central heating pipes.
Bronze	Copper (78-95%), tin (5-22%), plus manganese, phosphorus, aluminum, or silicon.	Decorative statues, musical instruments.
Cast iron	Iron (96-98%), carbon (2-4%), plus silicon.	Metal structures such as bridges and heavy-duty cookware.
Cupro-nickel (copper nickel)	Copper (75%), nickel (25%), plus small amounts of manganese.	Coins.
Duralumin	Aluminum (94%), copper (4.5-5%), magnesium (0.5-1.5%), manganese (0.5-1.5%).	Automobile and aircraft body parts, military equipment.
Gunmetal	Copper (80-90%), tin (3-10%), zinc (2-3%), and phosphorus.	Guns, decorative items.
Magnox	Magnesium, aluminum.	Nuclear reactors.
Nichrome	Nickel (80%), chromium (20%).	Firework ignition devices, heating elements in electrical appliances.
Nitinol	Nickel (50-55%), titanium (45-50%).	Shape memory alloy used in medical items, spectacle frames that spring back to shape, and temperature switches.
Pewter	Tin (80-99%) with copper, lead, and antimony.	Ornaments, used to make tableware before glass became more common.
Solder	Tin (50-70%), lead (30-50%), copper, antimony, and other metals.	Connecting electrical components into circuits.
Steel (general)	Iron (80-98%), carbon (0.2-2%), plus other metals such as chromium, manganese, and vanadium.	Metal structures, car and airplane parts, and many other uses.

Steel (stainless)	Iron (50%+), chromium (10-30%), plus smaller amounts of carbon, nickel, manganese, molybdenum, and other metals.	Jewelry, medical tools, tableware.
Stellite	Cobalt (67%), chromium (28%), tungsten (4%), nickel (1%).	Coating for cutting tools such as saw teeth, lathes, and chainsaws.
Sterling silver	Silver (92.5%), copper (7.5%).	Cutlery, jewelry, medical tools, musical instruments.
White gold (18 carat)	Gold (75%), palladium (17%), silver (4%), copper (4%)	Jewelry.
Wood's metal	Bismuth (50%), lead (26.7%), tin (13.3%), cadmium (10%).	Solder, melting element in fire sprinkler systems.

Other Metal Alloys

Nickel silver

is a metal alloy of copper with nickel and often but not always zinc. It is named for its silvery appearance, but contains no elemental silver unless plated. Other common names for this alloy are **German silver**, **paktong**, **new silver** and **alpacca** (or **alpaca**).

Monel

Monel (or monel metal) is a trademarked name for a range of corrosion-resistant bright metal alloys containing typically 67 percent nickel, 30 percent copper, and trace proportions of iron, manganese, and other elements. It is not a synonym for Nickel Silver and should not be confused with it. Monel is more expensive than Nickel Silver because of the high proportion of nickel and its more specialist applications.

Gun Metal

An alloy in the bronze family, used especially where resistance to wear and corrosion is desired. Clasically, an alloy of Cu 88 %, Sn 10%, Zn 2%, traditionally used for making cannon and other industrial products. Also used loosely to describe other dark-grey cast metals such as found in toys, badges, buckles etc.

Pinchbeck

Pinchbeck is a yellow metal alloy in the brass family. Invented by Christopher Pinchbeck in the 18th century, it was claimed to be a secret recipe, but is generally believed to be 83% copper and 17% zinc. This ratio optimises the gold matching colour of the alloy. Commonly known as "poor man's gold". It and similar alloys were widely used in costume jewellery, and as the metal substrate for fire gilding and (from 1840) gilt electroplating. Now included under the generic name "Gilding Metal".

Spelter

Spelter is an alternative name for the metal zinc, especially when used in decorative arts manufacture and casting. Spelter castings were often patinated to imitate more valuable bronze.

Tutania

Tutania is an alloy of copper, antimony, zinc and tin patented in 1770 by William Tutin whose Birmingham firm (Tutin and Haycroft) used it in commercial production of housewares.

Cupro-Nickel

A silvery-coloured binary alloy of copper and nickel. Widely used for minting coinage. It is also called copper-nickel, especially in US usage. In the UK it has been used since 1947 for "silver" coins, usually in an alloy of Cu 75%, Ni 25%. The alloy in the current 20p coin of the UK is Cu 84%, Ni 16%.

Bronze

Any of various alloys of copper with tin and often zinc. Widely used for minting coinage. In the UK bronze coinage (the copper-coloured coins of 1860-1992) the alloy was Cu 95.5%, Sn 3%, Zn 1.5%

Nickel Brass

Any of various brass coloured alloys of copper with zinc and a small component of nickel. Widely used for minting coinage. In the UK's nickel brass coinage (the twelve-sided threepenny piece) the alloy was Cu 79%, Zn 20%, Ni 1%.

Britannia Metal

Britannia metal is another name for pewter in its modern lead-free formulation, usually 91% tin, 7.5% antimony, 1.5% copper.

10. SOME IMPORTANT COMPOUNDS

1.Ammonia

Uses

- Ammonia solutions are used to clean, bleach, and deodorize; to etch aluminum; to saponify (hydrolyze) oils and fats; and in chemical manufacture.
- Ammonia is also used in large amounts in the Ostwald process for the synthesis of nitric acid; in the Solvay process for the synthesis of sodium carbonate; in the synthesis of numerous organic compounds used as dyes, drugs, and in plastics; and in various metallurgical processes.
- The ammonia sold for household use is a dilute water solution of ammonia in which ammonium hydroxide is the active cleansing agent.
- As a constituent of smelling salt, it revives a fainted person. But it should be used with caution since it can attack the skin and eyes. The vapors are especially irritating prolonged exposure and inhalation cause serious injury and may be fatal.
- Ammonia and its compounds are mainly used as fertilizers.
- Liquid ammonia is used as refrigirant.

2.Sulphur Dioxide

Uses

- It is a powerful germicide and insecticide and hence it is used a household fumigant.
- It can bleach delicate fibres.
- It undergoes easy liquefaction and vaporization and hence it is used as refrigerent in cold storage plants.
- It is used in the manufacture of sulphuric acid by contact process
- It is raw material for manufacture of calcium bi sulphite used in treatment of wood pulp for paper industry.
- It is used in sugar industry for refining sugar.

3.Sulphuric acid

Uses

- In the manufacture of fertilizers, ammonium phosphate and calcium super phosphate.
- In the manufacture of rayon and nylon and also in the preparation of dyes and drugs from coal tar derivatives.
- In the manufacture of the explosives such as Tri-nitro toluene , Tri-nitro glycerine and picric acid.
- In the manufacture of nitric acid, hydrochloric acid and phosphoric acid.
- In the manufacture of sodium sulphate for glass industry and ferrous sulphate for ink industry.
- In the purification of petrol, kerosene, and lubricants.
- It is used in metallurgy for extraction of metals. Leaching of metallic compounds gives sulphates which on electrolysis gives the metal in pure form .It is used for pickling of metals.
- It is used in storage of batteries.
- It is used as a laboratory reagent for the preparation of iodine, carbon monoxide and hydrogen.

4. Sodium Carbonate (Na_2CO_3)

Popularly known as washing soda or soda ash, sodium carbonate is a commercially important compound. In earlier days, it was obtained from the ash of plants and from natural deposits in India and Egypt.

Uses of Sodium Carbonate

Sodium carbonate is used :

- as washing soda in laundry as a cleansing agent
- for softening hard water
- in manufacturing glass, paper, soap and caustic soda
- as a valuable laboratory reagent
- in quantitative analysis to standardise acid solutions
- in qualitative analysis in the detection of acid radicals of insoluble salts

5. Sodium Bicarbonate ($NaHCO_3$)

Sodium bicarbonate is commonly called baking soda.

Uses of Sodium Bicarbonate

- Used in the preparation of carbon dioxide
- Used as a constituent of baking powder, and in effervescent drinks. Baking powder has sodium bicarbonate and tartaric or citric acid. When it is

dissolved in water or heated carbon dioxide is produced. This carbon dioxide gas causes the puffiness and lightness of cakes, biscuits etc.

- Sodium bicarbonate is used to extinguish fire as it produces carbon dioxide gas.
- It is used to remove acidity. Due to its alkaline nature, it reacts with excess acid generated in the stomach and neutralises it to relieve acidity.

6. Bleaching Powder ($CaOCl_2$)

Calcium oxychloride is the chemical name of bleaching powder.

Uses

- Bleaching powder is commonly used for bleaching clothes.
- It is also used in bleaching wood pulp in the paper industry.
- It is used to disinfect drinking water.
- It is used in the manufacture of chloroform ($CHCl_3$), an anaesthetic.
- It is used as an oxidising agent.
- It is used to shrink wool.

7. Plaster of Paris ($CaSO_4$) $2.H_2O$

Chemically, plaster of paris is known as calcium sulphate hemihydrate (hemi means half).

Uses

- Plaster of Paris is used to set fractured bones due to its setting property on hydration.
- It is used as a sealant in laboratories.
- Can be used to make casts for toys, statues, ornaments and decorative items.
- It is used as a fire proofing material.
- Used in the manufacture of black-board chalk.

8. Cement

Portland cement is a very important building material. It was first discovered in England. It got its name because on setting, it hardened to a stone-like mass and was compared to the famous Portland Rock of England. It is a mixture of calcium and aluminium silicates with gypsum.

The approximate composition of cement is
Calcium oxide (CaO) = 50 - 60%
Silica (SiO_2) = 20 - 25%
Alumina (Al_2O_3) = 5 - 10%
Magnesium oxide (MgO) = 2 - 3%
Ferric oxide (Fe_2O_3) = 1 - 2%
Sulphur trioxide (SO_3) = 1 - 2%

9. Glass

Any amorphous and transparent solid that is a product of the solidification of a liquid is called glass. However, glass is generally referred to as the transparent substance obtained when white sand is fused with oxides and carbonates of alkaline earth metals and the molten mixture is cooled. Glass is a super cooled liquid i.e., it is a liquid cooled much below its freezing point. The ordinary room temperature is much below the freezing point of glass.

From Egypt to Alexandria to other European countries and the US, the history of glass dates back to the 17^{th} century and before.

Manufacture of Glass

Raw Materials

- Silica (in the form of sand)
- Compounds of alkali metals, like Na_2CO_3, Na_2SO_4, $NaNO_3$, K_2CO_3 and KNO_3.
- Compounds of alkaline earth metals, like $CaCO_3$, CaO, $BaCO_3$. (for glass with high refractive index)
- Oxides of heavy metals, like PbO, Pb_3O_4
- Calcium phosphate, $Ca_3(PO_4)_2$ (for opalescent glass that also contains arsenic and antimony oxides)
- Colouring materials - Metallic oxides like ferric oxide (yellow), chromic oxide (green), manganese oxide (purple) and cobalt oxide (blue) are added to fused silicates to get coloured glass.

Properties of Glass

As we have seen, glass is a mixture of number of silicates. Therefore, when heated, it does not melt at a fixed temperature. But, it softens gradually and hence can be moulded into any desired shape. It is this property that makes glass one of the widely used materials.

Annealing

Glass if cooled rapidly becomes brittle and fragile and if cooled very slowly becomes opaque because of devitrification. For this purpose, before making articles, glass is passed through a long tunnel like furnace that is very hot at one end and very cold at the other. When glass is passed through this furnace, it is progressively cooled. This process is known as annealing and takes several days to be completed.

Varieties of Glass

I. **Soda Glass**

Otherwise known as soft glass

- **Composition**

Sand /Quartz : SiO_2 : 75% (will be nice if this can be a mouse over)
Sodium Oxide : Na_2O : 15%
Calcium Oxide : CaO : 8%
Aluminium Oxide : Al_2O_3 : 2% (impurity)

Uses

Since it softens at a comparatively lower temperature and can be shaped into different forms, it finds use in making windowpanes, bottles, etc.

II. **Potash Glass (Hard Glass)**

- **Composition**

Sand /Quartz : SiO_2
Potassium oxide : K_2O
Calcium Oxide : CaO
Aluminium Oxide : Al_2O_3

Uses

Has a higher melting point and can withstand higher temperature. Hence it finds use in laboratory ware.

III. **Flint Glass**

- **Composition**

Silica : 45%
Sodium oxide : 4%
Potassium oxide : 4%
Calcium oxide : 3%
Lead oxide : 44%

Lead carbonate or oxide replaces calcium carbonate. Potassium carbonate partly replaces sodium carbonate.

Uses

It has higher density, transparency and refracting power than ordinary glass. Hence used for making optical instruments. It is also used for ornament purposes.

IV. **Pyrex Glass**

- **Composition**

Silica : 80%
Sodium oxide : 4%
Calcium oxide : 0.5%
Potassium oxide : 0.5%
Boron trioxide :12%
Aluminium trioxide : 3%

Uses

It has very low co-efficient of expansion and can withstand sudden changes in temperature. Therefore highly suitable for laboratory ware like flasks, beakers and oven proof cook wares.

V. **Jena Glass**

- It has lesser alkaline and higher alumina content than soda glass. It also contains barium oxide, zinc oxide and boron trioxide instead of silica.

Uses

More resistant to the action of acid or alkali. Hence can be used to make acid and alkali containers.

VI. **Crooke's Glass**

- Contains cerium oxide as one of the constituents as one of the constituents.

Uses

It is used for optical purposes as it has the capacity to cut off the ultra violetrays.

VII. **Safety Glass or Unbreakable Glass**

- It is prepared by placing a layer of transparent plastic (sheet of vinyl acetate resin) between two layers of glass and sealing the layers with adhesive.

Uses

This variety of glass does not break easily under ordinary impact. Even though it breaks under heavy impact, glass pieces are not shattered because they are held by plastic. Therefore it is used in making windscreens of automobiles, aeroplanes and trains. It can also serve as bullet proof glass to some extent.

10. Steel

Carbon content of steel is between 0.1 and 1.5%. This is intermediate between cast iron and wrought iron. The hardness of steel increases with increase in carbon content. Steel contains other elements like manganese, chromium, silicon, nickel, tungsten, vanadium, and molybdenum. These elements are added for making steels of different kinds.

Properties of Steel

The properties of steel depend on the carbon content and the heat treatment imparted to it.

If the carbon content is low, the steel is soft and ductile and is called mild steel.

As the carbon content increases, the ductility decreases, but the tensile strength increase upto 1.5% of carbon content. After that it decreases.

Steel melts at a lower temperature than wrought iron. Adding a little manganese imparts elasticity to steel and if 10% manganese is added, steel becomes very hard. It can be used in making mechanical crushers.

Adding chromium makes steel chemically resistant and is used as stainless steel in utensils, cutlery, surgical tools etc.

Heat Treatment of Steel

The hardness and elasticity of steel can be controlled by heat treatment. When it is heated to redness and then allowed to cool slowly, it becomes soft. This process is known as **annealing**.

If it is cooled suddenly by plunging into ice-cold water **(quenching)**, steel becomes very hard and brittle. On reheating to 250° - 300°C, the brittleness disappears but the hardness is retained.

The degree of hardness can be controlled by heating the product once again to a temperature ranging from 200° to 350°C and then allowing it cool slowly. This is called **tempering**. Based on the temperature, the colour of the oxide film formed on the surface varies.

Temperature	Colour
230°C	Pale yellow
260°C	Brown
280°C	Purple
300°C	Blue

Colour of oxide film formed due to tempering of steel

Case Hardening

When wrought iron absorbs carbon at the surface, its surface becomes hard. This is called **case-hardening**. This can also be done by heating wrought iron and potassium ferrocyanide. A surface layer of steel is formed on wrought iron. This is used to make armour plates and parts of machinery that face constant wear and tear.

Nitriding

When steel (containing 1% of aluminium) is heated in an atmosphere of ammonia at 550°C - 600°C, the surface of steel becomes very hard. This is called **nitriding.** Nitrogen formed by the dissociation of ammonia reacts with iron and aluminium to form the respective nitrides on the surface. These nitrides settle in the interstices (an intervening space, crevice) of the iron crystals resulting in a compact and hard surface.

11. Calcium Oxide (CaO)

Calcium oxide is commonly called Quick Lime. Quick lime has always been a cheap commodity because limestone deposits are readily available. Lime manufacturing and application dates back to the Roman, Greek and Egyptian civilizations.

Uses of Lime

- Lime is indispensable for use with mortar and plaster.
- Lime is used for medicinal purposes, insecticides and plant and animal food.
- It is used as a laboratory reagent for gas absorption, precipitation, dehydration etc.
- It is used as a reagent in the manufacture of paper, high grade steel and cement.
- If finds use in dehairing hides.
- It can be used for water softening and in the recovery of ammonia (by-product of Solvay process).
- It finds enormous use in the manufacture of soap, rubber, varnish, refractories and lime bricks.
- It also finds use in the preparation of calcium carbide, basic calcium nitrate and calcium bisulphite.
- Improves the quality of soil.

12. Slaked Lime $Ca(OH)_2$

When calcium oxide reacts with water, it liberates heat and cracks into a white powder. This white powder is calcium hydroxide or slaked lime. The process is called slaking of lime.

Uses

Calcium hydroxide is used for:

- Testing carbon dioxide (CO_2) in laboratories. It turns milky when carbon dioxide is passed into it due to the precipitation of calcium carbonate ($CaCO_3$).
- White washing buildings. This reacts slowly with carbon dioxide (CO_2) in the air to form calcium carbonate ($CaCO_3$) on the walls and give a bright appearance.
- Making mortar when mixed with sand and water.
- Preparing bleaching powder, caustic soda (NaOH) and ammonia (NH_3).
- Reducing acidity of soil.
- Softening temporary hard water.
- Tanning leather.

Summary

Common name	Chemical name	Formula
Washing soda	Sodium carbonate decahydrate	$Na_2CO_3.10H_2O$
Baking soda	Sodium bi carbonate	$NaHCO_3$
Quick lime	Calcium oxide	CaO
Bleaching powder	Calcium oxychloride	$CaOCl_2$
Slaked lime	Calcium hydroxide	$Ca(OH)_2$
Plaster of Paris	Calcium sulphate hemi hydrate	$(CaSO_4)_2.H_2O$
Gypsum	Calcium sulphate dihydrate	$CaSO_4.2H_2O$
Dead burnt plaster	Calcium sulphate anhydrous	$CaSO_4$
Lime stone	Calcium carbonate	$CaCO_3$

Some of the important compounds of sodium and calcium were discussed in this chapter. It may be understood that the properties of similar compounds of other elements in Group I and Group II will resemble the properties of the compounds discussed in this chapter. The fact that the elements are classified in groups help us in understanding their properties and therefore their application in a better perspective.

11.Chemistry in Everyday Life

Chemotherapy

Chemotherapy is the use of chemicals or drugs to selectively destroy infectious micro-organisms without destroying the live tissues or the host. Paul Ehrlich called drugs as magic bullets and the first milestone of his research was the discovery of Salvarsan for curing syphilis, in 1909. In 1935, Gerhard Domagk, administered a dose of a dye called prontosil (inhibits the growth of streptococci bacteria) to cure his daughter's fever. This laid the foundation for modern chemotherapy and got a Nobel Prize for medicine for Domagk in 1939. Ernest Fourneau, a French scientist in 1936 proved that in the human body, prontosil breaks down to give sulphanilamide. Sulphanilamide is the actual active agent that inhibits streptococci. This study led to the discovery of sulpha drugs and from there on growth of chemotherapy has reached amazing heights.

Analgesics

Drugs that are used as pain relievers are called analgesics. They are of two types:

a) Narcotics

b) Non-narcotics

Narcotics

These analgesics are mainly opium and its products. Some examples are

- morphine
- codeine and
- heroin.

They are effective analgesics but cause addiction. Over dosage can cause sleep and unconsciousness.

Non-narcotics

Drugs belonging to this group also have antipyretic properties (decrease body temperature). **Aspirin** and **analgin** are common drugs in this category.

Tranquillisers

Tranquillisers reduce anxiety and tension. They are of two types:

1) Sedatives
2) Antidepressants (mood elevators or Pep pills)

Sedatives

Sedatives are used for mentally agitated or violent patients. Equanil (chemical name - meprobanate) and calmpose (diazepam) are a couple of common drugs in this category.

Antidepressants or Mood Elevators or Pep Pills

Antidepressants are useful for patients who are highly depressed or have lost self-confidence. These drugs produce a feeling of well-being and improve efficiency. Tofranil, vitalin, amphetamines and cocaine are some examples.

Antiseptics and Disinfectants

Sterilization is the process of complete elimination of micro-organisms. The chemicals used for sterilization are classified as:

a) Antiseptics
b) Disinfectants

Antiseptics

Antiseptic can be used to kill bacteria or prevent their multiplication. Antiseptics do not harm the living tissues. Therefore, they can be applied on cuts and wounds. Dettol, cetavelon, savlon, acriflavin, gentian-violet, mercuro chrome, boric acid and potassium permanganate are some examples.

Disinfectants

Disinfectants are used to kill bacteria. They are used to sterilize instruments, utensils, clothes, floors, sanitary fittings, sputum and excreta. They harm the living tissues and cannot be used on skin. Some examples are phenol, methyl phenol, hydrogen peroxide and sulphur dioxide.

Sometimes the same substance may be used as an antiseptic or disinfectant. When the concentration is less, it is an antiseptic and when the concentration is more, the substance acts as disinfectant. For instance, 0.2% solution of phenol is an antiseptic and 1.0% solution of phenol is a disinfectant.

Anti-fertility Drugs

With global population growing by the day, birth control has become essential. There are drugs that control ovulation and if regularly consumed, function as effective contraceptives. Some examples of birth control pills are orthonovum and Enovid. Orthonovum is a mixture of norethindrone and mestranol, estratriene. Envoid is a mixture of norethynodrel and mestranol.

Antacids

Tension and mental stress escalate the level of acid in bile juice. This hyperacidity can be combated using bases like calcium carbonate, magnesium hydroxide or aluminium hydroxide in the form of tablets or aqueous suspensions. These react with hydrochloric acid in the stomach and neutralize it partially. Gelusil and Digene are two examples of antacids

Antihistamines

Histamine is naturally present in almost all body tissues. When the human body meets substances causing allergies, histamine is released. For e.g., when a person is suffering from hay fever, histamine is released. Amines that are used as drugs to control the allergy caused by histamines are called **Antihistamines.** Histamine release induces allergic responses in the human body like:

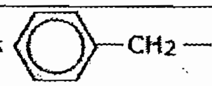
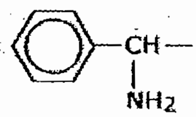
i) Tissue inflammation
ii) Itching
iii) Asthma
iv) Skin irritation

Antibiotics

They are produced by micro-organisms that are toxic to other micro organisms. Alexander Fleming in 1920 found that bacteria donot flourish in nutrient agar surrounded by the fungus Penicillium notatum westling. He found that this fungus produces an antibiotic called penicillin. There are many varieties of pencillin with the empirical formula $C_9H_{11}O_4SN_2R$. Penicillin is very effective for:

i) Pneumonia
ii) Bronchitis
iii) Sore throat

Six natural penicillins are isolated till now. They are got by substituting various groups for R.

Name	Substituent (R)
Penicillin G or Benzyl pencillin	R is 
Penicillin P	R is $CH_3CH_2CH{=}CH{-}CH_2{-}$
Penicillin K	R is $CH_3{-}(CH_2)_6{-}$
Ampicillin	R is 

Ampicillin though quite effective, can cause allergy in certain patients.

Other antibiotics

Chloramphenicol is a suitable drug for diseases like pneumonia, relapsing fever, typhoid, dysentry, whooping cough and urinary infections.

Streptomycin

Streptomycin is very effective against tuberculosis, throat and lung infections, ear and kidney infections as well.

