3. The Atmosphere

The vast expanse of air which envelopes the earth is called **atmosphere**. Among the four elements of environment, the atmosphere is most dynamic as changes take place in it not only from one season to another but also over shorter periods of a few hours. The atmosphere extends to thousands of kilometers above the earth's surface. However, it has no well-defined upper limits and gradually merges with the outer space. In the highest levels gases are extremely rarefied. The atmosphere is held to the earth by the force of gravity. Of the total mass of the atmosphere, about 99 per cent is within a height of 30 km from the earth's surface. It is within this layer that most of the atmospheric changes take place.

The atmosphere contains life-giving gases like oxygen for man and animals, and carbon dioxide for plants to be used in manufacture of food. It acts like a **greenhouse** by trapping the heat. Like the glass in a greenhouse, the atmosphere allows short wave radiation to enter it and reach the earth's surface. But it is nearly opaque to long wave terrestrial radiation and thus keeps the earth's average temperature 35°C warmer than it would otherwise be. Atmosphere protects the earth from the harmful radiation from the sun. It also serves as a storehouse for water vapour which leads to precipitation (rainfall) fairly distributed over land and sea. The presence of air and water on the earth makes it a unique planet in the solar system.

Composition of Atmosphere

The atmosphere is a mixture of many discrete gases, in which varying quantities of tiny solid particles are suspended. With increasing height above sea level the atmospheric pressure gradually decreases. It consists of a mixture of gases having a relatively uniform composition in the lower layers close to the earth. Pure dry air on an average, constitutes mainly of nitrogen (78%) and oxygen (21%) making thus 99% of the air by volume. Remaining one percent accounts for gases like argon (0.93%), carbon dioxide (0.03%), hydrogen, helium and ozone. Relative proportion of different gases are shown in Table 1.

Besides gases, water vapours, dust particles, smoke, salts and other impurities, microorganisms, pollen grains etc. are also present in the air in varying quantities in the lower layers of atmosphere. As a result, the composition of air is never constant and varies from time to time and place to place. However, if these variable elements are removed from the atmosphere, its composition world be fairly constant all over the earth, at least in the lower

Table 1. **Relative proporation of various gases (by volume) in atmosphere.**

Gases	Per cent	Gases	Per cent
Nitrogen	78.0841	Crypton	0.00011
Oxygen	20.9486	Xenon	0.00009
Argon	0.9340	Hydrogen	0.00006
Carbon dioxide	0.0318	Methane	0.00020
Neon	0.0018	Nitrous oxide	0.00005
Helium	0.0005	Ozone	0.000004

atmosphere. Of the many constituents, carbon dioxide, dust particles, water vapour and ozone, are of great importance for the earth's climatic conditions.

Water vapour

This is one of the most variable gases in the atmosphere. It may account for 4% of the air by volume in the warm and wet tropics, while even less than 1% of the air in the dry and cold areas of deserts and polar regions. The amount of water vapour decreases with altitude. Hence, about half of the water vapour in the air lies below an altitude of about 2,000 meters. It also decreases from the equator towards poles.

Water vapour absorbs parts of the insolation from sun and thus reduces its amount reaching the earth's surface. It also preserves the earth's radiated heat. It thus acts like a blanket allowing the earth neither to become too cold nor too hot. Normally in the earth, water can exist, besides vapour, in solid and liquid states also. During the change in its form water absorbs or releases its latent heat. Water vapour absorbs heat during the process of evaporation. Winds transport latent heat along with water vapour from one place to another, where this heat may be released through condensation and precipitation. The energy released by water molecules (latent heat of condensation) during condensation and precipitation is equivalent to that which was absorbed during evaporation. The released energy plays an important role in producing violent weather like tropical cyclones and thunderstorms.

Dust particles

The movements of the atmosphere are enough to keep large quantity of tiny solid particles suspended within it. Their sources of origin are sea salts, fine soil, smoke-soot, ash, pollen, dust and disintegrated particles of meteors. Dust particles are mostly concentrated in the lower layers of atmosphere. But they may be carried to greater heights by conventional air currents. Amount of dust particles is more in subtropieal and temperate areas because of dry and windy conditions than in the equatorial and polar regions. Meteorologically, dust particles are very important. Most of them act as **hygroscopic nuclei** around which water vapour condenses to produce clouds. They also intercept and reflect insolation of sun. Dust in the air produces marvellous optical phenomena of red and orange hues in the sky at sunrise and sunset. Dense haze and smog (smoke and fog) are also caused due to presence of dust particles in atmosphere.

Other gases

Though 0.03% by volume carbon dioxide is very important meteorologically as it is transparent to the incoming solar radiation but opaque to outgoing terrestrial radiation. It absorbs a part of terrestrial radiation and subsequently remits part of it towords the surface. Thus it keeps the air near the ground warmer and along with water vapour is largely responsible for the **greenhouse effect** of the atmosphere. Unlike other gases, the carbon dioxide content of the atmosphere has been rising in the past few decades (reaching about 352 ppm) due to burning of fossil fuels. This has caused **global warming**. On an average there is an increase in temperature of 0.4 to 0.5°C per decade.

Another important component of the atmosphere is ozone. It acts like a filter and absorbs UV-radiation from the sun. It concentrates mainly between 10 to 15 km above the earth's surface. Ozone protects life on the earth from exposure to UV- radiation of sun. In recent years, however there has been depletion of ozone layer in the atmosphere chiefly due to use of chlorofluoro- carbons (CFCs). These and related aspects of air pollution will be described in detail later in chapter on "Environmental Pollution".

