Chapter 3

MAJOR ECOSYSTEMS OF THE WORLD

3.1 INTRODUCTION

Our biosphere is agiant ecosystem, which consists of many thousands of ecosystems, from deserts to forests to grasslands to lakes, each one being a functional unit of biological and physical organization.

The biosphere includes portion of earth's hydrosphere (water), lithosphere (crust), and atmosphere (gases). Of the three spheres, the hydrosphere (comprising of oceans, lakes, rivers, ponds; etc.) harbors the greatest quantity of life. Majority of land organisms live near the illuminated surfaces of lithosphere (i.e. the rocky earth crust that form a number of terrestrial habitats or biomes). In the, gaseous atmosphere, organisms are found living at altitude below 7-10 kilometers.

. Bas.ed upon particular kinds. of habitats, the yariousecosystemsof our biosphere may be grouped into two categories, namely aquatic ecosystems and Terrestrial ecosystems. The aquatic ecosystems may further be subdivided into marine, estuarine and freshwater ecosystems. Similarly the terrestrial ecosystems may bedassified as alpine ecosystem, desert ecosystem, and forest ecosystem and so on.

This chapter will be restricted to a brief description of few selected major ecosystems of the world.

Ans: A natural effect that traps heat in the atmosphere near earth's surfa~.

3.2 MARINE ECOSYSTEM

I. MAIN CHARACTERISTICS

Among the major habitats of biosphere, the marine realm consisting of oceans and seas, provides the largest inhabitable space for living organisms. Oceans and seas are much alike; they are distinguished principally by size. The term ocean is generally reserved for the largest masses of salty water while the seas are generally of secondary size, more or less land-locked, like the Caribbean Sea, Arabian Sea, etc. The important features of a marine environment are:

1. The oceans cover 363 million sq.km. of earth's surface i.e. 70% area.

2. The major oceans of the world are Atlal1tic, Pacific, Indian, Arctic and Antarctic. These collectively form the largest, thickest and most stable ecosystem of the world.

3. Oceans are the larger storehouses of sun's heat and are thus able to regulate the temperature of the world.

4. All the seas are inter-connected with each other and not separated as are land and freshwater habitats. The main factors that determine the kinds of organisms at various locations or act as barrier to free movement of organisms, are temperature, salinity, depth, waves, tides, light intensity and currents.

5. The sea is in continuous circulation due to wind stress setup by air temperature difference between poles and equator. The sea is dominated by waves of many kinds and tides produced by pull of moon and sun.

6. The sea is salty, with an average salinity of 35 parts of salt per 1000 parts of water, usually written as 35 ppt.(Le. one kilogram of seawater contains 35 grams of salt). The chief salts are chlorides, sulphates, carbonates and bicarbonates of sodium, potassium, magnesium and calcium. Of these, sodium chloride is present in maximum amount (i,e. 86%).

Q. Define "Deforestation".

7. The mean temperature of seawater at the surface varies widely according to the region, from _2° C in polar waters to 27° C in equatorial waters. In enclosed seas, the temperature may be as high as 40° C. Unlike, freshwater, seawater becomes heavier as it cools and do~s not reach its greater density at 4° C. Thus, the limitation of 4° C-as the temperature of bottom water does not apply to the sea. Nevertheless, the temperature of sea bottom generally averages around 2° C, even in the tropics, if the water is deep enough. The temperature of the ocean floor over one mile deep is.3° C.

8. The sunlight does not usually penetrate the ocean below 100 meters. Considering that the average ocean depth is 3.8km, the sunlight zone is indeed very thin, permitting photosynthesiS in only the upper 2.0% ofthe ocean's volume.

9. One of the· most .characteristicfeatures of ocean is its tide action. Tides have periodicity of about 12.5 hours; high tides occur in most localities twice daily, being about 50 minutes later on successive days. Every two weeks when sun and moon are working together, the amplitude of the tide is increased (the so·called Spring tides) when high tides are too high and low tides are too low. Whereas midway in the fortnightly periods the range between low and high tides is smallest (the so-called Neap tides).