Tetracyclines

Tetracyclines (Chloro and oxy) are broad spectrum antibiotics (antibiotics capable of curing many infections) and cure diseases caused by many bacteria, large viruses, protozoa, parasites and rickettsiae. These can be orally administered since they are absorbed from the gastro intestinal tract.

Dyes - Chromophores

Unsaturated groups or groups with multiple bonds that impart color to the organic compound are called chromophores. Examples are the nitro, the nitroso and the azo groups.

Chromogens

The compounds containing the chromophoric group are called the chromogens. Depth of their color increases with the number of chromophores.

Auxochromes as Dyes

Auxochromes (salt forming groups like hydroxyl, amino) do not impart color to the chromogens in the absence of chromophores. However, when the chromogen has a chormophore, the auxochrome deepens the color of the chromogen. It is also used to make the chromogen a dye.

Dyes were obtained from animal and vegetable sources in the earlier days. Today most of the available dyes are prepared synthetically from aromatic compounds.

Classification of Dyes Based on Application

Direct or Substantive Dyes

These can be directly applied by immersing the cloth in a hot solution of the dye in water. They can be again classified into acid and basic dyes.

Acid dyes are sodium salts of sulphonic acid and nitrophenols. They are used for dyeing animal fibers (wool and silk) but not vegetable fibers (cotton). The dye solution is acidified with sulphuric or acetic acid.

Basic dyes are salts of color bases with hydrochloric acid or zinc chloride. They can directly dye animal fibers. They need a fixing agent called mordant (tannin) to dye vegetable fibers. These are used for dyeing silk and cotton.

Mordant or Adjective Dyes

Mordant is any substance that can be fixed to fiber and later dyed on. Hydroxides or basic salts of chromium aluminium or iron are examples. Tannic acid is a suitable mordant for basic dyes. The fabric is first dipped into the solution of mordant and then in the dye solution. An insoluble colored complex called lake is obtained. It is insoluble and fast to washing.

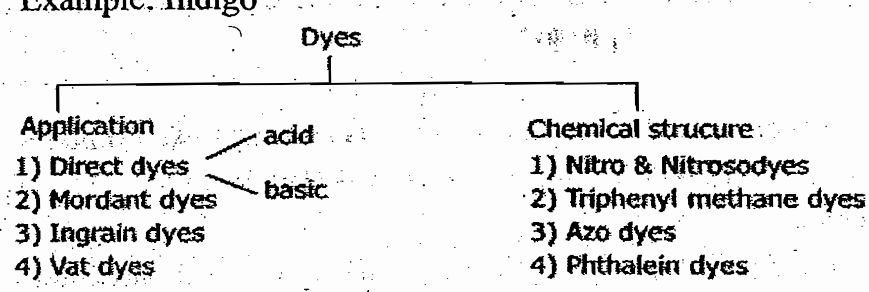
Ingrain Dyes

They are produced in the fiber itself during dyeing. For example, a cloth is soaked in an alkaline solution of □ - naphthol and dipped in a diazonium salt solution. Azodye is produced on the fiber due to coupling.

Vat Dyes

These are water insoluble colored compounds. They can be reduced to colorless (leuco) compounds, that are soluble in alkali and are easily reoxidized to give the dye. These dyes dye both animal and vegetable fibers directly. Mostly they are used for cotton fibers. The cloth treated with alkali is oxidised by air which makes the dye return to the insoluble form.

Example: Indigo



Classification of Dyes Based on Chemical Structure

Nitro and Nitroso dyes

Oldest synthetic dyes do not have much commercial importance.

Triphenyl methane dyes

These have brilliant colors but fade with washing and on exposure to light. They are used for coloring paper and typewriter ribbons. By introducing - NH_2, NR_2, or - OH groups (anxochromes) into the triphenyl methane ring (chromogen) a colorless leuco compound is obtained. The leuco compound gives the tertiary alcohol called the color base (colorless benzenoid compound) on oxidation. This in presence of acid readily changes to the quinonoid dye due to salt formation. We observe reversible changes.

$$\underset{\text{(colourless)}}{\text{Leuco base}} \underset{\text{reduction}}{\overset{\text{oxidation}}{\rightleftharpoons}} \underset{\text{(colourless)}}{\text{Colour base}} \underset{\text{alkali}}{\overset{\text{acid}}{\rightleftharpoons}} \underset{\text{(coloured)}}{\text{Dye}}$$

Examples are malachite green, para rosaniline, rosaniline, crystal violet and aurin.

Azodyes

They have the same chromophore - N = N -, the azo group. They differ in auxochromes. Common auxochromes are - NH_2, NR_2 and -OH groups. Examples are aniline yellow, butter yellow, methyl orange, methyl red, resorcin yellow, congo red, chrysoidone, bismark brown.

Phthaleins are got by the condensation of phenol with phthalic anhydride in the presence of dehydrating agent like concentrated sulphuric acid or anhydrous zinc chloride. Examples are phenolphthalein, fluorescein and eosin.

Natural Dyes (Alizarin and Indigo)

Dyes can also be classified as natural and synthetic dyes. Compounds extracted from plants are called natural dyes. These were used in olden days to color fabrics. Alizarin (red) and indigo (blue) are two examples. Synthetic dyes came into being to provide more varieties of colors.

Alizarin belongs to the anthraquinone class of dyes. Indigo belongs to the indigoid type of dyes.

Perfumes

Perfumes have pleasant smell due to the esters used in their synthesis.

Characteristics of a good perfume are:

Harmonious and lasting smell

- Stability
- Volatility
- Ability to affix in the cosmetic

Sources of Perfumes

Plant Sources

- Essential oils of
- Flowers
- Leaves

- Fruits
- Roots or wood

Animal Sources

- Musk
- Ambergris

Composition

Odoriferous components

These are essential oils or synthetic substances or both. Constitute 2 -10% of the perfume and impart a pleasant smell to the perfume. Blending many odoriferous components will give a harmonious fragrance.

Fixatives

These impart stability by fixing volatile odoriferous substances. Examples are civet, musk, vanillin and castor.

Solvent

Solvents dilute the odor causing substances. These solvents should be odorless, volatile, inert and harmless. Ethyl alcohol and water are examples. Components of essential oils such as terpenoids like citronellol, nerol, geraniol are widely used in perfumes.

Perfumes are widely used in soaps, lotions, shampoos, deodorants etc.

Deodorants

Decrease or eliminate body odors due to perspiration. Bacterial growth and action on perspiration causes objectionable odors. This odor varies from one person to another and also according to the diet and activity in the same person.

Salts of aluminium, iron and zinc prevent perspiration by their astringent action. Many such salts also have antibacterial properties and therefore are widely used as deodorants.

Talcum Powder

All kinds of facial and body powders contain hydrated magnesium silicate (talc - 3 Mg 0.4 $SiO_2.H_2O$). These powders absorb perspiration and superficial skin oil. A good powder should

- spread evenly
- stay on
- have the right degree of opacity (covering power)

Composition of Talcum Powder

- Calcium carbonate, magnesium carbonate - Help absorbency
- Titanium dioxide, zinc oxide, magnesium dioxide - Impart opacity

- Talc, metallic soaps - slipping
- Magnesium and zinc stearates - imparts adhesive property

Talc - Particle Size

Right grade or particle size of talc is important. A coarse talc has poor adhesiveness and is abrasive.

The particle size of talc should be less than 74 microns for face powder. The powder becomes soft, fluffy, light and transparent when the talc is of the right nature.

Talc can:

- repel water
- slide over with minimum friction because of the flat structure of its particles.

Role of Magnesium carbonate

It is about five times more powerful than talc in absorbing water. Hence it is often used to enhance absorbency and lightness of powders.

Boric acid in Powders

Boric acid being a germicide and a buffering agent is often added to powders. However, it is not advisable to use powders containing boric acid for babies.

Micro Alloys

Micro alloyed steels are intermediate carbon steel alloys with 0.3 to 0.6% carbon content. They also include vanadium, columbium (niobium), titanium and so on. These micro alloys are tougher than higher alloys. Their enhanced strength is due to the precipitation hardening reaction where nitrides or carbonitrides are formed in steel. Therefore, nitrogen level control is a key factor.

Today we have second-generation and third generation micro alloys. These have 0.1 to 0.3 % carbon and 0.15% carbon respectively. These second-generation and third generation micro alloys are tougher than the earlier micro alloy grades.

Applications

High performance micro alloys are used in automotive, agricultural, truck and heavy equipment components.

Chemical Preservatives

Chemicals added to food materials to prevent the growth of micro organisms or prevent spoilage and to increase their shelf life are called preservatives. Some examples are given below:

1. Sodium benzoate is used as a preservative for fruits, fruit juices, jams and squashes. 0.06% to 0.1% (concentration) of sodium benzoate is added. It is easily soluble in water and therefore readily mixes with the food product.
2. Potassium metabisulphite or sodium metasulphite can also be used as preservative for fruits like apples, lichies and raw mango preparations besides fruit juices. However, these chemicals cannot be used for preserving colored food materials as sulphur dioxide, one of their products, behaves as a bleaching agent with acids. Sulphur dioxide is a very good chemical to kill the harmful micro organisms in food.
3. Vinegar (acetic acid) is usually used as a preservative in pickles.

Antioxidants

Antioxidants prevent rancidity in oils and fats. For example, butylated hydroxy anisole is a very common antioxidant. Vitamin-E is a natural antioxidant.

Artificial Sweetening Agents

For diabetic patients, sugar cannot be used as a sweetening agent. Artificial sweetening agents that are non-nutritive in nature are used as substituents for sugar (specially in soft drinks). Examples are saccharin (500 times sweeter than sucrose) and cyclamates.

However cyclamates are suspected to cause cancer and are banned generally. Aspartame (160 times sweeter than sucrose), another artificial sweetener is the methyl ester of the dipeptide aspartyl phenylalanine.

Edible Colors and Flavors

Food colors are used in ice creams, dairy products, sweet meat, soft drinks, confectionery, etc. These colors are also used in oral medicines like capsules, tablets, syrups and liquids to improve their appearance. Some of the primary colors are water soluble. They are: quinoline yellow, tartrazine, sunset yellow FCF, erythrosine, poncean 4R, carmoisine, amaranth and brilliant blue.

Flavors are used to give pleasant smell for juices, jams etc. Vanillin is used as a flavor. Generally esters are used as flavors

Soaps and Detergents

Soaps are sodium or potassium salts of higher fatty acids like stearic, palmitic and oleic acids. Fatty acids are organic acids that have more than sixteen carbon atoms in their molecular structure. The sodium soaps are called hard soaps and the potassium soaps are known as soft soaps. Soaps are obtained from oils and fats. For e.g., tristearin is got from beef and mutton tallow, tripalmitin from palm oil and triolein from lard (pig fat), olive oil and cotton seed oil. In India, soap is commonly got from coconut, groundnut, til and mahua oils.

Manufacture of Soap - Saponification

Saponification is the process where oil or fat (tristearin) is treated with sodium hydroxide solution called lye, to form soap and glycerine.

$$\begin{array}{l} CH_2O.CO.C_{17}H_{35} \\ | \\ CHO.CO.C_{17}H_{35} \\ | \\ CH_2O.CO.C_{17}H_{35} \\ \text{Tristearin (fat)} \end{array} + \underset{\text{lye}}{3NaOH} \longrightarrow \begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \\ \text{glycerol} \end{array} + \underset{\text{sodium stearate (soap)}}{3C_{17}H_{35}COONa}$$

Soap can be manufactured by:

- The hot process
- The cold process
- The modern process

The Hot Process

Manufacture of soap by the hot process involves the following steps:

I. Saponification

Oil or fat is taken in a huge iron-pan called soap kettle and heated with open steam. 10% sodium hydroxide solution (lye) is added in a thin stream. The steam keeps the mass boiling and ensures thorough mixing as well. Saponification is complete after several hours to give a frothy mixture of sodium salts and glycerine.

Fat or Oil + Lye $\longrightarrow$ Soap + Glycerol

II. Salting out of Soap

Saponfication is complete when we see a slight excess of the alkali in the transparent reaction mixture. Common salt or brine is then added to precipitate soap and heating is continued. Soap forms in the upper layer as a thick mass. This is known as **salting out of soap**.

The unused alkali solution in the lower layer is called spent lye or sweet lye. This along with glycerol and salts is drawn from below the reaction vessel. Glycerol can be recovered from this.

III. Finishing

The soap obtained after salting out is boiled again with sodium hydroxide for complete saponificaiton. This converts all the unsaponified fat. The spent lye is then drawn off. The solid soap is then boiled with water to dissolve excess of alkali. It is then allowed to settle when the impure soap called **nigre** forms the lower layer. The pure soap in the upper layer is transferred through a swing pipe to a steam-jacketed tank called crutcher.

It is then shredded into small chips, dried to the requisite amount of moisture content and mixed with colouring substances and perfumes. Some fillers like rosin, sodium silicate, borax and sodium carbonate are added to laundry soaps. They have detergent value and are less expensive than soap.

In the next step, the soap is allowed to run into moulds and permitted to solidify. The bigger blocks are then cut with steel wires into smaller slabs, which are then cut into smaller cakes and stamped.

The Cold Process

Oil or molten fat is taken in an iron pan fitted with a stirrer. It is then treated with lye (any strong alkaline solution, like potassium hydroxide used for washing or cleansing). Stirring is continued till the soap begins to set. After solidification in frames, it is cut into slabs and further into cakes. All the glycerine remains in the soap. Starch or other fillers are thoroughly mixed with the oil before lye is added. This process is not so economical as the hot process and the soap obtained is also not pure.

Proportions of Ingredients

Alkali 1 part

Water 7 parts

Starch 1 part

Difference between Toilet Soap and Laundry Soap

Toilet Soap	Laundry Soap
High quality fats and oils as raw materials	Cheaper quality fats and oils
Expensive perfumes added	Cheap perfumes added
Care is taken to ensure that there is no free alkali content to prevent injuries to skin	No such care is taken
No fillers	Fillers present

Special Varieties of Soap

- Floating Soaps

Made by beating large quantities of air into soap in a crutcher when the soap is in a creamy state

- Transparent Soaps

Contains glycerol or alcohol. Obtained by dissolving soap in alcohol and evaporating the solvent alcohol.

- Medicated Soaps

Medicinal substances added. Examples are neem soap and carbolic soap.

- Shaving Soaps

Potassium sodium stearates (produces lasting lather) containing gum and glycerine to prevent lather drying.

Cleansing Action of Soap

Unimolecular film of soap molecules on water surface

A soap has two dissimilar ends. At one end is the hydrocarbon chain that is non-polar and hydrophobic (oil soluble). At the other end there is the carboxylate ion that is polar and hydrophilic (water soluble).

$C_{17}H_{35}$ – COO^+Na^- ⟶ 

non polar — polar — Polar

When soap is added to water, its molecules make a unimolecular film on the surface of water with their carboxyl groups dissolved in water and the hydrocarbon chains standing on end to form a hydrocarbon layer

Cleansing action of a soap

When a soiled cloth is soaked in soap solution, soap dissolves dirt (fat or oil with dust absorbed in it) by micelle formation. Micelles are an aggregate of molecules in a colloidal solution. The oil or fat is at the centre of the sphere with fat-soluble hydrocarbon chains of soap dissolved in it. The water soluble carboxylate ions make a hydrophilic surface around this sphere and render the miscelles of oil or fat water-soluble. Thus the micelles are dissolved in water and are washed away. Soap tends to concentrate on the solution surface and therefore lowers its surface tension, causing foaming. This helps it to penetrate the fabric. It emulsifies fat in dirt to form micelles and renders all the micelles water-soluble. Thus the water washes the dirt away.

Synthetic Detergents

They possess the desirable properties of ordinary soaps and can be used with hard water and in acidic solutions as well. Synthetic detergents are sodium salts of long chain benzene sulphonic acids or sodium salt of long chain alkyl hydrogen sulphates. Their calcium or magnesium salts are soluble in water.

The hydrophobic part is the hydrocarbon chain and the water soluble part can be:

- An anionic group like sulphate or sulphonate
- A cationic group like amine salt or quaternary ammonium compound
- A non-ionic group like alcohol or ether

Some examples of detergents are as follows:

Alkyl Sulphates (Anionic)

- $CH_3(CH_2)_{10}CH_2OSO_3^-Na^+$ - sodium lauryl sulphate
- $CH_3(CH_2)_{16}CH_2OSO_3^-Na^+$ - sodium stearyl sulphate
- Alkyl benzene sulphonates (Anionic)

Properties

Some of the synthetic detergents with a branched hydrocarbon chain have very low biodegradability. They are resistant to bacterial attack and are not fully degraded in sewage treatment units. Therefore, they cause water pollution when they are discharged into a river or any other water body. Phosphate salts present in synthetic detergents cause rapid growth of algae that deplete the oxygen content in the water. (A condition known as eutrophication). Due to this aquatic animals die resulting in the imbalance of the ecosystem as well.

These detergents lower the surface tension of water and act as cleansing agents (wetting agents). They can be used for delicate fabrics because they do not hydrolyze to give hydroxyl ions. They have equal action in both hard and soft water.

Composition of a Common Detergent

Sodium alkylbenzene sulphonate	18%
Dedusting agent	3%
Foam booster	3%
Sodium tripolyphosphate, builder	50%
Anti-corrosion agent	6%
Optical brightener	0.3%
Water and inorganic filler	19.7%

Tripolyphosphate can produce hydroxyl ions by reacting with water. It keeps the wash water slightly alkaline, to emulsify grease particles. They can also tie up calcium and magnesium ions that cause hardness of water.

Advantages of Detergents Over Soaps

Soaps are not suitable when hard water is used. Detergents can be used with both hard and soft water. Detergents are more soluble in water than soaps. They also have a stronger cleansing action than soaps. Detergents do not need expensive vegetable oil for their preparation as they can be prepared from hydrocarbons of petroleum. They can be used in acidic solutions whereas soaps cannot be used (free fatty acids are precipitated).

Soaps	**Detergents**
Soaps are sodium salts of higher fatty acids	Detergents are sodium salts of long chain benzene sulphonic acid or the sodium salts of a long chain alkyl hydrogen sulphate
Calcium and magnesium salts of soaps are in soluble in water. Therefore cleansing action of soap reduces in hard water	Calcium and magnesium salts of detergents are soluble in water. Therefore cleansing action of detergents remain unaffected in hard water
Soaps are prepared from natural oils and fats	Synthetic detergents are prepared from hydrocarbons of petroleum

Soaps cannot be used in acidic medium	Detergents can be used in acidic medium
Soaps are biodegradable	Most of the detergents are non-biodegradable

Dry cleaning

Dry cleaning is any cleaning process for clothing and textiles using an organic solvent rather than water. The solvent used is typically tetrachloroethylene (perchloroethylene), abbreviated "perc" in the industry and "dry-cleaning fluid" by the public. Dry cleaning is necessary for cleaning items which would otherwise be damaged by water and soap or detergent. It may be used if hand washing— needed for some delicate fabrics — is excessively laborious.

Solvents used:

Modern

- **Glycol ethers** (dipropylene glycol tertiary-butyl ether) (Rynex) — In many cases more effective than perchloroethylene (perc) and in all cases more environmentally friendly.
- **Hydrocarbon** — This is most like standard dry cleaning, but the processes use hydrocarbon solvents such as Exxon-Mobil's DF-2000 or Chevron Phillips' EcoSolv. These petroleum-based solvents are less aggressive than perc and require a longer cleaning cycle.
- **Liquid silicone** (decamethylcyclopentasiloxane or D5) — gentler on garments than Perc and does not cause color loss.
- **Modified hydrocarbon blends** (Pure Dry)
- **Perchloroethylene** — In use since the 1940s, perc is the most common solvent, the "standard" for cleaning performance, and most aggressive cleaner. It can cause color bleeding/loss, especially at higher temperatures, and may destroy special trims, buttons, and beads on some garments. Better for oil-based stains (which account for about 10% of stains) than more common water-soluble stains (coffee, wine, blood, etc). Known for leaving a characteristic chemical smell on garments. Nonflammable.
- **Liquid CO_2** — superior to conventional methods, but the Drycleaning and Laundry Institute commented on its "fairly low cleaning ability" in a 2007 report.
- **Wet cleaning** — Not a solvent, but a system that uses water and biodegradable soap. Computer-controlled dryers and stretching machines ensure that the fabric retains its natural size and shape. Wet cleaning is

claimed to clean a majority of "dry clean only" garments safely, including leather, suede, most tailored woolens, silk and rayon. (Neckties seem to be the one exception.)

Historical

- Carbon tetrachloride — Toxic and corrosive.
- Trichloroethane — Overly aggressive and harsh.
- Stoddard solvent — Very flammable and explosive.
- CFC-113 - Freon — Ozone destroying CFC.

Rocket Propellants

Propellants are the fuels used in rockets for propulsion. For example, alcohol, liquid hydrogen, liquid ammonia, kerosene, hydrazine and paraffin can be used as propellants.

To burn them, rocket fuels require an oxidising agent. Examples are: liquid oxygen, liquid fluorine, dinitrogen tetroxide (N_2O_4), nitric acid (HNO_3), a nitrate, chlorate or perchlorate.

There are two types of propellants:

Solid Propellants

Solid propellants are a mixture of solid hydrocarbon and an oxidising agent. This oxidising agent is stable at room temperature. For example, a mixture of paraffin and potassium nitrate (KNO_3). Paraffin is the solid hydrocarbon and KNO_3 acts as the oxidising agent. These are divided into:

- Composite and
- Double base propellants

Composite Propellants

They consist of a polymeric binder (polyurethane or polybutadiene) and ammonium perchlorate (oxidiser). Additives like finely divided aluminium or magnesium enhance their performance.

Double Base Propellants

Double base propellants mainly use nitroglycerine and nitrocellulose. These two together constitute a gel to give a semisolid mass.

Disadvantage

Fire caused due to the burning of solid propellants is very difficult to control.

Liquid Propellants

Liquid propellants are widely used as rocket fuels. They can be monopropellants or biliquid propellants based on the number of liquids in the propellant mixture.

Advantages

- They give better thrust than solid propellants
- By propellant flow regulation, thrust can be controlled

A mixture of liquid oxygen and liquid hydrogen is one of the most important liquid propellants. Oxygen burns liquid hydrogen to produce heat energy.
Liquid propellant examples are alcohols, liquid ammonia, kerosene, hydrazine (unsymmetrical dimethyl hydrazine - UDMH and monomethyl hydrazine - MMH)

Oxiding agents can be liquid oxygen, liquid fluorine, hydrogen peroxide and nitric acid.

Hybrid Propellant

When the propellant has a solid fuel and a liquid oxidiser composition, it is called a hybrid propellant.

Example: A mixture of acrylic rubber and liquid dinitrogen tetraoxide

Characteristics of Propellants

A good rocket propellant must

- produce large volumes of gases for every gram of fuel which undergoes combustion
- burn at a fast rate
- burn completely without leaving behind residue or ash (dead weight)
- have high calorific value for high efficiency of fuel

Principle

When the fuel is ignited, combustion occurs. The liberated gases pass through the nozzle of the rocket motor, providing the necessary thrust for the rocket to lift and take off.

Insect Repellents

The chemicals like dimethyl phthalate, N, N-diethyl - meta - toulamide (Deet), N - N - diethyl benzamide are used as effective repellents against mosquitoes, flies and other insects. These are widely used in insect repellant body creams.

Pheromones or Sex Attractants

Another way to get rid of insects is to use pheromones or insect sex attractants. These chemicals help induce the mating urge and attract insects of opposite sex. When coated on poisonous baits, they prove fatal for insects. Methyl engenol attracts the oriental fruit fly. Bombykol attracts the silk worm moth.