Structure of Atmosphere

The atmosphere consists of almost concentric layers of air with varying density and temperature. Density is highest on the earth's surface and decreases rapidly upwards. In the atmosphere, broadly **five** layers can be identified; viz. troposphere, stratosphere, mesosphere, ionosphere and the exosphere (Fig. 1). These are detailed below :

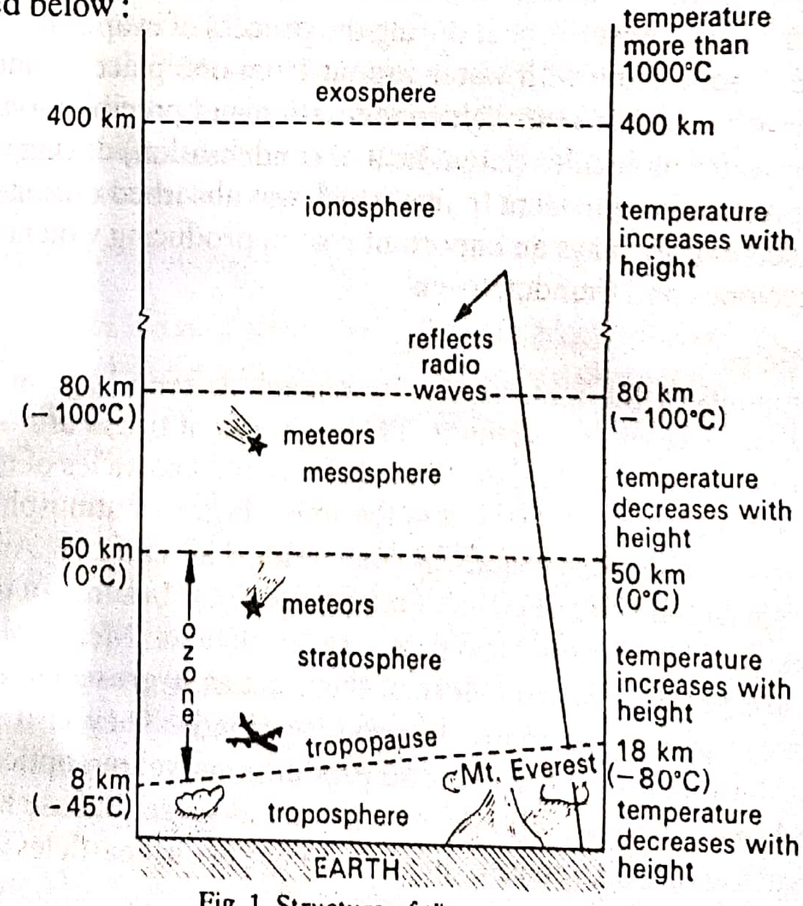

Fig. 1. Structure of the atmosphere.

[I] Troposphere

This is the lowest layer of atmosphere, thus lying closet to the earth's surface. It extends roughly to a height of 8 km near the poles and about 18 km at the equator. It is thickest at the equator as heat is transported to great heights by strong convectional currents. Temperature in this layer decreases with increasing height, roughly at rate of 1°C for 165 meters of ascent. This is known as **normal lapse rate.** Troposphere contains dust particles and over 90% of the earth's water vapour. All important atmospheric processes leading to various climatic and weather conditions take place in the troposphere, hence most significant layer. Aviators of jet aeroplanes often avoid this layer due to presence of bumpy air pockets.

[II] Stratosphere

It lies beyond the troposphere, and the zone separating the two is called **tropopause.** Stratosphere extends up to a height of 50 km Temperature ceases to fall, and remains constant up to a height of 20 km Afterwards it gradually increases up to a height of 50 km due to presence of ozone layer which absorbs the UV-radiation of sun. Clouds are almost absent and very little dust or water vapour. The air movements are almost horizontal. Air temprature at the tropopause is about –80°C over the equator and about – 45°C over the poles. What a paradox ? The lowest temperature in the atmosphere being vertically overhead the equator rather than over the poles.

[III] Mesosphere

This is the third layer over the stratosphere extending up to a height of 80 km. Temperature decreases with height again reaching up to –100°C at the height of 80 km.

[IV] Ionosphere

The fourth layer, ionosphere is located between 80 and 400 km. It is an electrically charged layer, in which ions reflect radio waves back to the earth's surface and enable wireless communication. Temperature again starts increasing with height due to radiation from the sun.

[V] Exosphere

This is the uppermost layer of atmosphere extending beyond the ionosphere above a height of about 400 km. This layer is extremely rarefied and gradually merges with the outer space.

We would now examine briefly the distribution of different elements of atmosphere i.e. light, temperature, moisture (humidity), pressure, winds and precipitation, and their role in the life and distribution of plants and ainmals, since these elements determine the weather and climate of a place.

Light and Temperature Factors

These are considered together because they are closely inter-linked with each other. The main source of light and temperature is **insolation** received from the sun.

Sun

The main source of energy for all types of circulation in the atmosphere is sun. The sun is a vast, hot gaseous mass containing predominantly hydrogen and helium. In the central core of sun, hydrogen is converted into helium releasing huge amounts of energy in all directions. The sun is continuously radiating heat energy as electro-magnetic waves into space, which is known as **solar radiation**. Of the huge quantity of this energy radiated by sun, only one in two billion parts (1 in 2,000,000,000) is intercepted by the earth because of its small size and great distance from the sun. Yet this small proportion of solar radiation reaching the earth is of great importance. Being the only major source of energy on the earth, it controls many of the physical and biological processes on the earth.