10. The chief components of plant communities in marine water are planktonic diatoms, dinoflagellates and profuse growth of green, brown and red algae which together form the so-called "sea-weeds"; Brown algae are most conspicl!0us due to their large size.

11. The deepest part of the ocean is Marine Trench in Pacific Ocean which is about 11,000· meters: The average depth of marine environment, however, is 3800 meters.

Ans: Removal of trees from a forestld area without adequate replanting.

II. ZONATION OF MARINE ENVIRONMENT

The various zones of the sea are shown in (Fig. 3.1). The ocean itself is divided into two main regions, the **Pelagic** (Le. open water region) and the **Benthic** (or bottom region).

The pelagic region is further divided horizontally into two provinces, i) the Neritic province and ii) the Oceanic province, The term neritic zone is applied to the shallow turbulent waters covering the continental shelf. The continental shelf may be defined as the underwater extension of the continent and generally extends to a depth of roughly 200 meters; The term oceanic zone is applied to the remaining waters with depths greater than 200 meters.

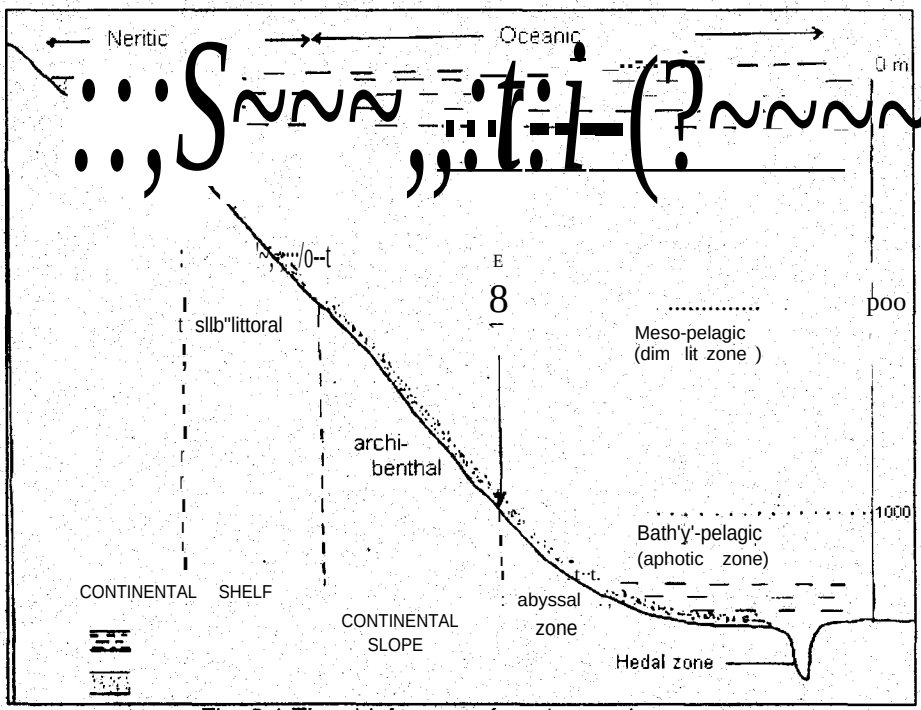

Fig. 3.1 The chief zones of marine environment

Vertically, the pelagic zone may be divided into three layers. namely,

a. **Epipelagic:** From surface to about 200 meters is Euphotic or Epipelagiczone. In this zone there is sharp gradient of illumination, temperature and salinity.

b. **Mesopelagic:** .From 200. meters to 1000 meters where little light penetrates; temperature is more even, and

c. **Bathypelagic:** Below mesopelagic zone is bathypelagicwhere darkness is virtually complete; water temperature is low; pressure is very great.