Insects like pink bollworms, cabbage loopers and natural silk worm moth are attracted by these pheromones.

Commercially Important Condensation Polymers

Polyesters

Polymers with ester linkage are called polyesters.

Terylene or Dacron

Terylene or Dacron is manufactured from ethylene glycol and terephthalic acid. The reaction is carried out at 420 - 460 K in the presence of catalyst zinc acetate and antimohy trioxide.

Properties

Terylene forms strong fibers. It is crease resistant, has high moisture absorption and has a high tensile strength.

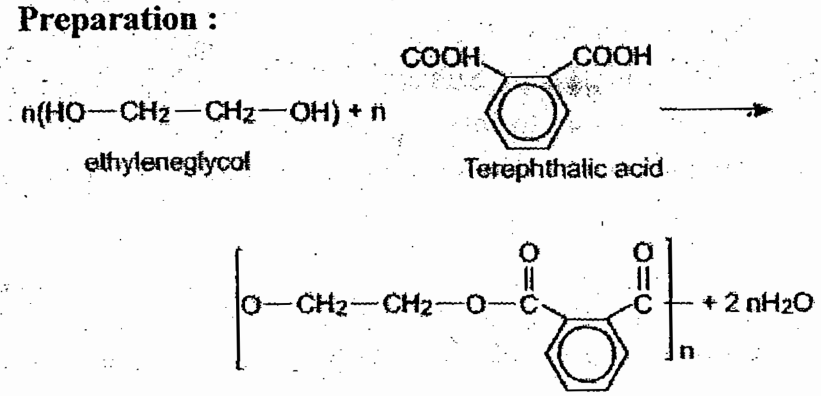
Uses

i) Making wash and wear garments.

ii) In seat belts and sails.

Glyptal or Alkyl Resin

Preparation :



Property

It is a thermoplastic. It dissolves in suitable solvent and the solution on evaporation leaves a tough but non flexible film.

Uses

It is used in the manufacture of paints and lacquers.

Polyamides

Polyamides are polymers with amide linkage (-NH-CO-).

Nylon-66

In Nylon-66 both monomers have 6 carbon atoms each and hence the name.

Preparation of Nylon-66

Here the polyamide Nylon-66 is formed by heating the reactant mixture under pressure and the process has been developed so that the molecular mass of the polymer is controlled in the range of 12,000 to 20,000 amu.

$$\underset{\text{Adipic acid}}{nHO-\overset{\overset{O}{\|}}{C}-(CH_2)_4-\overset{\overset{O}{\|}}{C}-OH} + \underset{\text{Hexamethylene diamine}}{nH_2N-(CH_2)_6-NH_2} \longrightarrow$$

$$\left[-\overset{\overset{O}{\|}}{C}-(CH_2)_4-\overset{\overset{O}{\|}}{C}-NH(CH_2)_6-NH-\right]_n + 2\,nH_2O$$

Properties of Nylon-66

High tensile strength, tough, abrasion resistant and elastic.

Uses of Nylon-66

It is fabricated into sheets, bristles for brushes and in textiles as crinkled nylon fibers that are used for making elastic hosiery.

Nylon-6 or (perlon)

Preparation

Nylon-6 is prepared from the monomer caprolactum which is obtained from cyclohexane (petrochemical). Since caprolactum is more easily available, it is used for polymerization which is carried out in the presence of water that first hydrolyses the caprolactum to amino acid. Subsequently the amino group of the amino acid can react with caprolactum to form the polyamide polymer. Filaments of Nylon-6 are obtained by melt-spinning of the polymer. The fibers are cooled by a stream of air.

Uses of Nylon-6

i) Nylons are insoluble in common solvents, have good strength and absorb little moisture.

ii) It is used for tyre cords, fabrics, ropes, carpets and manufacture of garments.

Formaldehyde Resins

Bakelite (Phenol Formaldehyde Resin)

Bakelite is made from phenol and formaldehyde in the presence of a base catalyst. It involves formation of methylene bridges at the ortho and para positions. The reaction starts with the initial formation of ortho and/or para-hydroxymethyl phenol derivatives which further react with phenol to form compounds where the rings are formed to each other with -CH_2 groups.

Thus linear and cross linked material can be prepared. Cross linked bakelite is a thermosetting polymer.

On further heating with HCHO, novalac undergoes cross-linking to an infusible solid called bakelite. It is hard scratch and water resistant.

Soft bakelite (Low degree of polymerization)

Used as bonding for laminated wooden planks and in varnish and paint.

Hard bakelite (High degree of polymerization)

It possesses excellent electrical insulating character and hence its major use in making electrical goods.

Used to make combs, fountain pen barrels, gramophone records, electric goods, formica table tops. Sulphonated bakelites are used as ion exchange resins.

Melamine Formaldehyde Resins

Uses

Hard and unbreakable - so used to make non-breakable plastic crockery i.e., cups and plates that do not break on being dropped.

Natural Rubber

Natural rubber is an excellent example of a natural polymer and an **elastomer** in particular. Elastomers are substances that can be readily stretched. They retract rapidly to their original form when released. It undergoes long range reversible extension under relatively small applied force. This elasticity makes it valuable for variety of uses. Natural rubber is also called plantation rubber.

Preparation

Latex, the white milky liquid obtained by making a cut in the rubber tree contains 30%-40% of rubber and is a colloidal solution of rubber in water. This is coagulated (changed from fluid to solid state or clotting) with acetic or formic acid and can then be squeezed, rolled, milled and vulcanized.

Vulcanization of Rubber

Charles Goodyear discovered the process of vulcanization in 1893 to modify the properties of natural rubber. Vulcanization is the addition of right amount of sulphur to natural rubber to impart high elasticity, tensile strength and resistance to abrasion.

Synthetic Rubbers

Synthetic rubbers are made by the polymerization of dienes, in the presence of Zeigler-Natta catalyst. These rubbers are tougher, more flexible and more durable than natural rubbers.

Polymerization of 1,3 - butadiene

Synthetic rubbers are either homopolymers of 1,2-butadiene derivatives or are copolymers in the formation of which one of the monomers is 1,3-butadiene or its derivative so that the polymer has the availability of double bonds for its vulcanization.

Synthetic or artificial rubbers are also polymers. They are not natural rubbers and are superior to natural rubber.

Neoprene or Polychloroprene

The first commercially successful rubber substitute, manufactured in the US is neoprene (1931). It is prepared by the polymerization of chloroprene (2-chlorobutadiene).

$$n\,CH_2=\underset{\underset{\displaystyle Cl}{|}}{C}-CH=CH_2 \longrightarrow -[-CH_2-\underset{\underset{\displaystyle Cl}{|}}{C}=CH-CH_2-]_n-$$

chloroprene (2 – chlorobutadiene) neoprene

Commonly used synthetic rubbers are Buna-S, Buna-N and neoprene.

Properties of Neoprene

Neoprene is superior to natural rubber because of the following properties:

- ❖ Neoprene is non-inflammable but natural rubber is inflammable.
- ❖ Neoprene is resistant to oils, organic solvents, petrol and grease. Natural rubber swells and rots in contact with these materials.
- ❖ Neoprene is stable even at high temperatures. Natural rubber retains its usefulness only over a low range of temperatures.
- ❖ Neoprene does not require vulcanization like natural rubber.
- ❖ Neoprene is resistant to the action of oxygen and ozone. Natural rubber deteriorates when exposed to oxygen.

- Neoprene is a thermoplastic. It need not be vulcanized but can be compounded with other suitable ingredients like magnesia, wood resin and zinc oxide before using.

Uses of Neoprene

Neoprene is used for making transmission belts, printing rolls and flexible tubing for carrying oil and petrol. It is also used as insulator making conveyor belts and printing rollers.

Biopolymers

Nature has many polymeric species which are essential for life and are called biopolymers. Polysaccharides, proteins and nucleic acids are examples.

Biodegradable Polymers

The large scale use of synthetic polymers has been based on their relative inertness to environmental process so that degradation reactions leading to any change in the properties of the polymer during the service life of its product does not occur. It is due to this property that management of polymeric waste has become so difficult that use of polymers has created acute environmental problems.

In biological systems, biopolymers degrade mainly by enzymatic hydrolysis and to some extent by oxidation. Biodegradable synthetic polymers have been developed which are safe for use by humans and disposal of polymer waste does not arise.

These synthetic polymers mostly have functional groups prevalent in biopolymers and lipids.

Aliphatic polyesters are one important class of biodegradable polymers as several of them are commercially potential biomaterials.

Poly-hydroxybutyrate-co-□-hydroxyvalerate

(PHBV) is a copolymer of 3-hydroxybutanoic acid and 3-hydroxypentanoic acid, in which the monomer units are connected by ester linkages.

The properties of PHBV vary according to the ratio of both the acids.

3-hydroxybutanoic acid provides stiffness and 3-hydroxypentanoic acid imparts flexibility to the copolymer.

It is used in specialty packaging, orthopaedic devices and even in controlled drug release. When a drug is put into a capsule of PHBV it is released only after the polymer is degraded. PHBV also undergoes bacterial degradation in the environment.

Poly (Glycolic acid) and poly lactic acid

Poly (Glycolic Acid) and Poly Lactic Acid are commercially successful biodegradable polymers such as sutures. Dextrin was the first bio absorbable suture made from biodegradable polyesters for post-operative stitches.

Nylon-2-Nylon-6

Nylon-2-Nylon-6 an alternating polyamide copolymer of glycine and amino caproic acid and is biodegradable

Fuel Types.

Unleaded Petrol (ULP) ULP has a Research Octane Number (RON) of between 91 and 93.

Premium Unleaded Petrol (PULP)

PULP is a special blend of petrol designed to bring high octane, and hence high engine power, as well as knock- free performance to unleaded cars with a high-octane requirement. Most petrol companies have a specially named version of PULP PULP has a Research Octane Number (RON) of 95.

Diesel

Diesel engines are usually very efficient engines, offering better fuel economy in comparison to equivalent petrol models. Diesel engines emit very low levels of exhaust hydrocarbons and carbon monoxide when correctly tuned and maintained. The main concern diesel engines raise is the smoke they emit, which can be a health hazard.

Liquefied Petroleum Gas (LPG)

LPG, most commonly a blend of propane and butane, is an environmentally cleaner fuel compared to petrol and diesel. It is the most widely accepted alternative fuel for the automotive sector.

Despite LPG cars having lower fuel economy compared to petrol-powered vehicles, fuel costs will usually be

98 RON

98 RON has a Research Octane Number (RON) of 98. It is a high-octane unleaded fuel that maximizes engine power and performance, as well as producing

less pollution. It is more commonly used by imported and high performance vehicles

98 RON is promoted as providing excellent fuel economy. It has low levels of benzene, sulphur and lower aromatics and a sulphur content which is 10 times lower than the national standard for unleaded fuels.

Biodiesel and Biodiesel Blends (B20 diesel)

Biodiesel is 100% biodiesel fuel and is referred to as B100 or "neat biodiesel". Biodiesel is made from natural renewable sources and can be blended in almost any ratio with petroleum based diesel. Biodiesel blends are often known by the ratio of biodiesel to regular diesel i.e. B20 means 20% biodiesel and 80% petroleum based diesel. The most common blends available internationally are B5 (a mix of 5% biodiesel and 95% petroleum based diesel) and B20 (a mix of 20% biodiesel and 80% petroleum based diesel).

Ethanol

Ethanol is made from natural renewable sources and can be blended with petroleum based unleaded fuels. Ethanol is pure 100% ethanol, referred to as E100 or "neat ethanol". Ethanol blends are often known by the ratio of ethanol to regular petrol i.e. E10 means a mix of 10% ethanol and 90% unleaded petrol.

Lead Replacement Petrol (LRP)

Now phased out, LRP (96 RON) was introduced as an environmental alternative for cars that used leaded petrol. LRP was refined to contain no lead, along with lower concentrations of benzene and sulphur, respectively identified as health hazards and pollutants. Lead was historically added to petrol as a cost-effective way of increasing octane and hence engine power rating and providing a measure of engine protection by way of its lubricating qualities.

Rocket propellant

Rocket propellant is mass that is stored, usually in some form of propellant tank, prior to being used as the propulsive mass that is ejected from a rocket engine in the form of a fluid jet to produce thrust.

Chemical rocket propellants are most commonly used, which undergo exothermic chemical reactions which produce hot gas which is used by a rocket for propulsive purposes.

The first stage will usually use high-density (low volume) propellants to reduce the area exposed to atmospheric drag and because of the lighter tankage and higher thrust/weight ratios. Thus, the Apollo-Saturn V first stage used kerosene-liquid oxygen rather than the liquid hydrogen-liquid oxygen used on the upper stages (hydrogen is highly energetic per kilogram, but not per cubic metre).

Chemical propellants

There are three main types of propellants: solid, liquid, and hybrid.

Solid propellants

The earliest rockets were created hundreds of years ago by the Chinese, and were used primarily for fireworks displays and as weapons. They were fueled with black powder, a type of gunpowder consisting of a mixture of charcoal, sulfur and potassium nitrate (saltpeter). Rocket propellant technology did not advance until the end of the 19th century, by which time smokeless powder had been developed, originally for use in firearms and artillery pieces. Smokeless powders and related compounds have seen use as double-base propellants.

Solid propellants (and almost all rocket propellants) consist of an oxidizer and a fuel. In the case of gunpowder, the fuel is charcoal, the oxidizer is potassium nitrate, and sulfur serves as a catalyst. (Note: sulfur is not a true catalyst in gunpowder as it is consumed to a great extent into a variety of reaction products such as K_2S. The sulfur acts mainly as a sensitizer lowering threshold of ignition.) During the 1950s and 60s researchers in the United States developed what is now the standard high-energy solid rocket fuel. The mixture is primarily ammonium perchlorate powder (an oxidizer), combined with fine aluminium powder (a fuel), held together in a base of PBAN or HTPB (rubber-like fuels). The mixture is formed as a liquid, and then cast into the correct shape and cured into a rubbery solid. Solid fueled rockets are much easier to store and handle than liquid fueled rockets, which makes them ideal for military applications. In the 1970s and 1980s the U.S. switched entirely to solid-fuelled ICBMs: the LGM-30 Minuteman and LG-118A Peacekeeper (MX). In the 1980s and 1990s, the USSR/Russia also deployed solid-fuelled ICBMs (RT-23, RT-2PM, and RT-2UTTH), but retains two liquid-fuelled ICBMs (R-36 and UR-100N). All solid-fuelled ICBMs on both sides have three initial solid stages and a precision-maneuverable liquid-fuelled bus used to fine tune the trajectory of the reentry vehicle.

Their simplicity also makes solid rockets a good choice whenever large amounts of thrust are needed and cost is an issue. The Space Shuttle and many other orbital launch vehicles use solid fuelled rockets in their first stages (solid rocket boosters) for this reason.

However, solid rockets have a number of disadvantages relative to liquid fuel rockets. Solid rockets have a lower specific impulse than liquid fueled rockets. It is also difficult to build a large mass ratio solid rocket because almost the entire rocket is the combustion chamber, and must be built to withstand the high combustion pressures. If a solid rocket is used to go all the way to orbit, the payload fraction is very small. (For example, the Orbital Sciences Pegasus rocket is an air-launched three-stage solid rocket orbital booster. Launch mass is 23,130 kg, low earth orbit payload is 443 kg, for a payload fraction of 1.9%. Compare to a Delta IV Medium, 249,500 kg, payload 8600 kg, payload fraction 3.4% without air-launch assistance.)

A drawback to solid rockets is that they cannot be throttled in real time, although a predesigned thrust schedule can be created by altering the interior propellant geometry.

Solid rockets can often be shut down before they run out of fuel. Essentially, the rocket is vented or an extinguishant injected so as to terminate the combustion process. In some cases termination destroys the rocket..

Liquid propellants

Liquid fueled rockets have better specific impulse than solid rockets and are capable of being throttled, shut down, and restarted. Only the combustion chamber of a liquid fueled rocket needs to withstand combustion pressures and temperatures. On vehicles employing turbopumps, the fuel tanks carry very much less pressure and thus can be built far more lightly, permitting a larger mass ratio. For these reasons, most orbital launch vehicles and all first- and second-generation ICBMs use liquid fuels for most of their velocity gain.

The primary performance advantage of liquid propellants is the oxidizer. Several practical liquid oxidizers (liquid oxygen, nitrogen tetroxide, and hydrogen peroxide) are available which have much better specific impulse than ammonium perchlorate when paired with comparable fuels.

Most liquid propellants are also cheaper than solid propellants. For orbital launchers, the cost savings do not, and historically have not mattered; the cost of fuel is a very small portion of the overall cost of the rocket, even in the case of solid fuel.

The main difficulties with liquid propellants are also with the oxidizers. These are generally at least moderately difficult to store and handle due to their high reactivity with common materials, may have extreme toxicity (nitric acids), moderately cryogenic (liquid oxygen), or both (liquid fluorine, FLOX- a fluorine/LOX mix). Several exotic oxidizers have been proposed: liquid ozone (O_3), ClF_3, and ClF_5, all of which are unstable, energetic, and toxic.

Liquid fuelled rockets also require potentially troublesome valves and seals and thermally stressed combustion chambers, which increase the cost of the rocket. Many employ specially designed turbopumps which raise the cost enormously due to difficult fluid flow patterns that exist within the casings.

Though all the early rocket theorists proposed liquid hydrogen and liquid oxygen as propellants, the first liquid-fuelled rocket, launched by Robert Goddard on March 16, 1926, used gasoline and liquid oxygen. Liquid hydrogen was first used by the engines designed by Pratt and Whitney for the Lockheed CL-400 Suntan reconnaissance aircraft in the mid-1950s. In the mid-1960s, the Centaur and Saturn upper stages were both using liquid hydrogen and liquid oxygen.

The highest specific impulse chemistry ever test-fired in a rocket engine was lithium and fluorine, with hydrogen added to improve the exhaust thermodynamics (making this a tripropellant). The combination delivered 542 seconds (5.32 kN·s/kg, 5320 m/s) specific impulse in a vacuum. The impracticality of this chemistry highlights why exotic propellants are not actually used: to make all three components liquids, the hydrogen must be kept below -252 °C (just 21 K) and the lithium must be kept above 180 °C (453 K). Lithium and fluorine are both extremely corrosive, lithium ignites on contact with air, fluorine ignites on contact with most fuels, and hydrogen, while not hypergolic, is an explosive hazard. Fluorine and the hydrogen fluoride (HF) in the exhaust are very toxic, which damages the environment, makes work around the launch pad difficult, and makes getting a launch license that much more difficult. The rocket exhaust is also ionized, which would interfere with radio communication with the rocket.

The common liquid propellant combinations in use today:

- LOX and kerosene (RP-1). Used for the lower stages of most Russian and Chinese boosters, the first stages of the Saturn V and Atlas V, and all stages of the developmental Falcon 1 and Falcon 9. Very similar to Robert Goddard's first rocket. This combination is widely regarded as the most practical for civilian orbital launchers.

- LOX and liquid hydrogen, used in the Space Shuttle, the Centaur upper stage, Saturn V upper stages, the newer Delta IV rocket, the H-IIA rocket, and most stages of the European Ariane rockets.

- Nitrogen tetroxide (N_2O_4) and hydrazine (N_2H_4), MMH, or UDMH. Used in military, orbital and deep space rockets, because both liquids are storable for long periods at reasonable temperatures and pressures. This combination is hypergolic, making for attractively simple ignition sequences. The major inconvenience is that these propellants are highly toxic, hence they require careful handling. Hydrazine also decomposes energetically to nitrogen, hydrogen, and ammonia, making it a fairly good monopropellant.

Gas propellants

A gas propellant usually involves some sort of compressed gas. However, due to the low density and high weight of the pressure vessel, gases see little current use.

Hybrid propellants

A hybrid rocket usually has a solid fuel and a liquid or gas oxidizer. The fluid oxidizer can make it possible to throttle and restart the motor just like a liquid fuelled rocket. Hybrid rockets are also cleaner than solid rockets because practical high-performance solid-phase oxidizers all contain chlorine, versus the more benign liquid oxygen or nitrous oxide used in hybrids. Because just one propellant is a fluid, hybrids are simpler than liquid rockets.

Hybrid motors suffer two major drawbacks. The first, shared with solid rocket motors, is that the casing around the fuel grain must be built to withstand full combustion pressure and often extreme temperatures as well. However, modern composite structures handle this problem well, and when used with nitrous oxide or hydrogen peroxide relatively small percentage of fuel is needed anyway, so the combustion chamber is not especially large.

The primary remaining difficulty with hybrids is with mixing the propellants during the combustion process. In solid propellants, the oxidizer and fuel are mixed in a factory in carefully controlled conditions. Liquid propellants are generally mixed by the injector at the top of the combustion chamber, which directs many small swift-moving streams of fuel and oxidizer into one another. Liquid fuelled rocket injector design has been studied at great length and still resists reliable performance prediction. In a hybrid motor, the mixing happens at the melting or evaporating surface of the fuel. The mixing is not a well-controlled process and generally quite a lot of propellant is left unburned[citation needed], which limits the efficiency and thus the exhaust velocity of the motor. Additionally, as the burn continues, the hole down the center of the grain (the 'port') widens and the mixture ratio tends to become more oxidiser rich.

There has been much less development of hybrid motors than solid and liquid motors. For military use, ease of handling and maintenance have driven the use of solid rockets. For orbital work, liquid fuels are more efficient than hybrids and most development has concentrated there. There has recently been an increase in hybrid motor development for nonmilitary suborbital work.

Chemical Names of Common Substances

Alternate Words for Familiar Materials

Chemical or scientific names are used to give an accurate description of a substance's composition. Even so, you rarely ask someone to pass the sodium chloride at the dinner table. It's important to remember that common names are inaccurate and vary from one place and time to another. Therefore, don't assume that you know the chemical composition of a substance based on its common name. This is a list of archaic names and common names for chemicals, with their modern or IUPAC equivalent name.