Insolation

Insolation refers to incoming solar radiation. It is received in the form of short waves. The earth's surface receives this radiant energy at the rate of two calories per square centimeter per minute. The sun radiates nearly half of its energy at wavelengths of visible **light.** As the insolation enters the atmosphere, a part of it is **reflected**, another part is **absorbed** and the remaining (about 51% of total insolation) **reaches earth's surface.** Reflection of insolation takes place by clouds, snow-fields, oceans and other water bodies. About 35% of insolation is lost by reflection. Ozone persent in the upper layers of atmosphere (troposphere) absorbs UV-radiations. Other gases, dust particles etc. in the atmosphere together absorb only nearly 14% of insolation.

Terrestrial radiation

The remaining 51% of the insolation reaches the earth's surface which gets heated. The earth's surface in turn radiates heat as relatively long waves. This is called **terrestrial radiation.** As the amount of energy radiated by earth is equal to the amount of insolation absorbed by earth's surface, the terrestrial radiation may be estimated at 51 units. Out of this, water vapor, CO_2 and other gases in the lower layers of the atmosphere absorb 34 units or nearly 70%. Remaining 17 units are readiated back to space.

Heat balance (Heat budget)

Figure 2 shows that there is a delicate heat balance in the system and the average temperature of the earth remains rather constant. It has been possible because of the balance between the amount of incoming solar radiation and the amount of terrestrial radiation returned to space. This balance of incoming and outgoing radiation has been termed the earth's **heat balance.**

Let us assume that the total heat received by the top atmosphere is 100 units. Roughly 35 units are reflected back to space even before reaching the earth's surface. Of these 27 units are reflected back from the top of the clouds, 2 units from the snow, and the rest 6 from other parts of atmosphere. The reflected amount of radiation is called the **albedo of earth.** The remaining 65 units are absorbed, 14 units within the atmosphere and 51 units by the earth's surface. The earth radiates back 51 units in the form of terrestrial radiation. Of these, 17 units are radiated to space directly and the remaining 34 units are

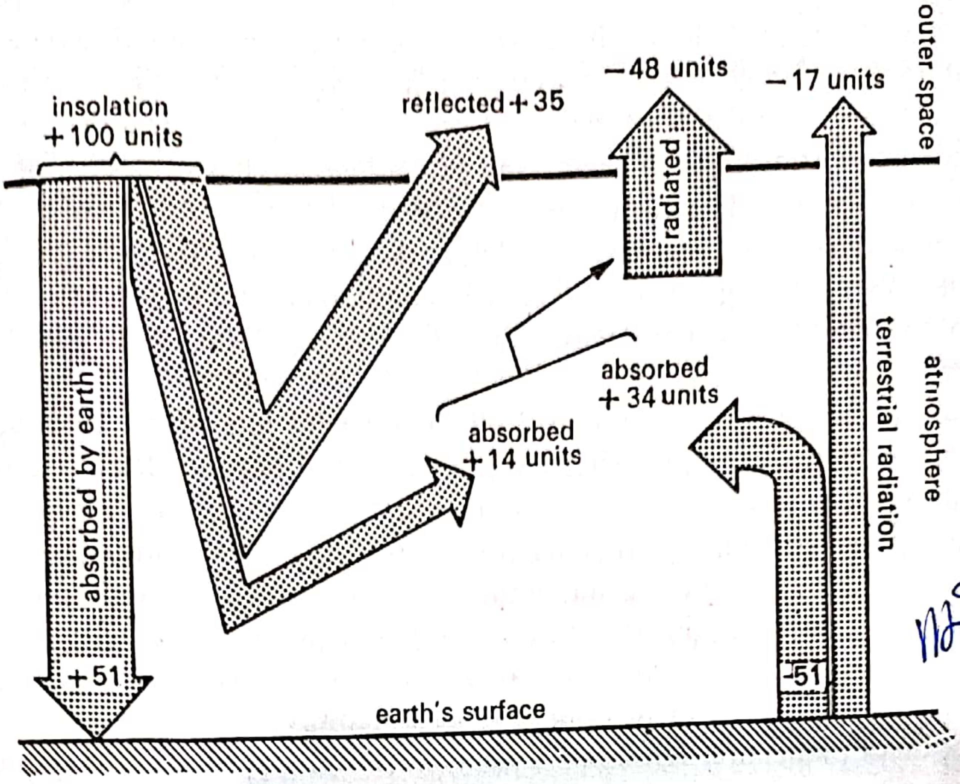

Fig.2. Fate of insolation in the atmosphere.

absorbed by the atmosphere (6 units absorbed directly by atmosphere, 9 units through convection and turbulenc and 19 units through latent heat of condensation). Thus it is important to know that heating and cooling of atmosphere is not directly due to incoming isolation, but depend on the terrestrial radiation (i.e. 34 units of terrestrial radiation absorbed by the atmosphere). Forty-eight units absorbed by the atmosphere (14 units from insolation plus 34 units from terrestrial radiation) are also radiated back into space. Thus, the total radiation returning from the earth and the atmosphere respectively is 17 + 48 = 65 units which balance the total of 65 units received from the sun. This is termed **heat budget** or **heat balance** of the earth.

Effect of Light on Organisms

Light intensity, reaching the earth's surface, shows much spatial variations, since it is inflnenced by factors as (i) atmosphere, including gases, suspended and solid particles etc. (ii) water layers, (iii) layers of vegetation, as in forests, and (iv) topographic factors as direction and slope of the land surfaces. Light intensities are closely related with atmospheric temperature and moisture (relative humidity).