The sea-bed or benthic region may be divided as follows:

a. **Littoral zone:** This zone extends from. the high tide level to about 400 meters off the sea shore and roughly to about 200 meters deep. The bottom is largely composed of clay, sand and mud. The plentiful of food, richness of oxygen and optimum conditions of temperature are responsiblef6r the richness of flora and fauna in this region. The littoral zone is further divided into two zones, namely,

   i. **Eulittoral or Inter-tidal:** The shallow zone where sea water meets land is. called inter-tidal zone. This area is often flooded by high tides and then left dry during low tides, about every 12 hours.

   ii. **Sublittoral:** This term is applied to the water overlying continental shelf below low tide mark. This region is about 200 meters below the. suriace of the sea. This isthe lowest depth at which plants can grow abundantly. It is ttie most productive zone"as far as variety and numbers of animals are concerned.

b. **Bathyal. or Arcllibenthalzone:** This zone extends from. 200 meters t01 000 meters deep. In this zone. bottom drops off steeply as continental stope; water .temperature is relatively constant; pressure averages 400 pounds per square inch; small amount of blue light reaches the lower layers but not enough to carry out photosynthesis.

c. **Abyssal zone:** It covers the ocean bottom runningupto 6000 meters. This region is characterized by no light; little dissolved oxygen; no seasonal change in temperature (average temperature being oS C - 3° C); little water movement; and high pressure.

d. **Hadal zone:** It occupies very deep areasortrenches beyond 6000 meters.

The substrate of archibenthic and abyssal zone is composed of calcareous ooze. and the red clay. All. the animals found in these zones are spoken 01 as "deep sea forms". The relative areas of various benthic regions is as under:

Continental shelf or Littoral zone	(0-200 m)	=	7.6%
Continental slope.or Bathyal zone	(200 - 1000 m)	=	8.1%
Abyssal zone	(1000 -6000 m)	=	82.2%
Hadal zone	(more than 6000 m)	=	2.1%

III. MARINE COMMUNITIES

The marine biota is varied and more rich, both quality and quantity wise as compared to freshwater habitats. Coelenterates, sponges, echinoderms and minor phyla (like bryozoans) are either absent or very poorly represented infreshwaters. The bacteria, algae, crustacea and fish play a dominant role in both aquatic. systems, but the variety of these organisms is far greater in the sea. Insects are absent, except in brackish waters. The marine biotic communities can be studied separately for different life zones of the oceans as under:

Q. What is Environmental degradation?

A. **Biotic** communities of **Neritic** zone:. Phytoplanktonic diatoms and dinoflagellates are the dominant producers almost everywhere in ocean. Besides, in neritic zone, large multicellular algae, mainly composed of red and brown., form thick forests or. so-called "kelp-beds"just below. the low tide mark. About 40% of the world's photosynthetic productivity is estimated to occur in the oce<;lns.

Neritic zooplankton which inhabit coastal waterS, may be divided into two groups, namely 1) Haloplankton, also known as permanent plankton, are those which remain as plankton for their entire life cycle. Almost all the major phyla are represented in the permanent plankton. Copepods crustaceans· are dominant.. Other. important ones •.are sagitta, jellyfishes, euphasids, ctenophores and.a number of protozoan species and 2). Meroplankton, also known as temporary plankton, are those which live as plankton temporarily for a short period in their life cycle. These include early developmental stages of benthic invertebrates (such as, crabs, bryozoans, tunicates, shrimps, gastropods, nemerteans,barnacles, enchinod.erms and others),eggs of fishes and their· larvae; These plankton show characteristic fluctuation in their population as the spawning time and habits of different animals varies greatly.

Marine benthos is characterized by the large number of sessile or relatively inactive animals, which exhibit marked zonation. Bottom organisms are generally distinct for-each of the three primary divisions of neritic zones (supratidal, intertidal and subtidal). Again the bottom f.auna varies a great deal depending upon the nature of beach, whether rocky, sandy or muddy.

Benthos of littoral zone includes a vari.ety of crabs, shrimps, amphipods, isopods, bivalves, gastropods, barnacles, sea anemones. tunicates ahdsponges.

In addition to th~ vast majority and variety of fish species, some of the larger crustacea, molluscs, turtles, snakes, mammals (such as, whales, seals, sea-cows, etc) and marine birds constitutethenektonic fauna.

Bacteria are. the most important decomposers and abundant in quantity. Fun~i are not very important in such habitat.