Common Name	**Chemical Name**
acetone	dimethyl ketone; 2-propanone (usually known as acetone)
acid potassium sulfate	potassium bisulfate
acid of sugar	oxalic acid
ackey	nitric acid
alcali volatil	ammonium hydroxide
alcohol, grain	ethyl alcohol
alcohol sulfuris	carbon disulfide
alcohol, wood	methyl alcohol
alum	aluminum potassium sulfate
alumina	aluminum oxide
antichlor	sodium thiosulfate

antimony black	antimony trisulfide
antimony bloom	antimony trioxide
antimony glance	antimony trisulfide
antimony red (vermillion)	antimony oxysulfide
aqua ammonia	aqueous solution of ammonium hydroxide
aqua fortis	nitric acid
aqua regia	nitrohydrochloric acid
aromatic spirit of ammonia	ammonia in alcohol
arsenic glass	arsenic trioxide
azurite	mineral form of basic copper carbonate
asbestos	magnesium silicate
aspirin	acetylsalicylic acid
baking soda	sodium bicarbonate
banana oil (artificial)	isoamyl acetate
barium white	barium sulfate
benzol	benzene
bicarbonate of soda	sodium hydrogen carbonate or sodium bicarbonate
bichloride of mercury	mercuric chloride
bichrome	potassium dichromate
bitter salt	magnesium sulfate
black ash	crude form of sodium carbonate
black copper oxide	cupric oxide
black lead	graphite (carbon)
blanc-fixe	barium sulfate
bleaching powder	chlorinated lime; calcium hypochlorite
blue copperas	copper sulfate (crystals)
blue lead	lead sulfate
blue salts	nickel sulfate

blue stone	copper sulfate (crystals)
blue vitriol	copper sulfate
bluestone	copper sulfate
bone ash	crude calcium phosphate
bone black	crude animal charcoal
boracic acid	boric acid
borax	sodium borate; sodium tetraborate
bremen blue	basic copper carbonate
brimstone	sulfur
burnt alum	anhydrous potassium aluminum sulfate
burnt lime	calcium oxide
burnt ochre	ferric oxide
burnt ore	ferric oxide
brine	aqueous sodium chloride solution
butter of antimony	antimony trichloride
butter of tin	anhydrous stannic chloride
butter of zinc	zinc chloride
calomel	mercury chloride; mercurous chloride
carbolic acid	phenol
carbonic acid gas	carbon dioxide
caustic lime	calcium hydroxide
caustic potash	potassium hydroxide
caustic soda	sodium hydroxide
chalk	calcium carbonate
Chile saltpeter	sodium nitrate
Chile nitre	sodium nitrate
Chinese red	basic lead chromate
Chinese white	zinc oxide

chloride of soda	sodium hypochlorite
chloride of lime	calcium hypochlorite
chrome alum	chromic potassium sulfate
chrome green	chromium oxide
chrome yellow	lead (VI) chromate
chromic acid	chromium trioxide
copperas	ferrous sulfate
corrosive sublimate	mercury (II) chloride
corundum (ruby, sapphire)	chiefly aluminum oxide
cream of tartar	potassium bitartrate
crocus powder	ferric oxide
crystal carbonate	sodium carbonate
dechlor	sodium thiophosphate
diamond	carbon crystal
emery powder	impure aluminum oxide
epsom salts	magnesium sulfate
ethanol	ethyl alcohol
farina	starch
ferro prussiate	potassium ferricyanide
ferrum	iron
flores martis	anhydride iron (III) chloride
fluorspar	natural calcium fluoride
fixed white	barium sulfate
flowers of sulfur	sulfur
'flowers of' any metal	oxide of the metal
formalin	aqueous formaldehyde solution
French chalk	natural magnesium silicate
French vergidris	basic copper acetate

galena	natural lead sulfide
Glauber's salt	sodium sulfate
green verditer	basic copper carbonate
green vitriol	ferrous sulfate crystals
gypsum	natural calcium sulfate
hard oil	boiled linseed oil
heavy spar	barium sulfate
hydrocyanic acid	hydrogen cynanide
hypo (photography)	sodium thiosulfate solution
Indian red	ferric oxide
Isinglass	agar-agar gelatin
jeweler's rouge	ferric oxide
killed spirits	zinc chloride
lampblack	crude form of carbon; charcoal
laughing gas	nitrous oxide
lead peroxide	lead dioxide
lead protoxide	lead oxide
lime	calcium oxide
lime, slaked	calcium hydroxide
limewater	aqueous solution of calcium hydroxide
liquor ammonia	ammonium hydroxide solution
litharge	lead monoxide
lunar caustic	silver nitrate
liver of sulfur	sufurated potash
lye or soda lye	sodium hydroxide
magnesia	magnesium oxide
manganese black	manganese dioxide
marble	mainly calcium carbonate

mercury oxide, black	mercurous oxide
methanol	methyl alcohol
methylated spirits	methyl alcohol
milk of lime	calcium hydroxide
milk of magnesium	magnesium hydroxide
milk of sulfur	precipitated sulfur
"muriate" of a metal	chloride of the metal
muriatic acid	hydrochloric acid
natron	sodium carbonate
nitre	potassium nitrate
nordhausen acid	fuming sulfuric acid
oil of mars	deliquescent anhydrous iron (III) chloride
oil of vitriol	sulfuric acid
oil of wintergreen (artificial)	methyl salicylate
orthophosphoric acid	phosphoric acid
Paris blue	ferric ferrocyanide
Paris green	copper acetoarsenite
Paris white	powdered calcium carbonate
pear oil (artificial)	isoamyl acetate
pearl ash	potassium carbonate
permanent white	barium sulfate
plaster of Paris	calcium sulfate
plumbago	graphite
potash	potassium carbonate
potassa	potassium hydroxide
precipitated chalk	calcium carbonate
Prussic acid	hydrogen cyanide
pyro	tetrasodium pyrophosphate

quicklime	calcium oxide
quicksilver	mercury
red lead	lead tetraoxide
red liquor	aluminum acetate solution
red prussiate of potash	potassium ferrocyanide
red prussiate of soda	sodium ferrocyanide
Rochelle salt	potassium sodium tartrate
rock salt	sodium chloride
rouge, jeweler's	ferric oxide
rubbing alcohol	isopropyl alcohol
sal ammoniac	ammonium chloride
sal soda	sodium carbonate
salt, table	sodium chloride
salt of lemon	potassium binoxalate
salt of tartar	potassium carbonate
saltpeter	potassium nitrate
silica	silicon dioxide
slaked lime	calcium hydroxide
soda ash	sodium carbonate
soda nitre	sodium nitrate
soda lye	sodium hydroxide
soluble glass	sodium silicate
sour water	dilute sulfuric acid
spirit of hartshorn	ammonium hydroxide solution
spirit of salt	hydrochloric acid
spirit of wine	ethyl alcohol
spirits of nitrous ether	ethyl nitrate
sugar, table	sucrose

sugar of lead	lead acetate
sulfuric ether	ethyl ether
talc or talcum	magnesium silicate
tin crystals	stannous chloride
trona	natural sodium carbonate
unslaked lime	calcium oxide
Venetian red	ferric oxide
verdigris	basic copper acetate
Vienna lime	calcium carbonate
vinegar	impure dilute acetic acid
vitamin C	ascorbic acid
vitriol	sulfuric acid
washing soda	sodium carbonate
water glass	sodium silicate
white caustic	sodium hydroxide
white lead	basic lead carbonate
white vitriol	zinc sulfate crystals
yellow prussiate of potash	potassium ferrocyanide
yellow prussiate of soda	sodium ferrocyanide
zinc vitriol	zinc sulfate
zinc white (philosopher's wool)	zinc oxide

Chemistry of Firework Colors

Creating firework colors is a complex endeavor, requiring considerable art and application of physical science. Excluding propellants or special effects, the points of light ejected from fireworks, termed 'stars', generally require an oxygen-producer, fuel, binder (to keep everything where it needs to be), and color producer. There are two main mechanisms of color production in fireworks, incandescence and luminescence.

Incandescence

Incandescence is light produced from heat. Heat causes a substance to become hot and glow, initially emitting infrared, then red, orange, yellow, and white light as it becomes increasingly hotter. When the temperature of a firework is controlled, the glow of components, such as charcoal, can be manipulated to be the desired color (temperature) at the proper time. Metals, such as aluminum, magnesium, and titanium, burn very brightly and are useful for increasing the temperature of the firework.

Luminescence

Luminescence is light produced using energy sources other than heat. Sometimes luminescence is called 'cold light', because it can occur at room temperature and cooler temperatures. To produce luminescence, energy is absorbed by an electron of an atom or molecule, causing it to become excited, but unstable. When the electron returns to a lower energy state the energy is released in the form of a photon (light). The energy of the photon determines its wavelength or color.

Sometimes the salts needed to produce the desired color are unstable. Barium chloride (green) is unstable at room temperatures, so barium must be combined with a more stable compound (e.g., chlorinated rubber). In this case, the chlorine is released in the heat of the burning of the pyrotechnic composition, to then form barium chloride and produce the green color. Copper chloride (blue), on the other hand, is unstable at high temperatures, so the firework cannot get too hot, yet must be bright enough to be seen.

Quality

Pure colors require pure ingredients. Even trace amounts of sodium impurities (yellow-orange) are sufficient to overpower or alter other colors. Careful formulation is required so that too much smoke or residue doesn't mask the color. With fireworks, as with other things, cost often relates to quality. Skill of the manufacturer and date the firework was produced greatly affect the final display (or lack thereof).

Firework Colorants

Color	Compound
Red	strontium salts, lithium salts lithium carbonate, Li_2CO_3 = red strontium carbonate, $SrCO_3$ = bright red
Orange	calcium salts calcium chloride, $CaCl_2$ calcium sulfate, $CaSO_4 \cdot xH_2O$, where x = 0,2,3,5
Gold	incandescence of iron (with carbon), charcoal, or lampblack
Yellow	sodium compounds sodium nitrate, $NaNO_3$ cryolite, Na_3AlF_6
Electric White	white-hot metal, such as magnesium or aluminum barium oxide, BaO
Green	barium compounds + chlorine producer barium chloride, $BaCl^+$ = bright green
Blue	copper compounds + chlorine producer copper acetoarsenite (Paris Green), $Cu_3As_2O_3Cu(C_2H_3O_2)_2$ = blue copper (I) chloride, CuCl = turquoise blue
Purple	mixture of strontium (red) and copper (blue) compounds
Silver	burning aluminum, titanium, or magnesium powder or flakes

Explosives

Explosives are materials that produce violent chemical or nuclear reactions. These reactions generate large amounts of heat and gas in a fraction of a second. Shock waves produced by rapidly expanded gases are responsible for much of the destruction seen following an explosion.

Probably the oldest known explosive is black gunpowder, a mixture of charcoal (carbon), sulfur, and saltpeter (potassium nitrate). When these three chemicals are ignited, a chemical reaction takes place very quickly. The products of that reaction are carbon dioxide, carbon monoxide, sulfur dioxide, and nitric oxide (all gases) as well as potassium carbonate and potassium sulfide (two solids). The four gases formed in the reaction are heated to very high temperatures and expand very rapidly. They form shock waves that have the ability to knock down trees, buildings, people, and other objects in their way. The shock wave also carries with it very hot gases that can burn objects and initiate fires. The combination of shock wave and high temperature is characteristic of most kinds of explosives.

History

Gunpowder was first invented in China no later than about A.D. 850. For hundreds of years, it was used mainly to create fireworks. The Chinese did not use gunpowder as a weapon of war; it was the Europeans who first adapted explosives for use in weapons. By the fourteenth century, Europeans were widely using the explosive as a military device to project stones, spearlike projectiles, and metal balls from cannons and guns.

Words to Know

Chemical explosive: A compound or mixture that releases chemical energy violently and rapidly, creating heat and a shock wave generated by a release of gases.

Dynamite: An explosive made by soaking an inert (inactive or stable), absorbent substance with a mixture of (1) nitroglycerin or ammonium nitrate, (2) a combustible substance (a substance with the ability to burn), such as wood pulp, and (3) an antacid.

Gunpowder: An explosive mixture of charcoal, potassium nitrate, and sulfur often used to propel bullets from guns and shells from cannons.

Nitroglycerine: An explosive liquid used to make dynamite. Also used as a medicine to dilate blood vessels.

Nuclear explosive: A device that obtains its explosive force from the release of nuclear energy.

TNT: Trinitrotoluene, a high explosive.

For the next 500 years, gunpowder was used almost exclusively for pyrotechnic (fireworks) displays and in warfare. Then, in 1856, Italian chemist Ascanio Sobrero (1812–1888) invented the first modern explosive, nitroglycerin. Sobrero's discovery was, unfortunately for many early users, too unstable to be used safely. Nitroglycerin readily explodes if bumped or shocked.

In 1859, Swedish inventor Alfred Nobel (1833–1896) began to look for a way to package nitroglycerin safely. His solution was to mix nitroglycerin with an inert (inactive) absorbent material called *kieselguhr*. He called his invention dynamite.

Virtually overnight, Nobel's invention revolutionized the mining industry. Dynamite was five times as powerful as gunpowder, relatively easy to produce, and reasonably safe to use. For the first time in history, explosives began to be used for a productive purpose: the tearing apart of land in order to gain access to valuable minerals.

Nobel became extremely wealthy as a result of his discovery. But he is said to have been worried about the terrible potential for destruction that his invention had made possible. When he died, he directed that his fortune be used to create the Nobel Foundation, the purpose of which was to bring about lasting peace and advance technology. The Nobel Prizes in various fields of science are now the highest honors that scientists can earn.

Types of explosives

Explosives can be classified into one of four large categories: primary, low, high, and nuclear explosives.

Primary explosives. Primary explosives are generally used to set off other explosives. They are very sensitive to shock, heat, and electricity and, therefore, must be handled with great care. Two common examples are mercury fulminate and lead azide. Primary explosives also are known as initiating explosives, blasting caps, detonators, or primers.

Low explosives. Low explosives are characterized by the fact that they burn only at their surface. For example, when a cylinder of black gunpowder is ignited, it begins burning at one end of the cylinder and then continues to the other end. This process takes place very rapidly, however, and is complete in just a few thousandths of a second.

This property of slowed combustion is preferred in guns and artillery because too rapid an explosion could cause the weapon itself to blow up. A slower explosive has the effects of building up pressure to force a bullet or shell smoothly out of the weapon. Fireworks also are low explosives.

High explosives. High explosives are much more powerful than primary explosives. When they are detonated, all parts of the explosive blow up within a few millionths of a second. Some also are less likely than primary explosives to explode by accident. Examples of high explosives include ANFO (ammonium nitrate-fuel oil mixture), dynamite, nitroglycerin, PETN (pentaerythritol tetranitrate), picric acid, and TNT (trinitrotoluene). They provide the explosive force delivered by hand grenades, bombs, and artillery shells.

High explosives that are set off by heat are called primary explosives. High explosives that can be set off only by a detonator are called secondary explosives. When mixed with oil or wax, high explosives become like clay. These plastic explosives can be molded into various shapes to hide them or to direct explosions. In the 1970s and 1980s, plastic explosives became a favorite weapon of terrorists (people who use violence in order to force a government into granting their demands). Plastic explosives can even be pressed flat to fit into an ordinary mailing envelope for use as a "letter bomb."

Nuclear explosives. Research during World War II (1939–45) produced an entirely new kind of explosive: nuclear explosives. Nuclear explosives produce their explosive power not by chemical reactions, as with traditional explosives, but through nuclear reactions. In some types of nuclear reactions, large atomic nuclei are split (or fissioned) into two pieces with the release of huge amounts of energy. In a second type of nuclear reaction, small atomic nuclei are combined (or fused) to make a single large nucleus, again with the release of large amounts of energy.

These two kinds of nuclear explosives were first used as weapons at the end of World War II. The world's first atomic bomb, dropped on Hiroshima, Japan, in 1945, for example, was a fission weapon. The world's first hydrogen bomb, tested at Bikini Atoll in the Pacific Ocean in 1952, was a fusion weapon.

Since the end of World War II, a half-dozen nations in the world have continued to develop and build both fission and fusion weapons. Efforts also have been made to find peaceful uses for nuclear explosives, as in mining operations, although these efforts have not been fully successful.

Composition of the material

An explosive may consist of either a chemically pure compound, such as nitroglycerin, or a mixture of an oxidizer and a fuel, such as black powder.

Mixtures of an oxidizer and a fuel

An oxidizer is a pure substance (molecule) that in a chemical reaction can contribute some atoms of one or more oxidizing elements, in which the fuel component of the explosive burns. On the simplest level, the oxidizer may itself be an oxidizing element, such as gaseous or liquid oxygen.

- **Black powder**: Potassium nitrate, charcoal and sulfur
- **Flash powder**: Fine metal powder (usually aluminium or magnesium) and a strong oxidizer (e.g. potassium chlorate or perchlorate).
- **Ammonal**: Ammonium nitrate and aluminium powder.

- **Armstrong's mixture**: Potassium chlorate and red phosphorus. This is a very sensitive mixture. It is a primary high explosive in which sulfur is substituted for some or all phosphorus to slightly decrease sensitivity.
- **Sprengel explosives**: A very general class incorporating any strong oxidizer and highly reactive fuel, although in practice the name most commonly was applied to mixtures of chlorates and nitroaromatics.
    - **ANFO**: Ammonium nitrate and fuel oil.
    - **Cheddites**: Chlorates or perchlorates and oil.
    - **Oxyliquits**: Mixtures of organic materials and liquid oxygen.

Chemically pure compounds

Some chemical compounds are unstable in that, when shocked, they react, possibly to the point of detonation. Each molecule of the compound dissociates into two or more new molecules (generally gases) with the release of energy.

- **Nitroglycerin**: A highly unstable and sensitive liquid.
- **Acetone peroxide**: A very unstable white organic peroxide
- **TNT**: Yellow insensitive crystals that can be melted and cast without detonation.
- **Nitrocellulose**: A nitrated polymer which can be a high or low explosive depending on nitration level and conditions.
- **RDX, PETN, HMX**: Very powerful explosives which can be used pure or in plastic explosives.

- C-4 (or Composition C-4): An RDX plastic explosive plasticized to be adhesive and malleable.

The above compositions may describe the majority of the explosive material, but a practical explosive will often include small percentages of other materials. For example, dynamite is a mixture of highly sensitive nitroglycerin with sawdust, powdered silica, or most commonly diatomaceous earth, which act as stabilizers. Plastics and polymers may be added to bind powders of explosive compounds; waxes may be incorporated to make them safer to handle; aluminium powder may be introduced to increase total energy and blast effects. Explosive compounds are also often "alloyed": HMX or RDX powders may be mixed (typically by melt-casting) with TNT to form Octol or Cyclotol

SRIRAM'S IAS

GENERAL STUDIES

PHYSICS

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INDEX

1.One Dimensional Motion

Physics concerns itself with a variety of broad topics. One such topic is **mechanics** - the study of the motion of objects

Kinematics is the science of describing the motion of objects using words, diagrams, numbers, graphs, and equations. Kinematics is a branch of mechanics. The goal of any study of kinematics is to develop sophisticated mental models which serve to describe (and ultimately, explain) the motion of real-world objects.

Scalars and Vectors

- **Scalars** are quantities which are fully described by a magnitude (or numerical value) alone.
- **Vectors** are quantities which are fully described by both a magnitude and a direction.

Distance and Displacement

Distance and displacement are two quantities which may seem to mean the same thing yet have distinctly different definitions and meanings.

- **Distance** is a scalar quantity which refers to "how much ground an object has covered" during its motion.
- **Displacement** is a vector quantity which refers to "how far out of place an object is"; it is the object's overall change in position.

Speed and Velocity

Speed is a scalar quantity which refers to "how fast an object is moving." Speed can be thought of as the rate at which an object covers distance.

Velocity is a vector quantity which refers to "the rate at which an object changes its position." velocity is *direction aware*. When evaluating the velocity of an object, one must keep track of direction.

Calculating Average Speed and Average Velocity

The average speed during the course of a motion is often computed using the following formula:

$$\text{Average Speed} = \frac{\text{Distance Traveled}}{\text{Time of Travel}}$$

Meanwhile, the average velocity is often computed using the equation

$$\text{Average Velocity} = \frac{\Delta\text{ position}}{\text{time}} = \frac{\text{displacement}}{\text{time}}$$

Average Speed versus Instantaneous Speed

Since a moving object often changes its speed during its motion, it is common to distinguish between the average speed and the instantaneous speed. The distinction is as follows.

Instantaneous Speed - the speed at any given instant in time.

Average Speed - the average of all instantaneous speeds; found simply by a distance/time ratio.

one might think of the instantaneous speed as the speed which the speedometer reads at any given instant in time and the average speed as the average of all the speedometer readings during the course of the trip.

Acceleration

Acceleration is a vector quantity which is defined as the rate at which an object changes its velocity. An object is accelerating if it is changing its velocity.

The Meaning of Constant Acceleration

Sometimes an accelerating object will change its velocity by the same amount each second.. This is referred to as a **constant acceleration** since the velocity is changing by a constant amount each second.

Calculating the Average Acceleration

The average acceleration (a) of any object over a given interval of time (t) can be calculated using the equation

$$\text{Ave. acceleration} = \frac{\Delta\text{velocity}}{\text{time}} = \frac{v_f - v_i}{t}$$

Acceleration values are expressed in units of velocity/time. Typical acceleration units include the following:

m/s/s
mi/hr/s
km/hr/s
m/s^2

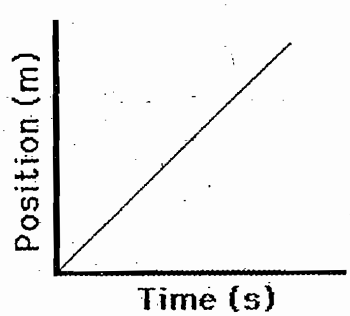
The Direction of the Acceleration Vector

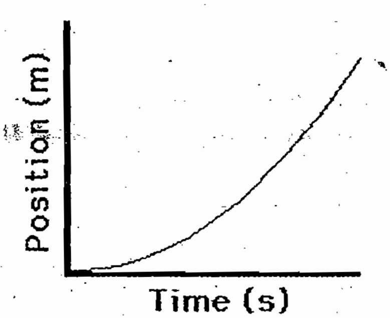
Since acceleration is a vector quantity, it has a direction associated with it. The direction of the acceleration vector depends on two things:

- whether the object is speeding up or slowing down
- whether the object is moving in the + or - direction

Describing Motion with Position vs. Time Graphs

The Meaning of Shape for a p-t Graph





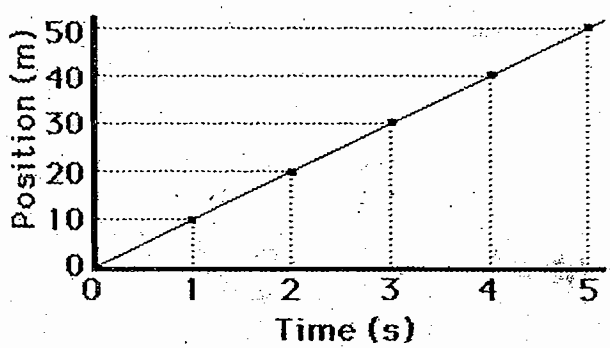
The shapes of the position versus time graphs for these two basic types of motion - constant velocity motion and accelerated motion (i.e., changing velocity) - reveal an important principle. The principle is that the slope of the line on a position-time graph reveals useful information about the velocity of the object. It is often said, "As the slope goes, so goes the velocity." Whatever characteristics the velocity has, the slope will exhibit the same (and vice versa). If the velocity is constant, then the slope is constant (i.e., a straight line). If the velocity is changing, then the slope is changing (i.e., a curved line). If the velocity is positive, then the slope is positive (i.e., moving upwards and to the right). This very principle can be extended to any motion conceivable.

The Meaning of Slope for a p-t Graph

The slope of a position vs. time graph reveals pertinent information about an object's velocity. For example, a small slope means a small velocity; a negative slope means a negative velocity; a constant slope (straight line) means a constant velocity; a changing slope (curved line) means a changing velocity. Thus the shape of the line on the graph (straight, curving, steeply sloped, mildly sloped, etc.) is descriptive of the object's motion.

Determining the Slope on a p-t Graph

Let's begin by considering the position versus time graph below.



The line is sloping upwards to the right. But mathematically, by how much does it slope upwards for every 1 second along the horizontal (time) axis? To answer this question we must use the slope equation.

$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\text{rise}}{\text{run}}$$

The slope equation says that the slope of a line is found by determining the amount of *rise* of the line between any two points divided by the amount of *run* of the line between the same two points. In other words,

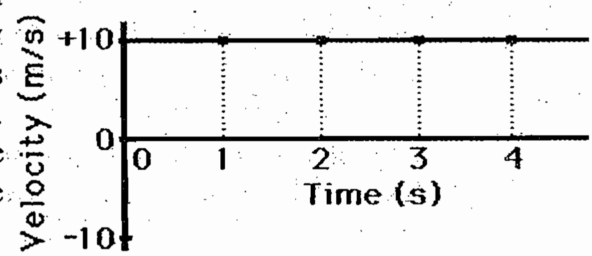
- Pick two points on the line and determine their coordinates.
- Determine the difference in y-coordinates of these two points (*rise*).
- Determine the difference in x-coordinates for these two points (*run*).
- Divide the difference in y-coordinates by the difference in x-coordinates (rise/run or slope).