Light affects organisms directly as well as indirectly. For instance, light affects basic physiological processes of plants (e.g. photosynthesis, transpiration, seed germination, growth and flowering) as well as of animals (metabolism, reproduction, development, locomotion, pigmentation etc.).

The layers of vegetation bring about variations in light intensities reaching at various heights of mountain. This becomes evident, when we study light conditions in **forests**, where a major proportion of light intensity is absorbed by tree vegetation and the light reaching to the lower part of the ground vegetation is considerably reduced by 90–98% of that in the exposed areas. The amount of light reaching the forest floor depends upon the height of canopy, crown development of trees, age of trees, and phenological characteristics of the constituent species. Thus in a forest, the mature tallest tree receives full insolation, undershrubs receive subdued illumination, and herbs and especially epigenous cryptogams grow in weaker light conditions. When leaves of a tree are fully expanded, its canopy may reduce light to less than 1% of full solar radiation.

Layers of water have pronounced effects on light intensities. In aquatic bodies life forms are found growing in distinct zones, althought such a zonation is not always due to different light intensities at various depths. Submerged plants receive weaker illumination than the exposed plants, as some of the light is reflected at the water surface and of the remainder, much is absorbed by the upper layers of water. Light penetration in water depends upon the turbidity, solute content, motion, and planktonic growth of the water. The intensity of light decreases successively with increasing depth. However, in their studies on distribution of plants in English lakes, Pearsall (1920) and Misra (1938) could show that the zonation in such water bodies is not solely due to differences in light conditions at various depths, but the physical and chemical characteristics of the rooting medium i.e., edaphic factors also play an important role in plants distribution. Importance of mud characteristics in plants distribution has also been recognised for plants of low-lying lands by Misra (1946). Generally at dawn, sunset, and in water, light intensities are weaker. At equator daylight prevails for about 12 hours out of every 24, in both summer and winter. Towards the poles, in summer day length becomes longer than 12 hours.

Temperature Factor

Temperature should not be confused with heat. Essentially **heat** is a form of energy or in other words, it refers to quantity of energy that makes things hotter. Temperature measures intensity of heat ie. degree of hotness. Both are related.

Heating and cooling of atmospheric air occur in three ways : **radiation** (direct heating by transmission of heat waves), **conduction** (transfer of heat through matter by molecular activity), and **convection** (transfer of heat by the movement of a mass or substance from one place to another). Atmosphere is heated more by terrestrial radiation than the incoming solar radiation. That's why the atmosphere is heated from the ground up.

The amount of insolation reaching the earth's surface and its effectiveness per unit area depend upon (i) the angle of incidence or the inclination of sun rays, (ii) the duration of sunshine or day length and (iii) transparency of the atmosphere. Hence, these factors also influence the temperature values of the area. The total annual insolation is maximum within the tropics, beyond which it gradually decreases towards poles. Along the parallels of 45° lat. it is only about 75% of that at the equator. It is reduced to 50% along the Arctic and the Antarctic Circles and only about 40% at the poles. On the basis of differences in temperature values due to inclination of sun's rays, there are **three** latitudinal zones on the earth viz. (i) tropical zones (maximum insolation), (ii) temperate zones (more contrasts between summer and winter than those in tropical zone), and (iii) polar zones (quite low temperatures).

Factors Controlling Temperature

Since atmosphere is primarily heated by terrestrial radiation, the shape of eart. and its rotation and revolution are important factors affecting temperature.

[I] Latitude

We have already seen as how insolation is responsible for varation in temperature, in latitudinal zones on the earth. This is due to difference in the receipt of incoming solar radiation which varies with the latitude. Thus, insolation is an important factor, which through inclination (angle of incidence) of sun's rays and duration, affects temperature of atmosphere. They are responsible for warm temperatures in the tropics and gradual decrease in temperature values towards poles. However, **latitude** is not the only factor controlling temperature. If it were so, all places along the same parallel would have identical temperatures. Several other factors such as differential heating of land and water, prevailing wind, ocean currents, altitude and aspects of slope (degree of slope and direction facing the sun) also exert strong influence upon temperature. This is responsible for temperature anomaly.

[II] Land and water

Since air is heated more by terrestrial radiation, differential heating of land and water surfaces cause variations in the temperature of the air above. Land mass is heated and cooled more rapidly and to a greater degree than water. Thus temperature of air over land differs markedly from that of the air on expanse of water in the same latitude. More extremes of temperature are felt over land than over the oceans.

[III] Prevailing winds

A windward coastal location will experience the full moderating influence of the oceans-cool summer and mild winters. An inland station, on the other hand on the same latitude or a leeward coastal location will have a more continental temperature regimes because the winds do not bring oceanic influence to it.

[IV] Ocean currents

Ocean currents influence temperature of adjacent land areas considerably. Warm currents raise the temperatures of coastal areas, whereas cooler currents lower them. Wind directions, prevailing in the area carry in a particular direction the moderating effects of the oceanic currents. In higher latitudes (as Eurasia and North America), eastern coasts are cooler than western coasts at same latitude. The influence of cold currents is most pronounced in the tropics during summer months in mid-latitudes.

[V] Altitude

Atmosphere is heated mainly from below. The lowest layer of air in contact with earth's surface is therefore, the warmest. As one goes higher, the temperature gradually decreases and the air becomes cooler. The normal lapse rate is 1°C for every 165 meters of ascent. There are variations from the normal at different times of the day, in different seasons and in different locations.