Ans: Destruction of a renewable resource.such as, soil, wild life, forest, etc.

B. **Biotic communities of Oceanic region:** The oceanic region is not as rich in species and generally support less dense population compared to neritic zone. Pelagic animals are diverse and are specialized in many ways for the pelagic mode of life. A common feature of all the pelagic .form is the ability to keep afloat.. Another important feature of pelagic animals is either they are transparent or blue in colour which makes them .nearly invisible. Animals that .are .too thick to. be transparent frequently have smooth, shiny, silvery bodies which make themselves invisible by mirroring the water in which they swim.

Phytoplanktonic and dinoflagellates together produce most of the organic carbon in the sea and most of the oxygen in atmosphere. Large· multicellular brown and red algae is not found in this zone, except *Sargassum* weed which may have floating stage.

The zooplankton of pel(igic region includes representatives of every major phylum .. Common among haloplanktons are the *noctiluca,* forminifera, radiolaria, vellela, arrow worms, jelly fishes, shrimps. euphasids, copepods and cladocerans.

Nektonic fauna is very rich in pelagic region. This includes, squids, octopuses, nautilids, bony fishes, sharks, turtles, whales, etc. Certain fishes, like tuna, sardihes, anchovies, mackerals, herrings and sharks are dominant in this region.

C. **Biotic communities** of Abyssal **region:** The abyssal zone or deep sea of oceanic region is pitch dark due to the absence of light. Hence there is no vegetation. The deep sea forms mainly depends upon the particulate organic matter (Le. detritus) that fall out from photic zone. The bottom of sea is a soft zone made of organic remains and shells of foraminifera, radiolaria ahd other animals. Sea cucumbers, sea anemones, clams, etc. constitute benthic fauna. Majority is detritus feeders while many of them are carnivores.

Q. Where does everything that supports your life come from?

3.3 ESTUARINE ECOSYSTEM

The word estuary is derived from a Latin word "aestus" that means tide. Waters of stream and rivers ultimately drain into the sea; theplace where this freshwater joins the salt water is called ESTUARY. Estuaries differ in shape, size and volume of water flow …… all influenced by the coastal geomorphology of the region.

As the river reaches the sea, the river carried sediments are dropped in quieter water. These accumulate to form delta in the upper reaches of mouth and shorten the estuary. Continued building by sedimentation gives rise to coastal wetlands called Mudflats or Tidalflats. Mudflats are common features of estuarine basins. These, composed of loose sand and silt, often divide and braid the original channel of estuary. At the same time ocean currents and tides erode the coastline and deposits material on the seaward side ofth.e estuary, also shortening the mouth. If more material is deposited than is carried or washed away, then barrier beaches, islands and brackish lagoons appear.

I. PHYSICOCHEMICAL CHARACTERISTICS OF ESTUARIES:

a. **Slope:** Estuaries may be with steep slope or with gradual slope. If there isa steep slope, the flow of water is fast, sand and mud is less, and life is poor. However, if the slope of an estuary is gradual (which is generally the case), the flow of water is slow, the life is fairly good and mud-flats are formed at the mouth of the river.

b. **Currents:** The currents in estuaries are governed by three important factors, namely, the nature of oceanic tides, stream flow and wind. The morphology of the basin of estuary and the channel of the river affects the outflow of water into the sea as well as the tidal inflow.

Where there are no tides in an estuary to mix fresh and salt water, the lighter freshwater would simply flow over the heavier seawater and dissipate into the ocean (Fig. 3.2).

Ans: The sun and the earth.

However, the tidal action acts as a plunger to thoroughly flush the estuary and mix two types of water (Fig. 3.3).