The Meaning of Shape for a v-t Graph

The specific features of the motion of objects are demonstrated by the shape and the slope of the lines on a velocity vs. time graph.

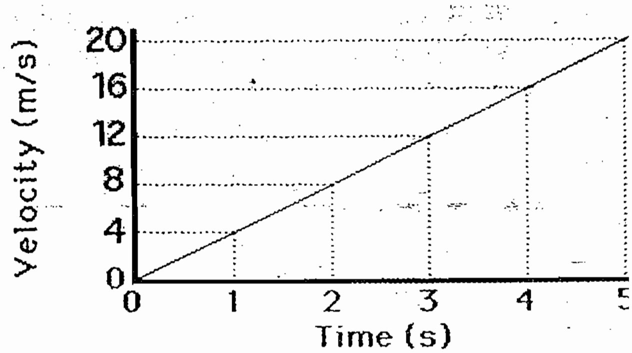
Consider a car moving with a **constant, rightward (+) velocity** - say of +10 m/s. As learned in an earlier, a car moving with a constant velocity is a car with zero acceleration.

If the velocity-time data for such a car were graphed, then the resulting graph would look like the graph at the right. Note that a motion described as a constant, positive velocity results in a line of zero slope **(a horizontal line has zero slope)** when plotted as a velocity-time graph. Furthermore, only positive velocity values are plotted, corresponding to a motion with positive velocity.



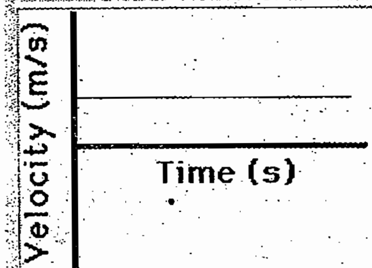
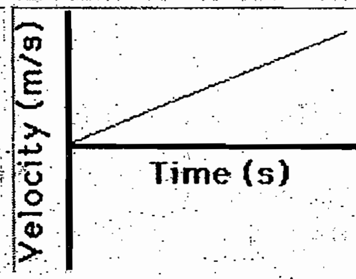
Now consider a car moving with a **rightward (+), changing velocity** - that is, a car that is moving rightward but speeding up or *accelerating*. Since the car is moving in the positive direction and speeding up, the car is said to have a *positive* acceleration.

If the velocity-time data for such a car were graphed, then the resulting graph would look like the graph at the right. Note that a motion described as a changing, positive velocity results in a sloped line when plotted as a velocity-time graph. The slope of the line is



positive, corresponding to the positive acceleration. Furthermore, only positive velocity values are plotted, corresponding to a motion with positive velocity.

The velocity vs. time graphs for the two types of motion - constant velocity and changing velocity (acceleration) - can be summarized as follows.

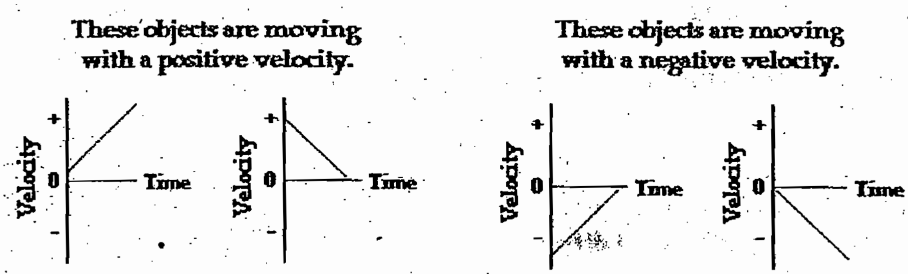
Positive Velocity **Zero Acceleration**	**Positive Velocity** **Positive Acceleration**
	

The Importance of Slope

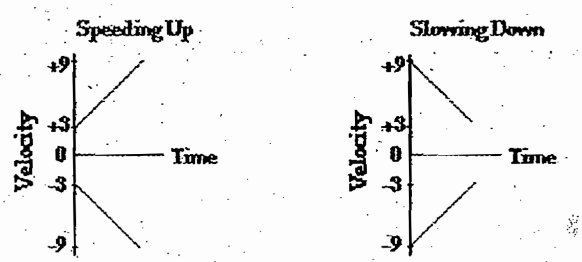
The shapes of the velocity vs. time graphs for these two basic types of motion - constant velocity motion and accelerated motion (i.e., changing velocity) - reveal an important principle. The principle is that **the slope of the line on a velocity-time graph reveals useful information about the acceleration of the object.** If the acceleration is zero, then the slope is zero (i.e., a horizontal line). If the acceleration is positive, then the slope is positive (i.e., an upward sloping line). If the acceleration is negative, then the slope is negative (i.e., a downward sloping line). This very principle can be extended to any conceivable motion.

The slope of a velocity-time graph reveals information about an object's acceleration. But how can one tell whether the object is moving in the positive direction (i.e., positive velocity) or in the negative direction (i.e., negative velocity)? And how can one tell if the object is speeding up or slowing down?

The answers to these questions hinge on one's ability to read a graph. Since the graph is a velocity-time graph, the velocity would be positive whenever the line lies in the positive region (above the x-axis) of the graph. Similarly, the velocity would be negative whenever the line lies in the negative region (below the x-axis) of the graph., a positive velocity means the object is moving in the positive direction; and a negative velocity means the object is moving in the negative direction. So one knows an object is moving in the positive direction if the line is located in the positive region of the graph (whether it is sloping up or sloping down). And one knows that an object is moving in the negative direction if the line is located in the negative region of the graph (whether it is sloping up or sloping down). And finally, if a line crosses over the x-axis from the positive region to the negative region of the graph (or vice versa), then the object has changed directions.



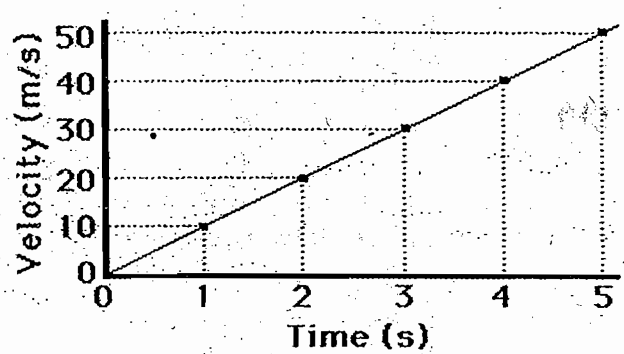
Now how can one tell if the object is speeding up or slowing down? Speeding up means that the magnitude (or numerical value) of the velocity is getting large. For instance, an object with a velocity changing from +3 m/s to + 9 m/s is speeding up. Similarly, an object with a velocity changing from -3 m/s to -9 m/s is also speeding up. In each case, the magnitude of the velocity (the number itself, not the sign or direction) is increasing; the speed is getting bigger. Given this fact, one would believe that an object is speeding up if the line on a velocity-time graph is changing from near the 0-velocity point to a location further away from the 0-velocity point. That is, if the line is getting further away from the x-axis (the 0-velocity point), then the object is speeding up. And conversely, if the line is approaching the x-axis, then the object is slowing down.



Determining the Slope on a v-t Graph

The slope of the line on a velocity versus time graph is equal to the acceleration of the object. If the object is moving with an acceleration of +4 m/s/s (i.e., changing its velocity by 4 m/s per second), then the slope of the line will be +4 m/s/s. If the object is moving with an acceleration of -8 m/s/s, then the slope of the line will be -8 m/s/s. If the object has a velocity of 0 m/s, then the slope of the line will be 0 m/s. Because of its importance, a student of physics must have a good understanding of how to calculate the slope of a line. In this part of the lesson, the method for determining the slope of a line on a velocity-time graph will be discussed.

Let's begin by considering the velocity versus time graph below.



The line is sloping upwards to the right. But mathematically, by how much does it slope upwards for every 1 second along the horizontal (time) axis? To answer this question we must use the slope equation.

$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\text{rise}}{\text{run}}$$

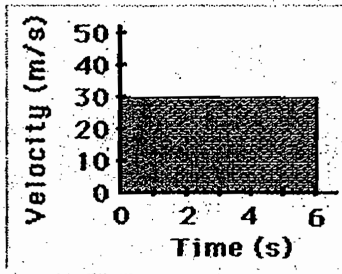
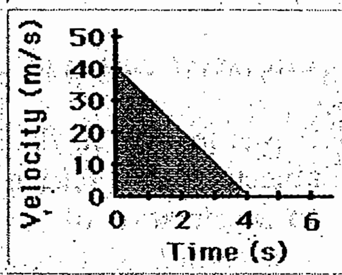
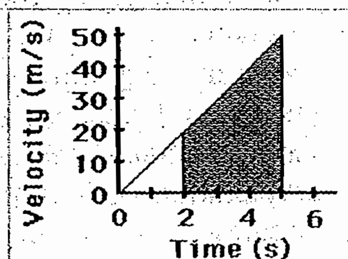
The slope equation says that the slope of a line is found by determining the amount of *rise* of the line between any two points divided by the amount of *run* of the line between the same two points. A method for carrying out the calculation is

1. Pick two points on the line and determine their coordinates.
2. Determine the difference in y-coordinates for these two points (*rise*).
3. Determine the difference in x-coordinates for these two points (*run*).
4. Divide the difference in y-coordinates by the difference in x-coordinates (rise/run or slope).

Determining the Area on a v-t Graph

As learned in an earlier part , a plot of velocity-time can be used to determine the acceleration of an object (the slope). In this part, we will learn how a plot of velocity versus time can also be used to determine the displacement of an object. For velocity versus time graphs, the area bound by the line and the axes represents

the displacement. The diagram below shows three different velocity-time graphs; the shaded regions between the line and the time-axis represents the displacement during the stated time interval.

The shaded area is representative of the displacement during from 0 seconds to 6 seconds. This area takes on the shape of a **rectangle** can be calculated using the appropriate equation.	
The shaded area is representative of the displacement during from 0 seconds to 4 seconds. This area takes on the shape of a **triangle** can be calculated using the appropriate equation.	
The shaded area is representative of the displacement during from 2 seconds to 5 seconds. This area takes on the shape of a **trapezoid** can be calculated using the appropriate equation.	

The method used to find the area under a line on a velocity-time graph depends upon whether the section bound by the line and the axes is a rectangle, a triangle or a trapezoid. Area formulas for each shape are given below.

Rectangle

$$\text{Area} = b \times h$$

Triangle

$$\text{Area} = \frac{1}{2} \times b \times h$$

Trapezoid

$$\text{Area} = \frac{1}{2} \times b \times (h_1 + h_2)$$

Introduction to Free Fall

A free-falling object is an object which is falling under the sole influence of gravity. Any object which is being acted upon only be the force of gravity is said to be in a state of **free fall.** There are two important motion characteristics which are true of free-falling objects:

- Free-falling objects do not encounter air resistance.
- All free-falling objects (on Earth) accelerate downwards at a rate of 9.8 m/s/s (often approximated as 10 m/s/s for *back-of-the-envelope* calculations)

The Acceleration of Gravity

It was learned in the previous part of this lesson that a free-falling object is an object which is falling under the sole influence of gravity. A free-falling object has an acceleration of 9.8 m/s/s, downward (on Earth). This numerical value for the acceleration of a free-falling object is such an important value that it is given a special name. It is known as the **acceleration of gravity** - the acceleration for any object moving under the sole influence of gravity. A matter of fact, this quantity known as the acceleration of gravity is such an important quantity that physicists have a special symbol to denote it - the symbol **g**. The numerical value for the acceleration of gravity is most accurately known as 9.8 m/s/s. There are slight variations in this numerical value (to the second decimal place) **which are dependent primarily upon on altitude.** We occasionally use the approximated value of 10 m/s/s in The Physics Classroom Tutorial in order to reduce the complexity of the many mathematical tasks

g = 9.8 m/s/s, downward

(~ 10 m/s/s, downward)

The Big Misconception

we have learnt that that the acceleration of a free-falling object (on earth) is 9.8 m/s/s. This value (known as the acceleration of gravity) is the same for all free-falling objects regardless of how long they have been falling, or whether they were initially dropped from rest or thrown up into the air. Yet the questions are often asked "doesn't a more massive object accelerate at a greater rate than a less massive object?" "Wouldn't an elephant free-fall faster than a mouse?" This question is a reasonable inquiry that is probably based in part upon personal observations made of falling objects in the physical world. After all, nearly everyone has observed the difference in the rate of fall of a single piece of paper (or similar object) and a textbook. The two objects clearly travel to the ground at different rates - with the more massive book falling faster.

The answer to the question (doesn't a more massive object accelerate at a greater rate than a less massive object?) is absolutely not! That is, absolutely not if we are considering the specific type of falling motion known as free-fall. Free-fall is the motion of objects which move under the sole influence of gravity; **free-falling objects do not encounter air resistance.** More massive objects will only fall faster if there is an appreciable amount of air resistance present.

The actual explanation of why all objects accelerate at the same rate involves the concepts of force and mass. The details will be discussed later. At that time, you will learn that **the acceleration of an object is directly proportional to force and inversely proportional to mass.** Increasing force tends to increase acceleration while increasing mass tends to decrease acceleration. Thus, the greater force on more massive objects is offset by the inverse influence of greater mass. **Subsequently, all objects free fall at the same rate of acceleration, regardless of their mass**

The Kinematic Equations

$$d = v_i{*}t + \frac{1}{2}{*}a{*}t^2 \qquad v_f^2 = v_i^2 + 2{*}a{*}d$$

$$v_f = v_i + a{*}t \qquad d = \frac{v_i + v_f}{2} * t$$

There are a variety of symbols used in the above equations. Each symbol has its own specific meaning. The symbol **d** stands for the **displacement** of the object. The symbol **t** stands for the **time** for which the object moved. The symbol **a** stands for the **acceleration** of the object. And the symbol **v** stands for the velocity of the object; a subscript of i after the v (as in v_i) indicates that the velocity value is the **initial velocity** value and a subscript of f (as in v_f) indicates that the velocity value is the **final velocity** value.

Each of these four equations appropriately describe the mathematical relationship between the parameters of an object's motion. As such, they can be used to predict unknown information about an object's motion if other information is known.

Kinematic Equations and Free Fall

As mentioned, a free-falling object is an object which is falling under the sole influence of gravity. That is to say that any object which is moving and being acted upon only be the force of gravity is said to be "in a state of **free fall.**" Such an object will experience a downward acceleration of 9.8 m/s/s. Whether the object is falling downward or rising upward towards its peak, if it is under the sole influence of gravity, then its acceleration value is 9.8 m/s/s.

Like any moving object, the motion of an object in free fall can be described by four kinematic equations. The kinematic equations which describe any object's motion are:

The Kinematic Equations

$$d = v_i{*}t + \frac{1}{2}{*}a{*}t^2 \qquad v_f^2 = v_i^2 + 2{*}a{*}d$$

$$v_f = v_i + a{*}t \qquad d = \frac{v_i + v_f}{2}{*}t$$

The symbols in the above equation have a specific meaning: the symbol **d** stands for the **displacement**; the symbol **t** stands for the **time**; the symbol **a** stands for the **acceleration** of the object; the symbol v_i stands for the **initial velocity** value; and the symbol v_f stands for the **final velocity**.

There are a few conceptual characteristics of free fall motion which will be of value when using the equations to analyze free fall motion. These concepts are described as follows:

- An object in free fall experiences an acceleration of -9.8 m/s/s. (The - sign indicates a downward acceleration.) Whether explicitly stated or not, the value of the acceleration in the kinematic equations is -9.8 m/s/s for any freely falling object.
- If an object is merely dropped (as opposed to being thrown) from an elevated height, then the initial velocity of the object is 0 m/s.
- If an object is projected upwards in a perfectly vertical direction, then it will slow down as it rises upward. The instant at which it reaches the peak of its trajectory, its velocity is 0 m/s. This value can be used as one of the motion parameters in the kinematic equations; for example, the final velocity (v_f) after traveling to the peak would be assigned a value of 0 m/s.
- If an object is projected upwards in a perfectly vertical direction, then the velocity at which it is projected is equal in magnitude and opposite in sign to the velocity which it has when it returns to the same height. These four principles and the four kinematic equations can be combined to solve problems involving the motion of free falling objects.

2. Newton's Laws of Motion

The focus here is Newton's first law of motion - sometimes referred to as the law of inertia.

Newton's first law of motion is often stated as:

An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction **unless acted upon by an unbalanced force.**

Everyday Applications of Newton's First Law

There are many applications of Newton's first law of motion. Several applications are listed below. Perhaps you could think about the law of inertia and provide explanations for each application.

- Blood rushes from your head to your feet while quickly stopping when riding on a descending elevator.
- The head of a hammer can be tightened onto the wooden handle by banging the bottom of the handle against a hard surface.
- A brick is painlessly broken over the hand of a physics teacher by slamming it with a hammer.
- To dislodge ketchup from the bottom of a ketchup bottle, it is often turned upside down and thrusted downward at high speeds and then abruptly halted.
- Headrests are placed in cars to prevent whiplash injuries during rear-end collisions.
- While riding a skateboard (or wagon or bicycle), you fly forward off the board when hitting a curb or rock or other object which abruptly halts the motion of the skateboard.

Inertia and Mass

Newton's first law of motion states that "An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force." Objects tend to "keep on doing what they're doing." In fact, it is the natural tendency of objects to resist changes in their state of motion. This tendency to resist changes in their state of motion is described as **inertia**.

Galileo and the Concept of Inertia

Galileo, a premier scientist in the seventeenth century, developed the concept of inertia. Galileo reasoned that moving objects eventually stop because of a force called friction.

Mass as a Measure of the Amount of Inertia

All objects resist changes in their state of motion. All objects have this tendency - they have inertia. But do some objects have more of a tendency to resist changes than others? Absolutely yes! The tendency of an object to resist changes in its state of motion varies with mass. Mass is that quantity which is solely dependent upon the inertia of an object. The more inertia which an object has, the more mass it has. A more massive object has a greater tendency to resist changes in its state of motion.

Force and Its Representation

The Meaning of Force

A **force** is a push or pull upon an object resulting from the object's *interaction* with another object. Whenever there is an *interaction* between two objects, there is a force upon each of the objects. When the *interaction* ceases, the two objects no longer experience the force. Forces only exist as a result of an interaction.

For simplicity sake, all forces (interactions) between objects can be placed into two broad categories:

- contact forces, and
- forces resulting from action-at-a-distance

Contact forces are those types of forces which result when the two interacting objects are perceived to be physically contacting each other. Examples of contact forces include frictional forces, tensional forces, normal forces, air resistance forces, and applied forces..

Action-at-a-distance forces are those types of forces which result even when the two interacting objects are not in physical contact with each other, yet are able to exert a push or pull despite their physical separation. Examples of action-at-a-distance forces include gravitational forces. For example, the sun and planets exert a gravitational pull on each other despite their large spatial separation. Even when your feet leave the earth and you are no longer in physical contact with the earth, there is a gravitational pull between you and the Earth. Electric forces are action-at-a-distance forces. For example, the protons in the nucleus of an atom and the electrons outside the nucleus experience an electrical pull towards each other despite their small spatial separation. And magnetic forces are action-at-a-distance forces. For example, two magnets can exert a magnetic pull on each other even when separated by a distance of a few centimeters.

Examples of contact and action-at-distance forces are listed in the table below.

Contact Forces	**Action-at-a-Distance Forces**
Frictional Force	Gravitational Force
Tension Force	Electrical Force
Normal Force	Magnetic Force
Air Resistance Force	
Applied Force	
Spring Force	

Force is a quantity which is measured using the standard metric unit known as the **Newton**. A Newton is abbreviated by a "N." To say "10.0 N" means 10.0 Newtons of force. One Newton is the amount of force required to give a 1-kg mass an acceleration of 1 m/s/s. Thus, the following unit equivalency can be stated:

$$1 \text{ Newton} = 1 \text{ kg} * \frac{\text{m}}{\text{s}^2}$$

A force is a vector quantity.

Newton's Second Law of Motion

The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object.

The net force is equated to the product of the mass times the acceleration.

$$\mathbf{F_{net} = m * a}$$

Newton's Third Law

Formally stated, Newton's third law is:

For every action, there is an equal and opposite reaction.

The statement means that in every interaction, there is a pair of forces acting on the two interacting objects. The size of the forces on the first object equals the size of the force on the second object. The direction of the force on the first object is opposite to the direction of the force on the second object. Forces always come in pairs - equal and opposite action-reaction force pairs.

Projectile Motion

What is a Projectile?

The most common example of an object which is moving in *two dimensions* is a projectile.

A projectile is an object upon which the only force acting is gravity. There are a variety of examples of projectiles. An object dropped from rest is a projectile (provided that the influence of air resistance is negligible). An object which is thrown vertically upward is also a projectile (provided that the influence of air resistance is negligible). And an object is which thrown upward at an angle to the horizontal is also a projectile (provided that the influence of air resistance is negligible). A projectile is any object which once *projected* or dropped continues in motion by its own inertia and is influenced only by the downward force of gravity.

By definition, a projectile has only one force acting upon it - the force of gravity. If there was any other force acting upon an object, then that object would not be a projectile.

3. Momentum and Its Conservation

Momentum refers to the quantity of motion that an object has.

Momentum can be defined as "mass in motion." All objects have mass; so if an object is moving, then it has momentum - it has its mass in motion. The amount of momentum which an object has is dependent upon two variables: how much *stuff* is moving and how fast the *stuff* is moving. Momentum depends upon the variables mass and velocity. In terms of an equation, the momentum of an object is equal to the mass of the object times the velocity of the object.

Momentum = mass • velocity

In physics, the symbol for the quantity momentum is the lower case "p". Thus, the above equation can be rewritten as

$\mathbf{p = m \cdot v}$

where **m** is the mass and **v** is the velocity. The equation illustrates that momentum is directly proportional to an object's mass and directly proportional to the object's velocity.

The units for momentum would be mass units times velocity units. The standard metric unit of momentum is the kg•m/s.

Momentum is a **vector quantity**

Momentum and Impulse Connection:

These concepts are merely an outgrowth of Newton's second law .Newton's second law ($F_{net} = m \cdot a$) stated that the acceleration of an object is directly proportional to the net force acting upon the object and inversely proportional to the mass of the object. When combined with the definition of acceleration (a = change in velocity / time), the following equalities result.

$$F = m * a = m * \frac{\Delta v}{t}$$

or

$$F = m * \frac{\Delta v}{t}$$

If both sides of the above equation are multiplied by the quantity t, a new equation results.

$$F * t = m * \Delta v$$

To truly understand the equation, it is important to understand its meaning in words. In words, it could be said that **the force times the time** equals **the mass times the change in velocity.** In physics, the quantity Force • time is known as **impulse**. And since the quantity m•v is the momentum, the quantity m•ΔV

must be the **change in momentum**. The equation really says that the

Impulse = Change in momentum

The physics of collisions are governed by the laws of momentum.

In a collision, an object experiences a force for a specific amount of time which results in a change in momentum. The result of the force acting for the given amount of time is that the object's mass either speeds up or slows down (or changes direction). The impulse experienced by the object equals the change in momentum of the object. In equation form, F • t = m • Δ v.

Momentum Conservation Principle

One of the most powerful laws in physics is the law of momentum conservation. The law of momentum conservation can be stated as follows.

For a collision occurring between object 1 and object 2 in an **isolated system,** the total momentum of the two objects before the collision is equal to the total momentum of the two objects after the collision. That is, the momentum lost by object 1 is equal to the momentum gained by object 2.