[VI] Slope features (Topographic features)

Direction of the slope and its angle control the amount of solar radiation received at a place. Slopes exposed more to sun receive more radiation than those away from the direct rays of sun. In many valleys settlements and cultivation are therefore concentrated on southern slopes, whereas northern slopes remain forested. In India, this is true in the Himalayan region.

Due to these factors, distribution of temperature over the earth is not uniform. It varies **horizontally** as well as **vertically**. Horizontal distribution of temperature occurs across the latitude. There are **isotherms** shown on map. An isotherm (*iso* -equal; *therms*-temperature) is an imaginary line joining places having equal temperatures, reduced to sea level to eliminate the effects of altitude. In vertical distribution, temperature decreases with increasing height. Since atmosphere is heated mainly by the terrestrial radiation, atmospheric layer overlying immediately the earth's surface receives maximum heat, and thus the warmest. As we go higher and higher, temperature gradually decreases, and the air becomes cooler.

There are also diurnal and seasonal variations in temperature. The daily cycle of temperature shows a gradual increase from sunrise to about 3.00 p.m. when the maximum temperature is recorded. Temperature decreases in evening and night and reaches a minimum before sunrise. The difference in temperature between maximum in a day and minimum during the night is called **diurnal range** of temperature. Seasonal differences in temperature are due to differences in the angle of incidence of sun rays and duration of sunlight.

We have seen that temperature varies even along the same parallel of latitude because of the factors like altitude, land and water contrasts, prevailing winds and ocean currents. The difference between mean temperature of any place and the mean temperature of its parallel is called **temperature anomaly or thermal anomaly.** Largest anomalies occur in the northen Hemisphere and the smallest in the southern Hemisphere.

Temperature and Plants' Distribution

Temperature shows pronounced temporal as well as spatial variations. Especially in a country like India, there are experienced marked seasonal extremes and fluctuations in the temperature values. Soil temperature is the result of heat gained by the absorption of solar heat energy, and soil temperatures are greatly influenced by the **latitude** (distance from the equator) of the particular place. Obviously, the temperature values are maximum at the equator, decreasing gradully towards the poles. The division of earth's vegetation into different zones, as equatorial, tropical, coniferous, alpine vegetations etc.,

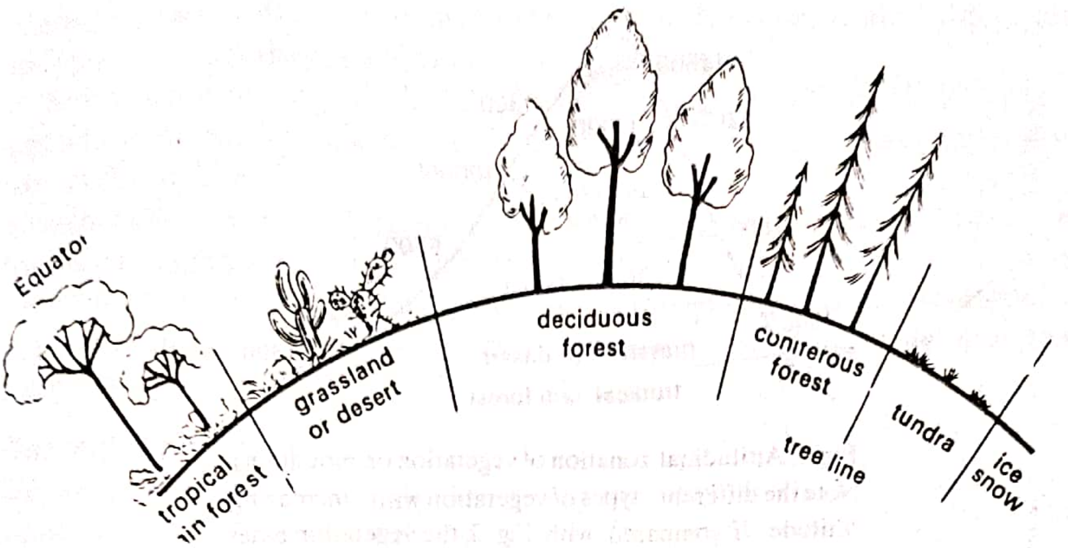

Fig.3. Latitudinal zonation of vegetation. Note the different types of vegetation from equator towards poles (increasing latitude).

rests on the marked variations in temperature at different latitudes. Similarly, **altitude** (height above the sea level) affects temperature values. Besides latitude and altitude, colour and composition of surfaces, plant cover, water content of soil, and such physiographic factors as the steepness of slope, exposure of shope, and direction of mountain chains etc. affect greatly the temperature conditions. For instance, on mountains, we generally experience a decrease in temperature with increasing altitude, and thus vegetation at different altitudes is different, showing distinct zonation. Generally, mean temperature of air decreases about 10°F for every degree of latitude north of equator, and for every 300' of altitude. In nature, valleys and lowlands are sometimes much cooler due to sinking in of the heavier cold air than the mountain tops.

Changes in both, latitude and the altitude, show more or less similar effect upon the type of major vegetations of the world. The various zones of different kinds of vegetation at increasing latitudes from equator towards poles (Fig. 3) and at increasing altitudes on mountains (Fig. 4) are more or less similar, showing that increase in latitude and altitude brings about more or less similar influence upon vegetation. Thus, we may find distinct latitudinal as well as altitudinal zonations in the vegetation.