The rate of flow of water varies with the seasons, being greater during rainy seasons and minimum during summer. The interaction of above mentioned three forces serve to create a restless and complex system of water movements. Tidal waves and river-falls increase the rate of circulation of nutrients and facilitate the removal of waste prodlSCts.

c. **Temperature:** The temperature of estuarine water, in general, is usually higher than that of marine or freshwater environment. The temperature in estuaries fluctuates diurnally and seasonally. The heat content of water is mainly due to solar radiations. The temperature of estuary is dependent of the temperature of inflowing river water and of tidal flow from the sea. Another factor which affects the temperature is flooding of marshes and mudflats during high tides.

d. **Salinity:** The salinity of estuarine waters not only varies vertically and horizontally but fluctuates seasonally and diurnally. Vertical salinity may be the same from top to the bottom or it may be stratified (with light layer of freshwater on top and a layer of dense saltwater on the bottom), or the salinity may be homogenous when tidal currents are strong enough to mix two types of waters from top to thebdttom.

Horizontally, the least saline waters are at the river end and most saline waters at the mouth of estuary.

Further, the salinity is exceeding variable duringthe day and night at any given location. At low tide, most of the water passing through the estuary is freshwater and the salinity is correspondingly low. At high tide, the salinity is correspondingly high, because most of the water is of marine origin. Again, salinity of estuaries remains highest during summer and during periods of drought when less freshwater flows into the estuary. It is lowest during the winter and spring, when river discharge is high. Thus, no stenohaline organisms could hope to survive in estuaries.

Q. What is canopy layer?

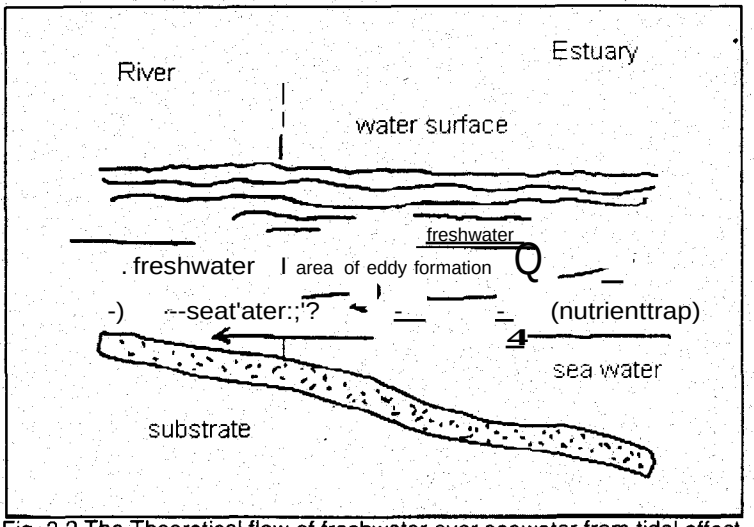

Fig. 3.2 The Theoretical flow of freshwater over seawater from tidal effect

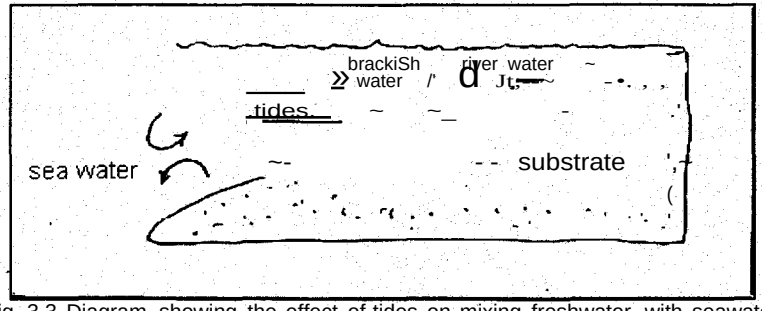

Fig. 3.3 Diagram showing the effect of tides on mixing freshwater with seawater

e. **Turbidity:** Another characteristic feature of the estuary is turbidity of water. Large volumes of silt are carried down the river usually and the maximum silt deposition into the estuary takes place during winter. This has' adverse. effect on many. animals, particularly; filter feeders which are choked by the sediments. Under such turbid conditiOns,the penetration of light is curtailed and hence it inhibits photosynthesis. Detritus feeders seem to flourish in estuaries because of rich organic and inorganic material in the slit.