The above statement tells us that the total momentum of a collection of objects (a *system*) is *conserved* - that is, the total amount of momentum is a constant or unchanging value..

Isolated Systems

Total system momentum is conserved for collisions occurring in isolated systems. But what makes a system of objects an isolated system? And is momentum conserved if the system is not isolated?

A system is a collection of two or more objects. An isolated system is a system which is free from the influence of a net external force which alters the momentum of the system. There are two criteria for the presence of a net external force; it must be...

- a force which originates from a source other than the two objects of the system
- a force that is not balanced by other forces.

A system in which the only forces which contribute to the momentum change of an individual object are the forces acting between the objects themselves can be considered an isolated system.

If a system is not isolated, then the total system momentum is not conserved. Because of the inevitability of friction and air resistance in any real collision, one might conclude that no system is ever perfectly isolated. The reasoning would be that there will always be a resistance force of some kind robbing the system of its momentum

Momentum Conservation in Explosions

For collisions occurring in isolated systems, there are no exceptions to this law. This same principle of momentum conservation can be applied to explosions. In an explosion, an internal impulse acts in order to propel the parts of a system (often a single object) into a variety of directions. After the explosion, the individual parts of the system (which is often a collection of fragments from the original object) have momentum. If the vector sum of all individual parts of the system could be added together to determine the total momentum after the explosion, then it should be the same as the total momentum before the explosion. Just like in collisions, total system momentum is conserved.

4. Work ,Energy and Power

When a force acts upon an object to cause a displacement of the object, it is said that work was done upon the object. **There are three key *ingredients* to work - force, displacement, and cause. In order for a force to qualify as having done *work* on an object, there must be a displacement and the force must *cause* the displacement.**

Read the following five statements to understand the concept of work.

Statement	Answer with Explanation
A teacher applies a force to a wall and becomes exhausted.	**No.** This is not an example of work. The wall is not displaced. A force must cause a displacement in order for work to be done
A book falls off a table and free falls to the ground.	**Yes.** This is an example of work. There is a force (gravity) which acts on the book which causes it to be displaced in a downward direction (i.e., "fall").
A waiter carries a tray full of meals above his head by one arm straight across the room at constant speed.	**No.** This is not an example of work. There is a force (the waiter pushes up on the tray) and there is a displacement (the tray is moved horizontally across the room). Yet the force does not cause the displacement. To cause a displacement, there must be a component of force in the direction of the displacement.
A rocket accelerates through space.	**Yes.** This is an example of work. There is a force (the expelled gases push on the rocket) which causes the rocket to be displaced through space.

Mathematically, work can be expressed by the following equation:-

$$W = F * d * \cos\Theta$$

where F is the force, d is the displacement, and the angle (theta) is defined as the angle between the force and the displacement vector.

The Meaning of Negative Work

On occasion, a force acts upon a moving object to hinder a displacement. Examples might include a car skidding to a stop on a roadway surface or a baseball runner sliding to a stop on the infield dirt. In such instances, the force acts in the direction opposite the objects motion in order to slow it down. The force doesn't cause the displacement but rather *hinders* it. These situations involve what is commonly called *negative work*. The *negative* of negative work refers to the numerical value which results when values of F, d and theta are substituted into the work equation.

Units of Work Whenever a new quantity is introduced in physics, the standard metric units associated with that quantity are discussed. In the case of work (and also energy), the standard metric unit is the **Joule** (abbreviated **J**). One Joule is equivalent to one Newton of force causing a displacement of one meter. In other words,

The Joule is the unit of work.

1 Joule = 1 Newton * 1 meter

Potential Energy

Potential energy is the stored energy of position possessed by an object.

Gravitational potential energy is the energy stored in an object as the result of its vertical position or height. The energy is stored as the result of the gravitational attraction of the Earth for the object. The gravitational potential energy of the massive ball of a demolition machine is dependent on two variables - the mass of the ball and the height to which it is raised. There is a direct relation between gravitational potential energy and the mass of an object. More massive objects have greater gravitational potential energy. There is also a direct relation between gravitational potential energy and the height of an object. The higher that an object is elevated, the greater the gravitational potential energy. These relationships are expressed by the equation:

PE_{grav} = mass * g * height

PE_{grav} = m * g * h

Elastic potential energy is the energy stored in elastic materials as the result of their stretching or compressing. Elastic potential energy can be stored in rubber bands, bungee chords, trampolines, springs, an arrow drawn into a bow, etc. The amount of elastic potential energy stored in such a device is related to the amount of stretch of the device - the more stretch, the more stored energy.

Springs are a special instance of a device which can store elastic potential energy due to either compression or stretching. A force is required to compress a spring; the more compression there is, the more force which is required to compress it further. For certain springs, the amount of force is directly proportional to the amount of stretch or compression (x); the constant of proportionality is known as the spring constant (k).

$$F_{spring} = k * x$$

Such springs are said to follow Hooke's Law. If a spring is not stretched or compressed, then there is no elastic potential energy stored in it. The spring is said to be at its *equilibrium position*. The equilibrium position is the position that the spring naturally assumes when there is no force applied to it. In terms of potential energy, the equilibrium position could be called the zero-potential energy position. There is a special equation for springs which relates the amount of elastic potential energy to the amount of stretch (or compression) and the spring constant. The equation is

$$PE_{spring} = \frac{1}{2} * k * x^2$$

where k= spring constant
x= amount of compression
(relative to equilibrium pos'n)

Kinetic energy is the energy of motion. An object which has motion - whether it be vertical or horizontal motion - has kinetic energy. The following equation is used to represent the kinetic energy (KE) of an object.

$$KE = \frac{1}{2} * m * v^2$$

where **m** = mass of object

v = speed of object

Kinetic energy is a scalar quantity; it does not have a direction.

$$1 \text{ Joule} = 1 \text{ kg} * \frac{m^2}{s^2}$$

The Total Mechanical Energy

The mechanical energy of an object can be the result of its motion (i.e., kinetic energy) and/or the result of its stored energy of position (i.e., potential energy). The total amount of mechanical energy is merely the sum of the potential energy and the kinetic energy. This sum is simply referred to as the total mechanical energy (abbreviated TME).

TME = PE + KE

Power

Power is the rate at which work is done. It is the work/time ratio. Mathematically, it is computed using the following equation.

$$\text{Power} = \frac{\text{Work}}{\text{time}}$$

The standard metric unit of power is the **Watt**.. Thus, a Watt is equivalent to a Joule/second. **For historical reasons, the *horsepower* is occasionally used to describe the power delivered by a machine. One horsepower is equivalent to approximately 750 Watts.**

5. Circular Motion and Planetary Motion

Suppose that you were driving a car with the steering wheel turned in such a manner that your car followed the path of a perfect circle with a constant radius. And suppose that as you drove, your speedometer maintained a constant reading of 10 mi/hr. In such a situation as this, the motion of your car could be described as experiencing uniform circular motion. **Uniform circular motion** is the motion of an object in a circle with a constant or uniform speed.

Calculation of the Average Speed

$$\text{Average Speed} = \frac{\text{distance}}{\text{time}} = \frac{\text{circumference}}{\text{time}}$$

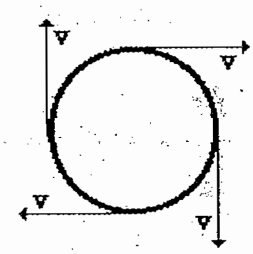
The circumference of any circle can be computed using from the radius according to the equation

Circumference = 2*pi*Radius

Combining these two equations above will lead to a new equation relating the speed of an object moving in uniform circular motion to the radius of the circle and the time to make one cycle around the circle **(period)**.

$$\text{Average Speed} = \frac{2 * \pi * R}{T}$$

The Direction of the Velocity Vector As the object *rounds* the circle, the direction of the velocity vector is different than it was the instant before. So while the magnitude of the velocity vector may be constant, the direction of the velocity vector is changing. The best word that can be used to describe the direction of the velocity veetor is the word **tangential**. The direction of the velocity vector at any instant is in the direction of a tangent line drawn to the circle at the object's location. (A tangent line is a line which touches a circle at one point but does not intersect it.) **The diagram at the right** shows the direction of the velocity vector at four different point for an object moving in a clockwise direction around a circle. While the actual direction of the object (and thus, of the velocity vector) is changing, it's direction is always tangent to the circle.



The direction of the velocity vector at every instant is in a direction tangent to the circle.

Acceleration

An accelerating object is an object which is changing its velocity. And since velocity is a vector which has both magnitude and direction, a change in either the magnitude or the direction constitutes a change in the velocity. **For this reason, it can be safely concluded that an object moving in a circle at constant speed is indeed accelerating. It is accelerating because the direction of the velocity vector is changing.** It is calculated using the following equation:

$$\text{Ave. acceleration} = \frac{\Delta\text{velocity}}{\text{time}} = \frac{\mathbf{v_f} - \mathbf{v_i}}{\mathbf{t}}$$

where $\mathbf{v_i}$ represents the initial velocity and $\mathbf{v_f}$ represents the final velocity after some time of **t**. The numerator of the equation is found by subtracting one vector ($\mathbf{v_i}$) from a second vector ($\mathbf{v_f}$).

The Centripetal Force Requirement

An object moving in a circle experiences an acceleration. Even if moving around the perimeter of the circle with a constant speed, there is still a change in velocity and subsequently an acceleration. This acceleration is directed towards the center of the circle. And in accord with Newton's second law of motion, an object which experiences an acceleration must also be experiencing a net force. The direction of the net force is in the same direction as the acceleration. So for an object moving in a circle, there must be an inward force acting upon it in order to cause its inward acceleration. This is sometimes referred to as the **centripetal force requirement.** The word *centripetal* means center-seeking. For object's moving in circular motion, there is a net force acting towards the center which causes the object to *seek* the center.

Centrifugal force An object traveling in a circle behaves as if it is experiencing an outward force. This force, known as the centrifugal force, depends on the mass of the object, the speed of rotation, and the distance from the center. The more massive the object, the greater the force; the greater the speed of the object, the greater the force; and the greater the distance from the center, the greater the force.

Mathematics of Circular Motion

There are three mathematical quantities which will be of primary interest to us as we analyze the motion of objects in circles. These three quantities are speed, acceleration and force. The speed of an object moving in a circle is given by the following equation.

$$\text{Average Speed} = \frac{\text{distance}}{\text{time}} = \frac{2 * \pi * R}{T}$$

where R represents radius
T represents period

The acceleration of an object moving in a circle can be determined by either two of the following equations.

$$\text{Acceleration} = \frac{v^2}{R} \qquad \text{Acceleration} = \frac{4 * \pi^2 * R}{T^2}$$

where v represents speed
R represents radius
T represents period

The equation on the right (above) is derived from the equation on the left by the substitution of the expression for speed.

The net force (F_{net}) acting upon an object moving in circular motion is directed inwards. While there may by more than one force acting upon the object, the vector sum of all of them should add up to the net force. In general, the inward force is larger than the outward force (if any) such that the outward force cancels and the unbalanced force is in the direction of the center of the circle. The net force is related to the acceleration of the object (as is always the case) and is thus given by the following three equations:

$$F_{net} = m * a \qquad F_{net} = m * \frac{v^2}{R} \qquad F_{net} = m * \frac{4 * \pi^2 * R}{T^2}$$

where m represents mass
v represents speed
R represents radius
T represents period

The equations in the middle (above) and on the right (above) are derived from the equation on the left by the substitution of the expressions for acceleration.

6. Universal Gravitation

Gravity is a force which exists between the Earth and the objects which are near it.. We have become accustomed to calling it the **force of gravity** and have even represented it by the symbol $\mathbf{F_{grav}}$.

Not to be confused with the force of gravity ($\mathbf{F_{grav}}$), the acceleration of gravity (**g**) is the acceleration experienced by an object when the only force acting upon it is the force of gravity. On and near Earth's surface, the value for the acceleration of gravity is approximately 9.8 m/s/s. It is the same acceleration value for all objects, regardless of their mass (and assuming that the only significant force is gravity).

The Apple, the Moon, and the Inverse Square Law

In the early 1600's, German mathematician and astronomer Johannes Kepler mathematically analyzed known astronomical data in order to develop three **laws to describe the motion of planets about the sun.** Kepler's three laws emerged from the analysis of data carefully collected over a span of several years by his Danish predecessor and teacher, Tycho Brahe. Kepler's three laws of planetary motion can be briefly described as follows:

- The path of the planets about the sun are elliptical in shape, with the center of the sun being located at one focus. (The Law of Ellipses)
- An imaginary line drawn from the center of the sun to the center of the planet will sweep out equal areas in equal intervals of time. (The Law of Equal Areas)
- The ratio of the squares of the periods of any two planets is equal to the ratio of the cubes of their average distances from the sun. (The Law of Harmonies)

While Kepler's laws provided a suitable framework for describing the motion and paths of planets about the sun, there **was no accepted explanation for why such paths existed.** The cause for how the planets moved as they did was never stated. Kepler could only suggest that there was some sort of interaction between the sun and the planets which provided the driving force for the planet's motion. To Kepler, the planets were somehow "magnetically" driven by the sun to orbit in their elliptical trajectories. There was however no interaction between the planets themselves.

Newton was troubled by the lack of explanation for the planet's orbits. To Newton, there must be some cause for such elliptical motion. Even more troubling was the circular motion of the moon about the earth. Newton knew that there must be some sort of force which governed the heavens; for the motion of the moon in a circular path and of the planets in an elliptical path required that there be an inward component of force. Circular and elliptical motion were clearly departures from the inertial paths (straight-line) of objects. And as such, these celestial motions required a cause in the form of an unbalanced force. The nature of such a force - its cause and its origin - bothered Newton for some time and was the fuel for much mental pondering. And according to legend, a breakthrough came at age 24 in an apple orchard in England. Newton never wrote of such an event, yet it is often claimed that the notion of gravity as the cause of all heavenly motion was instigated when he was struck in the head by an apple while lying under a tree in an orchard in England. Whether it is a myth or a reality, the fact is certain that it was Newton's ability to relate the cause for heavenly motion (the orbit of the moon about the earth) to the cause for Earthly motion (the falling of an apple to the Earth) which led him to his notion of **universal gravitation**

Newton's Law of Universal Gravitation

Isaac Newton compared the acceleration of the moon to the acceleration of objects on earth. Believing that gravitational forces were responsible for each, Newton was able to draw an important conclusion about the dependence of gravity upon distance. This comparison led him to conclude that the force of gravitational attraction between the Earth and other objects is inversely proportional to the distance separating the earth's center from the object's center. But distance is not the only variable affecting the magnitude of a gravitational force. Consider Newton's famous equation

$$\mathbf{F_{net} = m \bullet a}$$

Newton knew that the force which caused the apple's acceleration (gravity) must be dependent upon the mass of the apple. And since the force acting to cause the apple's downward acceleration also causes the earth's upward acceleration (Newton's third law), that force must also depend upon the mass of the earth. So for Newton, the force of gravity acting between the earth and any other object is directly proportional to the mass of the earth, directly proportional to the mass of the object, and inversely proportional to the square of the distance which separates the centers of the earth and the object.

But Newton's law of universal gravitation extends gravity beyond earth. Newton's law of universal gravitation is about the **universality** of gravity. Newton's place in the *Gravity Hall of Fame* is not due to his discovery of gravity, but rather due to his discovery that gravitation is universal. **ALL** objects attract each other with a force of gravitational attraction. Gravity is universal. This force of gravitational attraction is directly dependent upon the masses of both objects and inversely proportional to the square of the distance which separates their centers. Newton's conclusion about the magnitude of gravitational forces is summarized symbolically as

$$F_{grav} \sim \frac{m_1 * m_2}{d^2}$$

where F_{grav} represents the force of gravity between two objects

$\sim$ means "proportional to"

m_1 represents the mass of object 1

m_2 represents the mass of object 2

d represents the distance separating the objects' centers

Since the gravitational force is directly proportional to the mass of both interacting objects, more massive objects will attract each other with a greater gravitational force. So as the mass of either object increases, the force of gravitational attraction between them also increases. If the mass of one of the objects is doubled, then the force of gravity between them is doubled. If the mass of one of the objects is tripled, then the force of gravity between them is tripled. If the mass of both of the objects is doubled, then the force of gravity between them is quadrupled; and so on.

Since gravitational force is inversely proportional to the separation distance between the two interacting objects, more separation distance will result in weaker gravitational forces. So as two objects are separated from each other, the force of gravitational attraction between them also decreases.

Another means of representing the proportionalities is to express the relationships in the form of an equation using a constant of proportionality. This equation is shown below.

$$F_{grav} = \frac{G * m_1 * m_2}{d^2}$$

where G represents the universal gravitation constant

$(G = 6.67 \times 10^{-11}\ N \cdot m^2/kg^2)$

The constant of proportionality (G) in the above equation is known as the **universal gravitation constant.** The precise value of G was determined experimentally by Henry Cavendish in the century after Newton's death. The value of G is found to be

$G = 6.673 \times 10^{-11}\ N\ m^2/kg^2$

The units on G may seem rather odd; nonetheless they are sensible. When the units on G are substituted into the equation above and multiplied by $\mathbf{m_1 \bullet m_2}$ units and divided by $\mathbf{d^2}$ units, the result will be Newtons - the unit of force.

Planetary and Satellite Motion

Kepler's Three Laws

In the early 1600s, Johannes Kepler proposed three laws of planetary motion. Kepler was able to summarize the carefully collected data of his mentor - Tycho Brahe - with three statements which described the motion of planets in a sun-centered solar system. Kepler's efforts to explain the underlying reasons for such motions are no longer accepted; nonetheless, the actual laws themselves are still considered an accurate description of the motion of any planet and any satellite.

Kepler's three laws of planetary motion can be described as follows:

- The path of the planets about the sun are elliptical in shape, with the center of the sun being located at one focus. (The Law of Ellipses)
- An imaginary line drawn from the center of the sun to the center of the planet will sweep out equal areas in equal intervals of time. (The Law of Equal Areas)
- The ratio of the squares of the periods of any two planets is equal to the ratio of the cubes of their average distances from the sun. (The Law of Harmonies)

Circular Motion Principles for Satellites

A satellite is any object which is orbiting the earth, sun or other massive body. Satellites can be categorized as **natural satellites** or **man-made satellites**. The moon, the planets and comets are examples of natural satellites. Accompanying the orbit of natural satellites are a host of satellites launched from earth for purposes of communication, scientific research, weather forecasting, intelligence, etc. Whether a moon, a planet, or some man-made satellite, every satellite's motion is governed by the same physics principles and described by the same mathematical equations.

The fundamental principle to be understood concerning satellites is that a satellite is a projectile. That is to say, a satellite is an object upon which the only force is gravity. Once launched into orbit, the only force governing the motion of a satellite is the force of gravity. Newton was the first to theorize that a projectile launched with sufficient speed would actually orbit the earth

So what launch speed does a satellite need in order to orbit the earth? The answer emerges from a basic fact about the curvature of the earth. For every 8000 meters measured along the horizon of the earth, the earth's surface curves downward by approximately 5 meters. So if you were to look out horizontally along the horizon of the Earth for 8000 meters, you would observe that the Earth curves downwards below this straight-line path a distance of 5 meters. For a projectile to orbit the earth, it must travel horizontally a distance of 8000 meters for every 5 meters of vertical fall. It so happens that the vertical distance which a horizontally launched projectile would fall in its first second is approximately 5 meters ($0.5*g*t^2$). For this reason, a projectile launched horizontally with a speed of about 8000 m/s will be capable of orbiting the earth in a circular path. This assumes that it is launched above the surface of the earth and encounters negligible atmospheric drag. As the projectile travels tangentially a distance of 8000 meters in 1 second, it will drop approximately 5 meters towards the earth. Yet, the projectile will remain the same distance above the earth due to the fact that the earth curves at the same rate that the projectile falls. If shot with a speed greater than 8000 m/s, it would orbit the earth in an elliptical path.

Elliptical Orbits of Satellites

Occasionally satellites will orbit in paths which can be described as ellipses. In such cases, the central body is located at one of the foci of the ellipse. Similar motion characteristics apply for satellites moving in elliptical paths. The velocity of the satellite is directed tangent to the ellipse. The acceleration of the satellite is directed towards the focus of the ellipse. And in accord with Newton's second law of motion, the net force acting upon the satellite is directed in the same direction as the acceleration - towards the focus of the ellipse. Once more, this net force is supplied by the force of gravitational attraction between the central body and the orbiting satellite. In the case of elliptical paths, there is a component of force in the same direction as (or opposite direction as) the motion of the object. such a component of force can cause the satellite to either speed up or slow down in addition to changing directions. So unlike uniform circular motion, the elliptical motion of satellites is not characterized by a constant speed.

Meaning and Cause of Weightlessness

Weightlessness is simply a sensation experienced by an individual when there are no external objects touching one's body and exerting a push or pull upon it. Weightless sensations exist when all contact forces are removed. These sensations are common to any situation in which you are momentarily (or perpetually) in a state of free fall. When in free fall, the only force acting upon your body is the force of gravity - a non-contact force. Since the force of gravity cannot be felt without any other opposing forces, you would have no sensation of it. You would feel weightless when in a state of free fall.

These feelings of weightlessness are common at amusement parks for riders of roller coasters and other rides in which riders are momentarily airborne and lifted out of their seats. Suppose that you were lifted in your chair to the top of a very high tower and then your chair was suddenly dropped. As you and your chair fall towards the ground, you both accelerate at the same rate - g. Since the chair is unstable, falling at the same rate as you, it is unable to push upon you. Normal forces only result from contact with stable, supporting surfaces. The force of gravity is the only force acting upon your body. There are no external objects touching your body and exerting a force. As such, you would experience a weightless sensation. You would weigh as much as you always do (or as little), yet you would not have any sensation of this weight.

Weightlessness is only a sensation; it is not a reality corresponding to an individual who has lost weight. As you are free-falling on a roller coaster ride (or other amusement park ride), you have not momentarily lost your weight. Weightlessness has very little to do with weight and mostly to do with the presence or absence of contact forces. If by "weight" we are referring to the force of gravitational attraction to the Earth, a free-falling person has not "lost their weight;" they are still experiencing the Earth's gravitational attraction. Unfortunately, the confusion of a person's actual weight with one's feeling of weight is the source of many misconceptions.

Weightlessness in Orbit

Earth-orbiting astronauts are weightless for the same reasons that riders of a free-falling amusement park ride or a free-falling elevator are weightless. They are weightless because there is no external contact force pushing or pulling upon their body. In each case, gravity is the only force acting upon their body. Being an action-at-a-distance force, it cannot be felt and therefore would not provide any sensation of their weight. But for certain, the orbiting astronauts weigh something; that is, there is a force of gravity acting upon their body. In fact, if it were not for the force of gravity, the astronauts would not be orbiting in circular motion. It is the force of gravity which supplies the centripetal force requirement to allow the inward acceleration which is characteristic of circular motion. The force of gravity is the only force acting upon their body. The astronauts are in free-fall. Like the falling amusement park rider and the falling elevator rider, the astronauts and their surroundings are falling towards the Earth under the sole influence of gravity. The astronauts and all their surroundings - the space station with its contents - are falling towards the Earth without colliding into it. Their tangential velocity allows them to remain in orbital motion while the force of gravity pulls them inward.