On mountains, temperature and rainfall are commonly said to determine the type of vegetation at different altitudes. But Puri, G.S. has shown that at different altitudes, not only temperature and rainfall but edaphic conditions (soil characteristics) are also important. On mountains with deviations in elevation, in general, southern and western slopes register higher temperatures than do the northern or eastern slopes. The angle of the slope in relation to sun governs the total amount of radiation. These differences are probably due to different solar radiation received, differences in the amount of rainfall, snowfall, relative humidity and wind movement on the two slopes. At higher elevations, generally temperature decreases and rainfall increases, and these certainly affect the development of soil and vegetation. Due to low temperature and high

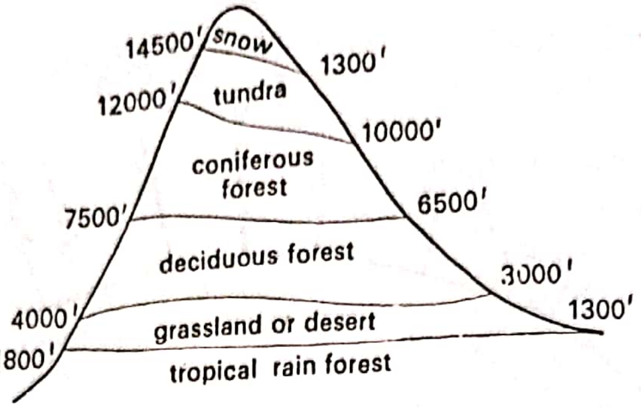

Fig. 4. Altitudinal zonation of vegetation on mountains. Note the different types of vegetation with increasing altitude. If compared with Fig. 3, the vegetation types are more or less similar in both.

rainfall the organic matter content of the soil increases at higher altitudes, with an increase in soil nitrogen and a decrease in its pH values. Generally, xerophytes are more common at lower altitudes and chamaephytes occur at higher altitudes.

In Himalayas, temperature variations are quite evident, and there is a general zonation of vegetation (Fig. 5) from lower to higher altitudes. The successive zones of vegetation from base upwards are tropical and subtropical, temperate, and alpine. However, there are practically no sharp boundaries between these vegetational zones due to differences in topography, soil and

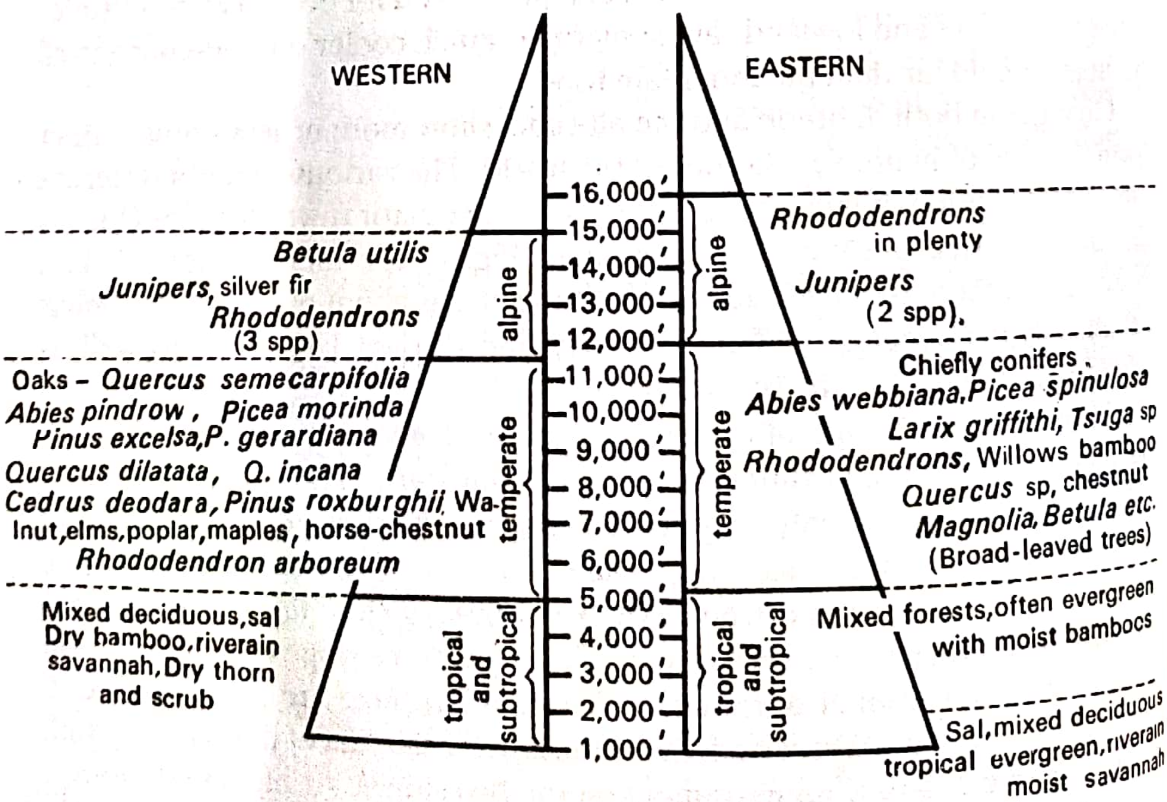

Fig. 5. Altitudinal zonation and distribution of various species of plants on the Western and Eastern Himalayas.

geology. Thus on Himalayas, western as well as eastern, the effect of temperature together with altitude and other factors becomes quite evident after studying the vegetational zones at different altitudes.