Conductors and Insulators

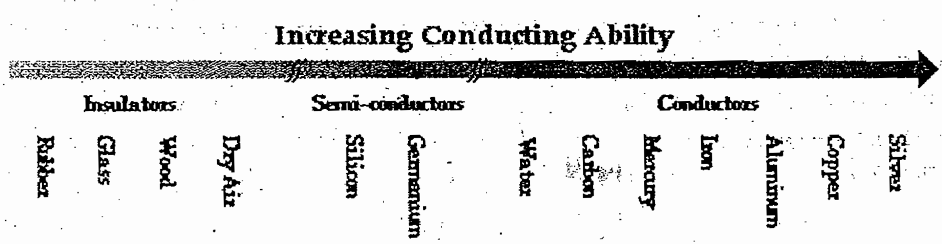
The behavior of an object which has been charged is dependent upon whether the object is made of a conductive or a nonconductive material. **Conductors** are materials which permit electrons to flow freely from atom to atom and molecule to molecule.

In contrast to conductors, **insulators** are materials which impede the free flow of electrons from atom to atom and molecule to molecule. If charge is transferred to an insulator at a given location, the excess charge will remain at the initial location of charging. The particles of the insulator do not permit the free flow of electrons; subsequently charge is seldom distributed evenly across the surface of an insulator.

Examples of conductors include metals, aqueous solutions of salts (i.e., *ionic compounds* dissolved in water), graphite, water and the human body.

Examples of insulators include plastics, Styrofoam, paper, rubber, glass and dry air.

The division of materials into the categories of conductors and insulators is a somewhat artificial division. It is more appropriate to think of materials as being placed somewhere along a continuum. Those materials which are super conductive (known as **superconductors**) would be placed at on end and the least conductive materials (best insulators) would be placed at the other end. Metals would be placed near the most conductive end and glass would be placed on the opposite end of the continuum. The conductivity of a metal might be as much as a million trillion times greater than that of glass.



Along the continuum of conductors and insulators, one might find the human body somewhere towards the conducting side of the middle. When the body acquires a static charge it has a tendency to distribute that charge throughout the surface of the body. Given the size of the human body, relative to the size of typical objects used in electrostatic experiments, it would require an abnormally large quantity of excess charge before its affect is noticeable. When a student places their hand upon the static ball, excess charge from the ball is shared with the human body. Being a conductor, the excess charge could flow to the human body and spread throughout the surface of the body, even onto strands of hair. As the individual strands of hair become charged, they begin to repel each other. Looking to distance themselves from their like-charged neighbors, the strands of hair begin to rise upward and outward - a truly hair-raising experience.

Many are familiar with the impact that **humidity** can have upon static charge buildups. You have likely noticed that bad hair days, doorknob shocks and static clothing are most common during winter months. Winter months tend to be the driest months of the year with humidity levels in the air dropping to lower values. Water, being a conductor, has a tendency to gradually remove excess charge from objects. When the humidity is high, a person acquiring an excess charge will tend to lose that charge to water molecules in the surrounding air. On the other hand, dry air conditions are more conducive to the buildup of static charge and more frequent electric shocks. Since humidity levels tend to vary from day to day and season to season.

Distribution of Charge via Electron Movement

At the location where the charge is imparted, there is an excess of electrons. That is, the multitude of atoms in that region possess more electrons than protons. Of course, there are a number of electrons who could be thought of as being *quite contented* since there is an accompanying positively charged proton to satisfy their attraction for an opposite. However, the so-called excess electrons have a repulsive response to each other and would prefer more space. Electrons, like human beings, wish to manipulate their surroundings in an effort to reduce repulsive affects. Since these excess electrons are present in a conductor, there is little hindrance to their ability to migrate to other parts of the object. And that is exactly what they do. In an effort to reduce the overall repulsive affects within the object, there is a mass migration of excess electrons throughout the entire surface of the object. Excess electrons migrate to distance themselves from their repulsive neighbors. In this sense, it is said that excess negative charge distributes itself throughout the surface of the conductor.

But what happens if the conductor acquires an excess of positive charge? What if electrons are removed from a conductor at a given location, giving the object an overall positive charge? If protons cannot move, then how can the excess of positive charge distribute itself across the surface of the material? While the answers to these questions are not as obvious, it still involves a rather simple explanation which once again relies on the two fundamental rules of charge interaction. Opposites attract and likes repel. Suppose that a conducting metal sphere is charged on its left side and imparted an excess of positive charge. (Of course, this requires that electrons be removed from the object at the location of charging.) A multitude of atoms in the region where the charging occurs have lost one or more electrons and have an excess of protons. The imbalance of charge within these atoms creates affects which can be thought of as disturbing the balance of charge within the entire object. The presence of these excess protons in a given location draws electrons from other atoms. Electrons in other parts of the object can be thought of as being *quite contented* with the balance of charge which they are experiencing. Yet there will always be some electrons who will feel the attraction for the excess protons some distance away. In human terms, we might say these electrons are drawn by curiosity or by the belief that the grass is greener on the other side of the fence. In the language of electrostatics, we simply assert that opposites attract - the excess protons and both the neighboring and distant electrons attract each other. The protons cannot do anything about this attraction since they are bound within the nucleus of their own atoms. Yet, electrons are loosely bound within atoms; and being present in a conductor, they are free to move. These electrons make the move for the excess protons, leaving their own atoms with their own excess of positive charge. This electron migration happens across the entire surface of the object, until the overall sum of repulsive affects between electrons across the whole surface of the object are minimized.

Polarization

In conducting objects, electrons are so loosely bound that they may be **induced** into moving from one portion of the object to another portion of the object. To get an electron in a conducting object to *get up and go*, all that must be done is to place a charged object nearby the conducting object.

In general terms, polarization means to separate into opposites. In the political world, we often observe that a collection of people becomes polarized over some issue. For instance, we might say that the United States has become polarized over the issue of the death penalty. That is, the citizens of the United States have been separated into opposites - those who are for the death penalty and those who are against the death penalty. In the context of electricity, **polarization** is the process of separating opposite charges within an object. The positive charge becomes separated from the negative charge. By **inducing** the movement of electrons within an object, one side of the object is left with an excess of positive charge and the other side of the object is left with an excess of negative charge. Charge becomes separated into opposites.

How Can an Insulator be Polarized?

The electrons surrounding the nucleus of an atom are believed to be located in regions of space with specific shapes and sizes. The actual size and shape of these regions is determined by the high-powered mathematical equations common to Quantum Mechanics. Rather than being located a specific distance from the nucleus in a fixed orbit, the electrons are simply thought of as being located in regions often referred to as **electron clouds**. At any given moment, the electron is likely to be found at some location within the cloud. The electron clouds have varying density; the density of the cloud is considered to be greatest in the portion of the cloud where the electron has the greatest probability of being found at any given moment. And conversely, the electron cloud density is least in the regions where the electron is least likely to be found. In addition to having varying density, these electron clouds are also highly distortable. The presence of neighboring atoms with high electron affinity can distort the electron clouds around atoms. Rather than being located symmetrically about the positive nucleus, the cloud becomes asymmetrically shaped. As such, there is a polarization of the atom as the centers of positive and negative charge are no longer located in the same location. The atom is still a neutral atom; it has just become polarized.

Electron Cloud Distribution

Uniform distribution of electron cloud about the nucleus.

Non-uniform distribution of electron cloud – separation of + and - charge within atom.

This polarization leaves the molecule with areas which have a concentration of positive charges and other areas with a concentration of negative charges. This principle is utilized in the manufacture of certain commercial products which are used to reduce static cling. The centers of positive and negative charge within the product are drawn to excess charge residing on the clothes. There is a neutralization of the static charge buildup on the clothes, thus reducing their tendency to be attracted to each other. (Other products actually use a different principle. During manufacturing, a thin sheet is soaked in a solution containing positively charged ions. The sheet is tossed into the dryer with the clothes. Being saturated with positive charges, the sheet is capable of attracting excess electrons which are scuffed off of clothes during the drying cycle.)

Polarization is Not Charging

Perhaps the biggest misconception that pertains to polarization is the belief that polarization involves the charging of an object. Polarization is not charging! When an object becomes polarized, there is simply a redistribution of the centers of positive and negative charges within the object. Either by the movement of electrons across the surface of the object (as is the case in conductors) or through the distortion of electron clouds (as is the case in insulators), the centers of positive and negative charges become separated from each other. The atoms at one location on the object possess more protons than electrons and the atoms at another location have more electrons than protons. While there are the same number of protons and electrons within the object, these protons and electrons are not distributed in the same proportion across the object's surface. Yet, there are still equal numbers of positive charges (protons) and negative charges (electrons) within the object. While there is a separation of charge, there is NOT an imbalance of charge. When neutral objects become polarized, they are still neutral objects.

Methods of Charging

1.Charging by Friction

The presence of different atoms in objects provide different objects with different electrical properties. One such property is known as **electron affinity**. Simply put, the property of electron affinity refers to the relative amount of *love* which a material has for electrons. If atoms of a material have a high electron affinity, then that material will have a relatively high love for electrons

How Charging by Friction Works

The frictional charging process results in a transfer of electrons between the two objects which are rubbed together. Rubber has a much greater attraction for electrons than animal fur. As a result, the atoms of rubber pull electrons from the atoms of animal fur, leaving both objects with an imbalance of charge. The rubber balloon has an excess of electrons and the animal fur has a shortage of electrons. Having an excess of electrons, the rubber balloon is charged negatively. Similarly, the shortage of electrons on the animal fur leaves it with a positive charge. The two objects have become charged with opposite types of charges as a result of the transfer of electrons from the least electron-loving material to the most electron-loving material.

As mentioned, different materials have different affinities for electrons. By rubbing a variety of materials against each other and testing their resulting interaction with objects of known charge, the tested materials can be ordered according to their affinity for electrons. Such an ordering of substances is known as a **triboelectric series**. One such ordering for several materials is shown in the table at the right. Materials shown highest on the table tend to have a greater affinity for electrons than those below it. Subsequently, when any two materials in the table are rubbed together, the one which is higher can be expected to pull electrons from the material which is lower. As such, the materials highest on the table will have the greatest tendency to acquire the negative charge. Those below it would become positively charged.

Triboelectric Series

Celluloid
Sulfur
Rubber
Copper, Brass
Amber
Wood
Cotton
Human Skin
Silk
Cat Fur
Wool
Glass
Rabbit Fur
Asbestos

The Law of Conservation of Charge

Whenever a quantity like charge (or momentum or energy or matter) is observed to be the same prior to and after the completion of a given process, we say that the quantity is conserved. **Charge is always conserved.** When all objects involved are considered prior to and after a given process, we notice that the total amount of charge amidst the objects is the same before the process starts as it is after the process ends. This is referred to as the **law of conservation of charge.**

2.Charging by Induction

Induction charging is a method used to charge an object without actually touching the object to any other charged object involving the process of polarization

The fundamental principles principles of Induction charging are:

- The charged object is never touched to the object being charged by induction.
- The charged object does not transfer electrons to or receive electrons from the object being charged.
- The charged object serves to polarize the object being charged.
- The object being charged is touched by a ground; electrons are transferred between the ground and the object being charged (either into the object or out of it).
- The object being charged ultimately receives a charge that is opposite that of the charged object which is used to polarize it.

3.Charging by Conduction

Charging by conduction involves the contact of a charged object to a neutral object.. In contrast to induction, where the charged object is brought near but never contacted to the object being charged, conduction charging involves making the physical connection of the charged object to the neutral object. Because charging by conduction involves contact, it is often called **charging by contact.**

Grounding - the Removal of a Charge

We have discussed the three common methods of charging - charging by friction, charging by induction, and charging by conduction. A discussion of charging would not be complete without a discussion of *uncharging*. Objects with an excess of charge - either positive or negative - can have this charge *removed* by a process known as grounding. **Grounding is the process of *removing* the excess charge on an object by means of the transfer of electrons between it and another**

object of substantial size. When a charged object is grounded, the excess charge is balanced by the transfer of electrons between the charged object and a ground.

A **ground** is simply an object which serves as a seemingly infinite reservoir of electrons; the ground is capable of transferring electrons to or receiving electrons from a charged object in order to neutralize that object.

Any negatively charged object has an excess of electrons. If it is to have its charge removed, then it will have to lose its excess electrons. Once the excess electrons are removed from the object, there will be equal numbers of protons and electrons within the object and it will have a balance of charge. To remove the excess of electrons from a negatively charged electroscope, the electroscope will have to be connected by a conducting pathway to another object which is capable of receiving those electrons. The other object is the ground. In typical electrostatic experiments and demonstrations, this is simply done by touching the electroscope with one's hand. Upon contact, the excess electrons leave the electroscope and enter the person who touches it. These excess electrons subsequently spread about the surface of the person.

The previous discussion describes the grounding of a negatively charged electroscope. Electrons were transferred from the electroscope to the ground. But what if the electroscope is positively charged? How does electron transfer allow an object with an excess of protons to become neutralized? To explore these questions, we will consider the grounding of a positively charged electroscope. A positively charged electroscope must gain electrons in order to acquire an equal number of protons and electrons. By gaining electrons from *the ground*, the electroscope will have a balance of charge and therefore be neutral. Thus, the grounding of a positively charged electroscope involves the transfer of electrons from *the ground* into the electroscope.

Electric Force

Coulomb's Law Equation

The quantitative expression for the affect of these three variables on electric force is known as Coulomb's law. Coulomb's law states that the electrical force between two charged objects is directly proportional to the product of the quantity of charge on the objects and inversely proportional to the square of the separation distance between the two objects. In equation form, Coulomb's law can be stated as

$$F = \frac{k \bullet Q_1 \bullet Q_2}{d^2}$$

where Q_1 represents the quantity of charge on object 1 (in Coulombs), Q_2 represents the quantity of charge on object 2 (in Coulombs), and **d** represents the distance of separation between the two objects (in meters). The symbol **k** is a proportionality constant known as the Coulomb's law constant. **The value of this constant is dependent upon the medium that the charged objects are immersed in.** In the case of air, the value is approximately 9.0×10^9 N • m^2 / C^2. If the charged objects are present in water, the value of **k** can be reduced by as much as a factor **of 80.** It is worthwhile to point out that the units on **k** are such that when substituted into the equation the units on charge (Coulombs) and the units on distance (meters) will be canceled, leaving a Newton as the unit of force.

The Coulomb's law equation provides an accurate description of the force between two objects whenever the objects act as **point charges.** A charged conducting sphere interacts with other charged objects as though all of its charge were located at its center. While the charge is uniformly spread across the surface of the sphere, the center of charge can be considered to be the center of the sphere. The sphere acts as a point charge with its excess charge located at its center. Since Coulomb's law applies to point charges, the distance **d** in the equation is the distance between the centers of charge for both objects.

Electric Fields

Action at a Distance

How can an object be charged and what affect does that charge have upon other objects in its vicinity? we will explore this concept of **action-at-a-distance** using a different concept known as the **electric field.**

The Electric Field Concept

Action-at-a-distance forces are sometimes referred to as field forces. . An alternative to describing this action-at-a-distance affect is to simply suggest that there is something rather strange about the space surrounding a charged object. Any other charged object that is in that space feels the affect of the charge. A charged object creates an electric field - an alteration of the space in the region which surrounds it. Other charges in that field would feel the unusual alteration of the space. Whether a charged object enters that space or not, the electric field exists. Space is altered by the presence of a charged object. Other objects in that space experience the strange and mysterious qualities of the space.

A Stinky Analogy

With a concept such as the electric field, analogies are often appropriate and useful. While the following analogy might be a *wee-bit* crude, it certainly proves useful in many respects in describing the nature of an electric field. Anyone who has ever walked into a room of an infant with a soiled diaper (as in a *poopy* diaper) has experienced a *stinky field.* There is something about the space surrounding an infant's soiled diaper which exerts a strange influence upon other people who enter that space. When that *little stinker* needs a diaper change, you can't help but to notice it. When you walk into a room with such a diaper present, your detectors (i.e., the nose) begin to detect the presence of a stinky field. As you move closer and closer to the infant, the stinky field becomes more and more intense. And of course the worse the diaper, the stronger the stinky field becomes. It's not difficult to imagine that a soiled diaper could exert a smelly influence some distance away that would repel any nose that gets in that area. The diaper has altered the nature of the surrounding space and when your nose gets near, you know it. The stinky diaper has created a stinky field.

In the same manner, an electric charge creates an electric field - it has altered the nature of the space surrounding the charge. And if another charge gets near enough, that charge will sense that there is an affect when present in that surrounding space. And electric field is sensed by the detector charge in the same way that a nose senses the stinky field. The strength of the stinky field is dependent upon the distance from the stinky diaper and the amount of *stinky* in the diaper. And in an analogous manner, the strength of the electric field is dependent upon the amount of charge which creates the field and the distance from the charge.

Electric Field Intensity

The Force per Charge Ratio

Electric field strength is a vector quantity; it has both magnitude and direction. The magnitude of the electric field strength is defined in terms of how it is measured. Let's suppose that an electric charge can be denoted by the symbol **Q**. This electric charge creates an electric field; since **Q** is the source of the electric field, we will refer to it as the **source charge.** The strength of the source charge's electric field could be measured by any other charge placed somewhere in its surroundings. The charge that is used to measure the electric field strength is referred to as a **test charge** since it is used to *test* the field strength. The test charge has a quantity of charge denoted by the symbol **q**. When placed within the electric field, the test charge will experience an electric force - either attractive or repulsive. As is usually the case, this force will be denoted by the symbol **F**. The magnitude of the electric field is simply defined as the force per charge on the test charge.

$$\textbf{Electric Field Strength} = \frac{\textbf{Force}}{\textbf{Charge}}$$

If the electric field strength is denoted by the symbol **E**, then the equation can be rewritten in symbolic form as

$$\mathbf{E} = \frac{\mathbf{F}}{\mathbf{q}}$$

The standard metric units on electric field strength arise from its definition. Since electric field is defined as a force per charge, its units would be force units divided by charge units. In this case, the standard metric units are Newton/Coulomb or N/C.

In the above discussion, you will note that two charges are mentioned - the source charge and the test charge. Two charges would always be necessary to encounter a force. In the electric world, it takes two to attract or repel. The equation for electric field strength (E) has one of the two charge quantities listed in it. Since there are two charges involved, a student will have to be ultimately careful to use the correct charge quantity when computing the electric field strength. The symbol **q** in the equation is the quantity of charge on the test charge (not the source charge). Recall that the electric field strength is defined in terms of how it is measured or tested; thus, the test charge finds its way into the equation. Electric field is the force per quantity of charge *on the test charge*.

The electric field strength is not dependent upon the quantity of charge on the test charge. If you think about that statement for a little while, you might be bothered by it. After all, the quantity of charge on the test charge (**q**) is in the equation for electric field. So how could electric field strength not be dependent upon **q** if **q** is in the equation? Increasing the quantity of charge on the test charge - say, by a factor of 2 - would increase the denominator of the equation by a factor of 2. But according to Coulomb's law, more charge also means more electric force (**F**). In fact, a twofold increase in **q** would be accompanied by a twofold increase in **F**. So as the denominator in the equation increases by a factor of two (or three or four), the numerator increases by the same factor. These two changes offset each other such that one can safely say that the electric field strength is not dependent upon the quantity of charge on the test charge. So regardless of what test charge is used, the electric field strength at any given location around the source charge **Q** will be measured to be the same.

The Direction of the Electric Field Vector

The precise direction of the force is dependent upon whether the test charge and the source charge have the same type of charge (in which repulsion occurs) or the opposite type of charge (in which attraction occurs). To resolve the dilemma of whether the electric field vector is directed towards or away from the source charge, a convention has been established. The worldwide convention which is used by scientists is to define the direction of the electric field vector as the direction that a **positive test charge** is pushed or pulled when in the presence of the electric field. By using the convention of a positive test charge, everyone can agree upon the direction of **E**.

Given this convention of a positive test charge, several generalities can be made about the direction of the electric field vector. A positive source charge would create an electric field that would exert a repulsive affect upon a positive test charge. Thus, the electric field vector would always be directed away from positively charged objects. On the other hand, a positive test charge would be attracted to a negative source charge. Therefore, electric field vectors are always directed towards negatively charged objects.

Electrostatic equilibrium is the condition established by charged conductors in which the excess charge has optimally distanced itself so as to reduce the total amount of repulsive forces. Once a charged conductor has reached the state of electrostatic equilibrium, there is no further motion of charge about the surface.

Electric Fields Inside of Charged Conductors

Charged conductors which have reached electrostatic equilibrium share a variety of unusual characteristics. One characteristic of a conductor at electrostatic equilibrium is that the electric field anywhere beneath the surface of a charged conductor is zero.

If an electric field did exist beneath the surface of a conductor (and inside of it), then the electric field would exert a force on all electrons that were present there. This net force would begin to accelerate and move these electrons. But objects at electrostatic equilibrium have no further motion of charge about the surface. So if this were to occur, then the original claim that the object was at electrostatic equilibrium would be a false claim. If the electrons within a conductor have assumed an equilibrium state, then the net force upon those electrons is zero. The electric field lines either begin or end upon a charge and in the case of a conductor, the charge exists solely upon its outer surface. The lines extend from this surface outward, not inward. This of course presumes that our conductor does not surround a region of space where there was another charge.

This concept of the electric field being zero inside of a closed conducting surface was first demonstrated by Michael Faraday, a 19th century-physicist who promoted the field theory of electricity. Faraday constructed a room within a room, covering the inner room with a metal foil. He sat inside the inner room with an electroscope and charged the surfaces of the outer and inner room using an electrostatic generator. While sparks were seen flying between the walls of the two rooms, there was no detection of an electric field within the inner room. The excess charge on the walls of the inner room resided entirely upon the outer surface of the room.

The inner room with the conducting frame which protected Faraday from the static charge is now referred to as a **Faraday's cage.** The cage serves to shield whomever and whatever is on the inside from the influence of electric fields. Any closed, conducting surface can serve as a Faraday's cage, shielding whatever it surrounds from the potentially damaging affects of electric fields.

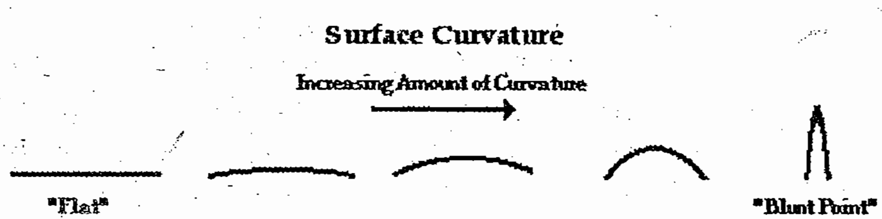
This principle of **shielding** is commonly utilized today as we protect delicate electrical equipment by enclosing them in metal cases. Even delicate computer chips and other components are shipped inside of conducting plastic packaging which shields the chips from potentially damaging affects of electric fields

Electric Fields are Perpendicular to Charged Surfaces

A second characteristic of conductors at electrostatic equilibrium is that the electric field upon the surface of the conductor is directed entirely perpendicular to the surface. There cannot be a component of electric field (or electric force) that is parallel to the surface. If the conducting object is spherical, then this means that the perpendicular electric field vector are aligned with the center of the sphere. If the object is irregularly shaped, then the electric field vector at any location is perpendicular to a tangent line drawn to the surface at that location.

Electric Fields and Surface Curvature

A third characteristic of conducting objects at electrostatic equilibrium is that the electric fields are strongest at locations along the surface where the object is most curved. The curvature of a surface can range from absolute flatness on one extreme to being curved to a *blunt* point on the other extreme.



A flat location has no curvature and is characterized by relatively weak electric fields. On the other hand, a *blunt point* has a high degree of curvature and is characterized by relatively strong electric fields. A sphere is uniformly shaped with the same curvature at every location along its surface. As such, the electric field strength on the surface of a sphere is everywhere the same.

The fact that surfaces which are sharply curved to a blunt edge create strong electric fields is the underlying principle for the use of **lightning rods**.

Lightning

Perhaps the most known and powerful displays of electrostatics in nature is a lightning storm. Lightning storms are inescapable from humankind's attention. They are never invited, never planned, and never gone unnoticed. The rage of a lightning strike will wake a person in the middle of the night. They send children rushing into parent's bedrooms, crying for assurance that everything will be safe. The fury of a lightning strike is capable of interrupting midday conversations and activities. They're the frequent cause of canceled ball games and golf outings. Children and adults alike crowd around windows to watch the lightning displays in the sky, standing in awe of the power of static discharges. Indeed, a lightning storm is the most powerful display of electrostatics in nature.

Static Charge Buildup in the Clouds

The precursor of any lightning strike is the polarization of positive and negative charges within a storm cloud. The tops of the storm clouds are known to acquire an excess of positive charge and the bottom of the storm clouds acquire an excess of negative charge. Two mechanisms seem important to the polarization process. One mechanism involves a separation of charge by a process which bears resemblance to frictional charging. Clouds are known to contain countless millions of suspended water droplets and ice particles moving and whirling about in turbulent fashion. Additional water from the ground evaporates, rises upward and forms clusters of droplets as it approaches a cloud. This upwardly rising moisture collides with water droplets within the clouds. In the collisions, electrons are ripped off the rising droplets, causing a separation of negative electrons from a positively charged water droplet or a cluster of droplets.

The second mechanism which contributes to the polarization of a storm cloud involves a freezing process. Rising moisture encounters cooler temperatures at higher altitudes. These cooler temperatures cause the cluster of water droplets to undergo freezing. The frozen particles tend to cluster more tightly together and form the central regions of the cluster of droplets. The frozen portion of the cluster of rising moisture becomes negatively charged and the outer droplets acquire a positive charge. Air currents within the clouds can rip the outer portions off the clusters and carry them upward toward the top of the clouds. The frozen portion of the droplets with their negative charge tend to gravitate towards the bottom of the storm clouds. Thus, the clouds become further polarized.

These two mechanisms are believed to be the primary causes of the polarization of storm clouds. In the end, a storm cloud becomes polarized with positive charges carried to the upper portions of the clouds and negative portions gravitating towards the bottom of the clouds. The polarization of the clouds has an equally important affect on the surface of the Earth. The cloud's electric field stretches through the space surrounding it and induces movement of electrons upon Earth. Electrons on Earth's outer surface are repelled by the negatively charged cloud's bottom surface. This creates an opposite charge on the Earth's surface. Buildings, trees and even people can experience a buildup of static charge as electrons are repelled by the cloud's bottom. With the cloud polarized into opposites and with a positive charge induced upon Earth's surface, the stage is set for Act 2 in the drama of a lightning strike.

The Mechanics of a Lightning Strike

As the static charge buildup in a storm cloud increases, the electric field surrounding the cloud becomes stronger. Normally, the air surrounding a cloud would be a good enough insulator to prevent a discharge of electrons to Earth. Yet, the strong electric fields surrounding a cloud are capable of ionizing the surrounding air and making it more conductive. The ionization involves the shredding of electrons from the outer shells of gas molecules. The gas molecules which compose air are thus turned into a soup of positive ions and free electrons. The insulating air is transformed into a conductive **plasma**. The ability of a storm cloud's electric fields to transform air into a conductor makes charge transfer (in the form of a lightning bolt) from the cloud to the ground (or even to other clouds) possible.

A lightning bolt begins with the development of a **step leader**. Excess electrons on the bottom of the cloud begin a journey through the conducting air to the ground at speeds up to 60 miles per second. These electrons follow zigzag paths towards the ground, branching at various locations. The variables which affect the details of the actual pathway are not well known. It is believed that the presence of impurities or dust particles in various parts of the air might create regions between clouds and earth which are more conductive than other regions. As the step leader grows, it might be illuminated by the purplish glow which is characteristic of ionized air molecules. Nonetheless, the step leader is not the actual lightning strike, it merely provides the roadway between cloud and Earth along which the lightning bolt will eventually travel.

As the electrons of the step leader approach the Earth, there is an additional repulsion of electrons downward from Earth's surface. The quantity of positive charge residing on the Earth's surface becomes even greater. This charge begins to migrate upward through buildings, trees and people into the air. This upward rising positive charge - known as a **streamer** - approaches the step leader in the air above the surface of the Earth. The streamer might meet the leader at an altitude equivalent to the length of a football field. Once contact is made between the streamer and the leader, a complete conducting pathway is mapped out and the lightning begins. The contact point between ground charge and cloud charge rapidly ascends upward at speeds as high as 50 000 miles per second. As many as a billion trillion electrons can transverse this path in less than a millisecond. This initial strike is followed by several secondary strikes or charge surges in rapid succession. These secondary surges are spaced apart so closely in time that may appear as a single strike. The enormous and rapid flow of charge along this pathway between the cloud and Earth heats the surrounding air, causing it to expand violently. The expansion of the air creates a shockwave which we observe as thunder.

Lightning Rods and Other Protective Measures

Tall buildings, farm houses and other structures susceptible to lightning strikes are often equipped with **lightning rods**. The attachment of a grounded lightning rod to a building is a protective measure which is taken to protect the building in the event of a lightning strike. The concept of a lightning rod was originally developed by Ben Franklin. Franklin proposed that lightning rods should consist of a pointed metal pole which extends upward above the building which it is intended to protect. Franklin suggested that a lightning rod protects a building by one of two methods. First, the rod serves to prevent a charged cloud from releasing a bolt of lightning. And second, the lightning rod serves to safely divert the lightning to the ground in event that the cloud does discharge its lightning via a bolt. Franklin's theories on the operation of lightning rods have endured for a couple of centuries. And not until the most recent decades have scientific studies provided evidence to confirm the manner in which they operate to protect buildings from lightning damage.

8.Current Electricity

Electric Potential Difference

Electric Potential

Moving a positive test charge against the direction of an electric field is like moving a mass upward within Earth's gravitational field. Both movements would be like *going against nature* and would require work by an external force. This work would in turn increase the potential energy of the object. On the other hand, the movement of a positive test charge in the direction of an electric field would be like a mass falling downward within Earth's gravitational field. Both movements would be like *going with nature* and would occur without the need of work by an external force. This motion would result in the loss of potential energy. Potential energy is the stored energy of position of an object and it is related to the location of the object within a field. we will introduce the concept of **electric potential** and relate this concept to the potential energy of a positive test charge at various locations within an electric field.

Electric potential energy is dependent upon at least two types of quantities:

1) Electric charge - a property of the object experiencing the electrical field, and

2) Distance from source - the location within the electric field

While electric potential energy has a dependency upon the charge of the object experiencing the electric field, electric potential is purely location dependent. Electric potential is the potential energy per charge.

$$\text{Electric Potential} = \frac{PE}{Q}$$

The concept of electric potential is used to express the affect of an electric field of a source in terms of the location within the electric field. A test charge with twice the quantity of charge would possess twice the potential energy at a given location; yet its electric potential at that location would be the same as any other test charge. A positive test charge would be at a high electric potential when held close to a positive source charge and at a lower electric potential when held further away. In this sense, electric potential becomes simply a property of the location within an electric field

Electric Potential Difference

Consider the task of moving a positive test charge within a uniform electric field from location A to location B as shown in the diagram at the right. In moving the charge against the electric field from location A to location B, work will have to be done on the charge by an external force. The work done on the charge changes its potential energy to a higher value; and the amount of work which is done is equal to the change in the potential energy. As a result of this change in potential energy, there is also a difference in electric potential between locations A and B. This difference in electric potential is represented by the symbol ΔV and is formally referred to as the **electric potential difference**.

By definition, the electric potential difference is the difference in electric potential (V) between the final and the initial location when work is done upon a charge to change its potential energy. In equation form, the electric potential difference is

$$\Delta V = V_B - V_A = \frac{\text{Work}}{\text{Charge}} = \frac{\Delta PE}{\text{Charge}}$$

The standard metric unit on electric potential difference is the volt, abbreviated **V** and named in honor of Alessandra Volta. One Volt is equivalent to one Joule per Coulomb.. Because electric potential difference is expressed in units of volts, it is sometimes referred to as the **voltage.**

Electric Current

As a physical quantity, **current** is the rate at which charge flows past a point on a circuit. As depicted in the diagram below, the current in a circuit can be determined if the quantity of charge **Q** passing through a cross section of a wire in a time **t** can be measured. The current is simply the ratio of the quantity of charge and time.

Current is a rate quantity. In every case of a rate quantity, the mathematical equation involves some quantity over time. Thus, current as a rate quantity would be expressed mathematically as

$$\text{Current} = I = \frac{Q}{t}$$

Note that the equation above uses the symbol **I** to represent the quantity current.

The standard metric unit for current is the **ampere.** Ampere is often shortened to *Amp* and is abbreviated by the unit symbol A. A current of 1 ampere means that there is 1 coulomb of charge passing through a cross section of a wire every 1 second.

1 ampere = 1 coulomb / 1 second

Conventional Current Direction

The particles which carry charge through wires in a circuit are mobile electrons. The electric field direction within a circuit is by definition the direction which positive test charges are pushed. Thus, these negatively charged electrons move in the direction opposite the electric field. But while electrons are the charge carriers in metal wires, the charge carriers in other circuits can be positive charges, negative charges or both. **In fact, the charge carriers in semiconductors, street lamps and fluorescent lamps are simultaneously both positive and negative charges traveling in opposite directions.**

The **direction of an electric current** is by convention the direction in which a positive charge would move. Thus, the current in the external circuit is directed away from the positive terminal and toward the negative terminal of the battery. Electrons would actually move through the wires in the opposite direction. Knowing that the actual charge carriers in wires are negatively charged electrons may make this convention seem a bit odd and outdated. Nonetheless, it is the convention which is used world wide and one that a student of physics can easily become accustomed to.

The Nature of Charge Flow

Why does the light in a room or in a flashlight light immediately after the switched is turned on? Wouldn't there be a noticeable time delay before a charge carrier moves from the switch to the light bulb filament? The answer is NO! and the explanation of why reveals a significant amount about the nature of charge flow in a circuit.

charge carriers in the wires of electric circuits are electrons. These electrons are simply supplied by the atoms of copper (or whatever material the wire is made of) within the metal wire. Once the switch is turned to *on,* the circuit is closed and there is an electric potential difference is established across the two ends of the external circuit. The electric field signal travels at nearly the speed of light to all mobile electrons within the circuit, ordering them to begin *marching*. As the signal is received, the electrons begin moving along a zigzag path in their usual direction. Thus, the flipping of the switch causes an immediate response throughout every part of the circuit, setting charge carriers everywhere in motion in the same net direction. While the actual motion of charge carriers occurs with a slow speed, the signal which *informs* them to start moving travels at a fraction of the speed of light.

The electrons which light the bulb in a flashlight do not have to first travel from the switch through 10 cm of wire to the filament. Rather, the electrons which light the bulb immediately after the switch is turned to *on* are the electrons which are present in the filament itself. As the switch is flipped, all mobile electrons everywhere begin marching; and it is the mobile electrons present in the filament whose motion are immediately responsible for the lighting of its bulb. As those electrons leave the filament, new electrons enter and become the ones which are responsible for lighting the bulb. The electrons are moving together much like the water in the pipes of a home move. When a faucet is turned *on*, it is the water in the faucet which emerges from the spigot. One does not have to wait a noticeable time for water from the entry point to your home to travel through the pipes to the spigot. The pipes are already filled with water and water everywhere within the water circuit is set in motion at the same time.

Power

Electric circuits are designed to serve a useful function. The mere movement of charge from terminal to terminal is of little use if the electrical energy possessed by the charge is not transformed into another useful form. To equip a circuit with a battery and a wire leading from positive to negative terminal without an electrical device (light bulb, beeper, motor, etc.) would lead to a high rate of charge flow. **Such a circuit is referred to as a *short circuit*.** With charge flowing rapidly between terminals, the rate at which energy would be consumed would be high. Such a circuit would heat the wires to a high temperature and drain the battery of its energy rather quickly. When a circuit is equipped with a light bulb, beeper, or motor, the electrical energy supplied to the charge by the battery is transformed into other forms in the electrical device.

A light bulb, beeper and motor are generally referred to as a **load**. In a light bulb, electrical energy is transformed into useful light energy (and some non-useful thermal energy). In a beeper, electrical energy is transformed into sound energy. And in a motor, electrical energy is transformed into mechanical energy.

Power is the rate at which electrical energy is supplied to a circuit or consumed by a load. The electrical energy is supplied to the load by an energy source such as an electrochemical cell

Like current, power is a rate quantity. Its mathematical formula is expressed on a *per time* basis.

$$\text{Power} = \frac{\text{Work Done on Charge}}{\text{Time}} = \frac{\text{Energy Consumed by Load}}{\text{Time}}$$

Whether the focus is the energy gained by the charge at the energy source or the energy lost by the charge at the load, electrical power refers to the rate at which the charge changes its energy. In an electrochemical cell (or other energy source), the change is a positive change (i.e., a gain in energy) and at the load, the change is a negative change (i.e., a loss in energy). Thus, power is often referred to as the rate of energy change and its equation is expressed as the energy change per time. Like mechanical power, the unit of electrical power is the **watt**, abbreviated **W**. (Quite obviously, it is important that the symbol **W** as the unit of power not be confused with the symbol **W** for the quantity of work done upon a charge by the energy source.) A watt of power is equivalent to the delivery of 1 joule of energy every second. In other words:

1 watt = 1 joule / second

The kilowatt-hour

A kilowatt is a unit of power and an hour is a unit of time. So a kilowatt • hour is a unit of Power • time. If Power = ΔEnergy / time, then Power • time = ΔEnergy. So a unit of power • time is a unit of energy. The kilowatt • hour is a unit of energy. When an electrical utility company charges a household for the electricity which they used, they are charging them for electrical energy.

It is a common misconception that the utility company provides electricity in the form of charge carriers or electrons. The fact is that the mobile electrons which are in the wires of our homes would be there whether there was a utility company or not. The electrons come with the atoms that make up the wires of our household circuits. The utility company simply provides the energy which causes the motion of the charge carriers within the household circuits. And when they charge us for a few hundred kilowatt-hours of electricity, they are providing us with an energy bill.

Calculating Power

The relationship between power, current and electric potential difference can be derived by combining the mathematical definitions of power, electric potential difference and current. Power is the rate at which energy is added to or removed from a circuit by a battery or a load. Current is the rate at which charge moves past a point on a circuit. And the electric potential difference across the two ends of a circuit is the potential energy difference per charge between those two points. In equation form:

$$P = \frac{\Delta V \cdot Q}{t}$$

In the equation above, there is a **Q** in the numerator and a **t** in the denominator. This is simply the current; and as such, the equation can be rewritten as

$$P = \Delta V \cdot I$$

The electrical power is simply the product of the electric potential difference and the current.

Electrical Resistance

Journey of a Typical Electron

An electron's journey through a circuit can be described as a zigzag path which results from countless collisions with the atoms of the conducting wire. Each collision results in the alteration of the path, thus leading to a zigzag type motion. While the electric potential difference across the two ends of a circuit *encourages* the flow of charge, it is the collisions of charge carriers with atoms of the wire that *discourages* the flow of charge. Different types of atoms offer a different degree of hindrance to the flow of the charge carriers which pass through it.

The journey of an electron through an external circuit involves a long and slow zigzag path which is characterized by several successive losses in electric potential. Each loss of potential is referred to as a **voltage drop**. Accompanying this voltage drop is a *voltage boost* occurring within the internal circuit - for instance, within the electrochemical cell.

Resistance

An electron traveling through the wires and loads of the external circuit encounters resistance. **Resistance** is the hindrance to the flow of charge

Variables Affecting Electrical Resistance

The total amount of resistance to charge flow within a wire of an electric circuit is affected by some clearly identifiable variables.

1.the total length of the wires will affect the amount of resistance.

The longer the wire, the more resistance that there will be. There is a direct relationship between the amount of resistance encountered by charge and the length of wire it must traverse. After all, if resistance occurs as the result of collisions between charge carriers and the atoms of the wire, then there is likely to be more collisions in a longer wire. More collisions means more resistance.

2.The cross-sectional area of the wires will affect the amount of resistance.

Wider wires have a greater cross-sectional area. Water will flow through a wider pipe at a higher rate than it will flow through a narrow pipe. This can be attributed to the lower amount of resistance which is present in the wider pipe. In the same manner, the wider the wire, the less resistance that there will be to the flow of electric charge. When all other variables are the same, charge will flow at higher rates through wider wires with greater cross-sectional areas than through thinner wires.

3. the material that a wire is made of.

Not all materials are created equal in terms of their conductive ability. Some materials are better conductors than others and offer less resistance to the flow of charge. Silver is one of the best conductors but is never used in wires of household circuits due to its cost. Copper and aluminum are among the least expensive materials with suitable conducting ability to permit their use in wires of household circuits. The conducting ability of a material is often indicated by its **resistivity**. The resistivity of a material is dependent upon the material's electronic structure and its temperature. For most (but not all) materials, resistivity increases with increasing temperature. The table below lists resistivity values for various materials at temperatures of 20 degrees Celsius.

Material	Resistivity (ohm•meter)
Silver	1.59×10^{-8}
Copper	1.7×10^{-8}
Gold	2.4×10^{-8}
Aluminum	2.8×10^{-8}
Tungsten	5.6×10^{-8}
Iron	10×10^{-8}
Platinum	11×10^{-8}
Lead	22×10^{-8}
Nichrome	150×10^{-8}
Carbon	3.5×10^{5}
Polystyrene	$10^{7} - 10^{11}$
Polyethylene	$10^{8} - 10^{9}$
Glass	$10^{10} - 10^{14}$
Hard Rubber	10^{13}

As seen in the table, there is a broad range of resistivity values for various materials. Those materials with lower resistivities offer less resistance to the flow of charge; they are better conductors. The materials shown in the last five rows of the above table have such high resistivity that they would not even be considered to be conductors.

Mathematical Nature of Resistance

Resistance is a numerical quantity which can be measured and expressed mathematically. The standard metric unit for resistance is the ohm, represented by the Greek letter omega - Ω. An electrical device having a resistance of 5 ohms would be represented as **R** = **5** Ω. The equation representing the dependency of the resistance (**R**) of a cylindrically shaped conductor (e.g., a wire) upon the variables which affect it is

$$R = \rho \frac{L}{A}$$

where **L** represents the length of the wire (in meters), **A** represents the cross-sectional area of the wire (in meters^2), and ρ represents the resistivity of the material (in ohm•meter).

Ohm's Law

The predominant equation which pervades the study of electric circuits is the equation

$$\Delta V = I \cdot R$$

In words, the electric potential difference between two points on a circuit (ΔV) is equivalent to the product of the current between those two points (**I**) and the total resistance of all electrical devices present between those two points (**R**). Often referred to as the **Ohm's law** equation, this equation is a powerful predictor of the relationship between potential difference, current and resistance.

Ohm's Law as a Predictor of Current

The Ohm's law equation can be rearranged and expressed as

$$I = \frac{\Delta V}{R}$$

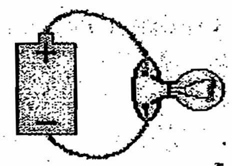
The current in a circuit is directly proportional to the electric potential difference impressed across its ends and inversely proportional to the total resistance offered by the external circuit. The greater the battery voltage (i.e., electric potential difference), the greater the current. And the greater the resistance, the less the current. Charge flows at the greatest rates when the battery voltage is increased and the resistance is decreased. In fact, a twofold increase in the battery voltage would lead to a twofold increase in the current (if all other factors are kept equal). And an increase in the resistance of the load by a factor of two would cause the current to decrease by a factor of two to one-half its original value.

Because the current in a circuit is affected by the resistance, resistors are often used in the circuits of electrical appliances to affect the amount of current which is present in its various components. By increasing or decreasing the amount of resistance in a particular *branch* of the circuit, a manufacturer can increase or decrease the amount of current in that *branch*. Kitchen appliances such as electric mixers and light dimmer switches operate by altering the current at the load by increasing or decreasing the resistance of the circuit. Pushing the various buttons on an electric mixer can change the mode from mixing to beating by reducing the resistance and allowing more current to be present in the mixer. Similarly, turning a dial on a dimmer switch can increase the resistance of its built-in resistor and thus reduce the current.

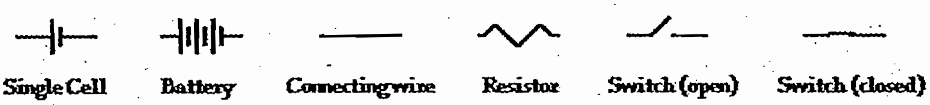
Circuit Connections

Circuit Symbols and Circuit Diagrams

Electric circuits, whether simple or complex, can be described in a variety of ways. An electric circuit is commonly described with mere words. Saying something like "A light bulb is connected to a D-cell" is a sufficient amount of words to describe a simple circuit.

Describing Circuits with Words	**Describing Circuits with Drawings**
"A circuit contains a light bulb and a 1.5-Volt D-cell."	

A final means of describing an electric circuit is by use of conventional circuit symbols to provide a schematic diagram of the circuit and its components. Some circuit symbols used in schematic diagrams are shown below.



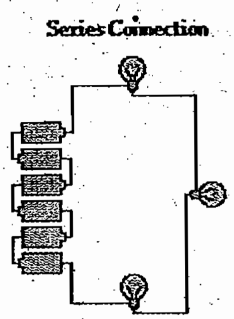
A single cell or other power source is represented by a long and a short parallel line. A collection of cells or battery is represented by a collection of long and short parallel lines. In both cases, the long line is representative of the positive terminal of the energy source and the short line represents the negative terminal. A straight line is used to represent a connecting wire between any two components of the circuit. An electrical device which offers resistance to the flow of charge is generically referred to as a resistor and is represented by a zigzag line. An open switch is generally represented by providing a break in a straight line by *lifting* a portion of the line upward at a diagonal.

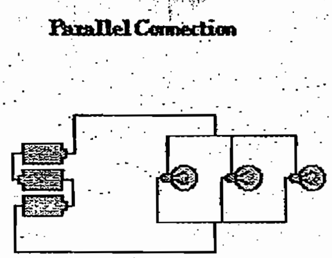
Circuit Connections

Two Types of Connections

When there are two or more electrical devices present in a circuit with an energy source, there are a couple of basic means by which to connect them. They can be connected **in series** or connected **in parallel**. Suppose that there are three light bulbs connected together in the same circuit. If connected in series, then they are connected in such a way that an individual charge would pass through each one of the light bulbs in consecutive fashion. When in series, charge passes through every light bulb. If connected in parallel, a single charge passing through the external circuit would only pass through one of the light bulbs. The light bulbs are placed within a separate branch line, and a charge traversing the external circuit will pass through only one of the branches during its path back to the low potential terminal. The means by which the resistors are connected will have a major affect upon the overall resistance of the circuit, the total current in the circuit, and the current in each resistor..

A comparison and contrast is made between the two circuits.





Series Circuits

In a series circuit, each device is connected in a manner such that there is only one pathway by which charge can traverse the external circuit.

Equivalent Resistance and Current

Charge flows together through the external circuit at a rate which is everywhere the same. The current is no greater at one location as it is at another location. The actual amount of current varies inversely with the amount of overall resistance. There is a clear relationship between the resistance of the individual resistors and the overall resistance of the collection of resistors. As far as the battery which is pumping the charge is concerned, the presence of two 6-Ω resistors in series would be equivalent to having one 12-Ω resistor in the circuit. The presence of three 6-Ω resistors in series would be equivalent to having one 18-Ω resistor in the circuit. And the presence of four 6-Ω resistors in series would be equivalent to having one 24-Ω resistor in the circuit.