Some persons, on the basis of temperature conditions divide world's vegetation into various classes as (i) **megatherms** – where high temperatures prevail throughout the year and dominant vegetation is tropical rain forest, (ii) **mesotherms** – with high temperature alternating with low temperature, and dominant vegetation is tropical deciduous forest, (iii) **microtherms** – where low temperatures prevail and vegetation is of mixed coniferous forests type, and (iv) **hekistotherms** – with very low temperatures and alpine vegetation being dominant.

Thermal stratification

We have described above the variations in temperature and its influence in plants of terrestrial conditions. Similarly, temperature values may show variations in aquatic habitats also which are considered below.

In aquatic habitats, submerged forms experience lesser fluctuations of temperature in the water medium. In large bodies of water, due to its high latent heat, it does not become so cool in night hours and, moreover, wind effects and water currents mix up and lessen the effects of local cooling and heating. Thus, diurnal variations in temperature are not much pronounced. However, in small ponds such diurnal variations may be pronounced. In deep waters of lakes, thermal stratification may be observed during summer. During summer, the atmospheric temperature reaches up to 27°C, which raises the temperature of upper layers of water to 22° to 23°C, whereas that of the bottom layers it is as low as only 5°C. Between this range of 5° to 22°C, there are generally differentiated three different zones of vegetation viz. (i) **epilimnion** – vertical gradient of gradully decreasing temperature from the surface, followed by (ii) **thermocline** or **metalimnion** – a short zone of rapidly falling temperature, and (iii) **hypolimnion** – bottom cold zone where no temperature gradient is evident. At the onset of summer, however, there is mixing up from bottom mud into lake water.

Atmospheric Pressure, Winds and Airmasses

Atmospheric pressure exerted on the earth, is rarely felt by us. But it is an important factor in producing changes in weather. It is closely linked with other elements of weather and climate in a cause and effect relationship. Changes in temperature cause changes in air density that are responsible for variations in pressure. These variations cause horizontal movements of air called **winds.** Winds transport heat and moisture from one region to another and thus help in precipitation and affect both temperature and humidity. There are horizontal as well as vertical distribution of pressure.

Wind is the horizontal movement of air. This is due to horizontal differences in air pressure, thus air flowing from areas of high pressure to areas of low pressure. There are different types of winds as **platenary winds** (blowing throughout the year from one latitude to another in response to latitudinal differences in air pressure), and **periodic winds** (changing their direction periodically with change in season). Periodic winds include monsoon winds, land and sea breezes, local winds, loo, mistral, foehn and chinook etc.

An **airmass** is a large body of air whose physical properties especially temperature and moisture content are relatively uniform horizontally. Most of the weather changes take place due to advances and interaction of airmasses and the related processes.

Moisture in tne Atmosphere

Water vapor content, though much variable and forming only a smaller proportion (0.0 to 4.0%) by volume of atmosphere, it is the most important constituent of air in determining weather and climate. In atmosphere, water exists in all three states i.e. gaseous-water vapour; liquid-water droplets; and solid-ice crystals. The amount of water vapor present in atmosphere indicates the atmosphere's potential capacity for precipitation; is a regulator of heat loss from the earth; decides the quantity of latent energy stored up in the atmosphere for the growth of storms; and affects the animal's body rate of cooling.

Hyarological Cycle

Water vapour in the atmosphere comes through evaporation from the oceans, lakes, rivers, ice-fields and glaciers all comprising about 75% of earth's surface. Besides these, evaporation from the moist ground, transpiration from plants, and animal respiration also contribute moisture to the atmosphere. Water vapor evaporated from these sources is carried for long distances on land from the oceans by wind and convective movements. Under favorable conditions it condenses and precipitates over the earth's surface as rain, snow and hail. Precipitation over oceans, completes the cycle rapidly to follow another one. However, precipitation on land takes more time in the completion of cycle. A part of land precipitation is soaked by the ground, some absorbed by plants which is later released in atmosphere through transpiration. Rest of the water infiltrated in ground moves under the surface and finally goes to springs, lakes or streams. Additional water, falling during precipitation flows over the surfaces of streams and lakes. Eventually, the water that soaks in or runs off goes to the oceans and then to atmopshere or directty to atmosphere. This continuous exchange of water between the oceans, the atmopshere and the continents through evaporation, transpiration, condensation and precipitation is called the **hydrological cycle**. Energy for the operation of cycle comes from the sun.

Humidity

This is the general term that describes the invisible amount of water vapor present in the air. It may be expressed quantitatively in different ways. The weight of actual total amount of water vapour in a unit volume of air is called **absolute humidity**. It is usually expressed as g/m^3 of air. This value changes from place to place and time to time. The ability of air to hold water vapour depends entirely on its temperature. Warm air can hold more moisture than the cold air. At 10°C, 1m^3 of air can hold 11.4 g of water vapour. If temperature rises, the same volume of air can hold 22.2 g of water vapour. Thus water vapor retaining capacity of air increases with rise in temperature and decreases with decrease in temperature. But, this is not a constant relationship as temperature and pressure changes cause changes in volume of air and hence in its absolute humidity.

Another way is to express humidity as the weight of water vapour per unit weight of air, or the proportion of the mass of water vapour to the total mass of air, called the **specific humidity.** Since it is measured in units of weight (g/kg), specific humidity is not affected by changes in pressure or temperature.

An important measure is **relative humidity,** which is the ratio of the air's actual water vapour content to its water vapour capacity at a given temperature. This relationship between absolute humidity and the maximum moisture holding capacity of air at a particular temperature is always expressed in percentage. Table 2 shows relative humidity values at different temperatures.

Table 2. **Relative humidity values at different temperatures.**

	Temperatures					
	0°C	10°C	20°C	25°C	25°C	25°C
Water-vapour (g/kg)	3.5	3.5	3.5	20	10	5
Capacity	3.5	7	14	20	20	20
Relative humidity	3.5/3.5 = 100%	3.5/7 = 50%	3.5/14 = 25%	20/20 = 100%	10/20 = 50%	5/20 = 25%

Since relative humidity is based on the air's water vapour content as well as on its capacity, it can be changed by changing moisture through evaporation, or by changing temperature. If moisture is added by evaporation, the relative humidity will incresse, and a decrease in temperature will cause an increase in relative humidity. Relative humidity determines the amount and rate of evaporation and hence an important climatic factor.

Evaporation and condensation

Evaporation is the process by which water is transformed from liquid to gaseous form. It takes about 600 cal. of energy to convert one gm of water to water vapour. The rate of evaporation is controlled by (i) temperature, (ii) moisture content or the degree of dryness of air, and (iii) movement of air.

Condensation is the process of change of state from gaseous to liquid or solid state. In free air, condensation results from cooling around tiny particles, **condensation nuclei.** Particles of dust, smoke and salt from the oceans, absorb fairly a good amount of water and thus are ideal condensation nuclei. Condensation in air itself can only take place if the temperature of air is reduced to below dew point. Condensation depends on (i) amount of cooling and (ii) relative humidity of air.

Forms of condensation

Condensation forms are usually classified on the basis of their location i.e. at or near the earth's surface, and in free air. Dew, white frost, fog and mist belong to the former, whereas the clouds to the latter category of condensation. Precipitation is the result of continuous condensation of water vapour in air into water droplets and ice.

When the moisture is deposited in the form of water droplets on cooler surface of solid objects like stone, grass blades, plant leaf etc. it is known as dew. A clear sky, little or no wind, high relative humidity and cold and long nights leading to greater radiation of heat from the earth for its cooling, are the ideal conditions of dew formation. Dew point must be above freezing point for dew formation. When condensation takes place at a dew point which is at or below freezing point (0°C), excess moisture is deposited in the form of minute ice crystals instead of water droplets. It is called **white frost**. This develops under more or less similar conditions ideal for dew, except that the air temperature must be at or below freezing point. **Fog** is defined as a cloud with its base at or near the ground. There are several kinds of fogs as radiation fogs, advection fog and frontal or precipitation fog. **Mist** is also a kind of fog in which the visibility is more than one kilometer but less than 2 kilometers. **Cloud** is a mass of minute droplets of water or tiny crystals of ice formed by the condensation of the water particles present in the atmosphere. Once frozen, these small ice granules grow in size and the air is unable to hold them. They start falling down. But the strong air currents again toss them up. In the process they collect more coating of ice, become large and begin downward journey. They may be tossed again. This continuo us process above freezing level results into additional layers of ice. Hailstones, thus have several concecentric layers of ice one over the other. On the basis of its origin, the precipitation may be cyclonic or (frontal), orographic, or convectional precipitation .

Different places receive different amounts of precipitation on earth's surface in a year and in different seasons. Generally high latitudes with diverging winds, experience rather dry conditions. Equatorial belt with low pressure and converging winds receives enough precipitation. Besides latitude, distribution of land and water complicates the global precipitation pattern. Mountain barriers alter ideal precipitation.

Weather and climate

Solar radiation, temperature, pressure, winds, humidity and precipitation exhibit spatial and seasonal variations. These are the major elements of weather and climate. **Weather** is the sum total of these atmospheric conditions in a place or in an area in terms of these elements at a particular instant. Thus it refers to specific atmospheric conditions. Weather conditions may vary at intervals of a few hours or a lew days as for example, cloudy and rainy weather. **Climate** is different from weather. It refers to the general features based on composite picture of the average weather conditions, including prominent departures from the average, spread over a long period , for a given larger area. Weather refers to particular place, climate refers to atmospheric conditions over a large area.

The climate of an area depends on a number of factors which affect the various elements of climate. We have already examined the factors which affect insolation, temperature, pressure, winds, and rainfall. All these factors of climate vary from place to place, and therefore, climatic conditions are also differnt in different parts of the earth. Besides regional variations, there are also seasonal variations in climate.

The most important factor affecting the climate is the **latitude**. Latitude determines the amount of insolation received from the sun, and the main temperature zones and major pressure and wind belts are also related to latitude. The amount of moisture in the atmosphere is also related to latitude indirectly through temperature.

The climate has many direct and indirect effects on natural vegetation and the crops cultivated in a particular region. Sugarcane, cotton, rice are the tropical region crops. The modes of life of tribal people are also directly related to the climatic conditions. The humans with an advanced technology are able to lead a comfortable life in any climatic condition. Climatic conditions in our country are different in different parts. Vegetation and animal population on Himalayas are different from desert of Rajasthan.

Questions

1. Define "atmosphere". Give an account of composition and structure of atmosphere.
2. What is insolation ? How this factor controls the climate of an area ?
3. Define "weather" and "climate". Give an account of climatic factors.
4. Discuss the role of climate in the distribution of organisms on the earth.
5. Write notes on :
   (i) Airmass (ii) Troposphere (iii) Hydrological cycle.
6. Define "climate". Give an account of the factors that control the temperature of an area.
7. Write notes on :
   (i) Light factor (ii) Moisture factor (iii) Condensation (iv) Precipitation.