Ans: The uppermost tree tops composing umbrella like structure.

f. **Nutrient** Trap: All estuaries have. a high productivity .. Becausec"\ typical estuary isshallpwand turbulent, the amount of dissolved oxygen tends to be fairly high. Furthermore, the tidaL action acts to accumulate the nutrients Cind energy materials that wash in from upstream or that enter from nutrient rich bottom waters of the sea. Thus the estuary acts as a zone of "nutrient trap" with an average nutrient level significantly higher than either the river or Sea. Likewise, concentration of·.energy rich organic materials also remain high in estuaries,

BIOTIC COMMUNITIES OF ESTUARIES

The plants of estuary are of four basic types,

a) phytoplankton, b) marginal or marsh plants, c) mudflat algae and d) the Jiphytic plants growing On marsh vegetation.

Phytoplanktonic forms include several species of diatoms, such as, *ynedra, Navicula, Fragilaria;* several species of green algae like, *Pediastrum, udorina, Spirogyra, Volvox, Chlorel/aand* blue-g'reenalgae like *Microcystis, 'scillatOria, Anabaena,* etc. . . .

The most significant marsh plants are *Spartina, Salicornea, Zostera* and *'1allasia.*Very few animals feed on these plants directly, but a very large amount consumed as detritus when these plants die and disintegrate. SUbmerged gae, like *Chara* and *Enteriomorpha* are ,also common in estuarine waters.

Animals of estuarine water must be able to tolerate continually changing llinity conditions. In other words, euryhaline (i.e. species having a wide range of llinity tolerance) animals~are far more likely to inhabit this environment ~rmanently.

Zooplankton •of estuarine water usually include protozoa.ns, such as, *9ridinium, Euglena, Arcel/a, qifflugia, Vorticella,* etc.; rotifers like *Brachionus, splancha;* copepods like *Diaptomus, Pseudodiaptomus, Cyclops;* cladocerans, .e *Moina, Bosmina* and larvae of a number of crustaceans, molluscs and fish.

What are decomposers?

The best known animals are detritus feeders like oysters, clams,. prawns, lobsters,crabsand polychaetes of many kinds. Beside, a few freshwater species of fish such as tilapia, snake-headed fish,. and catfishes pius a great many variety of marine fishes can be seen in estuarine waters.

Almost all of the strictly aquatic· organisms are of marine origin. contributions from freshWater being minor. Few insect larvae and gastropods enter the estuarine waters from the freshwaterwhile most marine phytoplankton, crustaceans, annelids, coelentrates, bryzoansand fish enter estuary from marine ecosystem ..

III. MANGROVE ASSOCIATIONS

Mangrove associations are a· special form of estuarine habitat in the tropics. The mangrove beach is characterized by trees with stilt roots such· as, *Avicennia, Rhizophora, Salsola, Sonneratia,* etc. The roots serve as sand binders, holding the debris and silt brought by the rivers. The mudflatsatlow tide support a remarkable assemblage of marine, freshwater and terrestrial animals. The crabs predominate in mangrove vegetation. They are adapted in coloration to match the bark of trees. The fiddler crab, *Uca* is found in plenty, living in small holes excavated in soft mudflats. Hermit crabs are found on the bottom as well as on the roots. Among bibalves, *Solenids, Cardium* and *Psammobids* predominate. Among gastropods, *Cerithium,· Hydrobia, Viviparus* are important.. Among the fishes, mudskippers and gobies are most common. Another important common commercial fish of estuarine waters is grey mullet. The mangrove vegetation of the estuary is frequently haunted by reptiles, birds and mammals for f<;>odbecause the shallow nature of estuary during low tide considerably expqses the animals as easy prey.

Ans: The bacteria and fungi which bring about decay of dead bodies.

3.4 FRESHWATER ECOSYSTEM

I. INTRODUCTION

The freshwater habitats occupy a relatively very small portion of earth's surface (i.e. 1% only) compared with marine (70%) and terrestrial habitats (28~'), but their importance to humans is far greater than their area fOr the following reason.

a. They are they most convenient and cheapest source of water >for domestic, agriculture and industrial purposes.

b. Freshwater ecosystems are the "bottle-neck" in the water cycle.

c. Freshwater ecosystems alongwith estuaries provide the most convenient and cheapest waste disposal system. The world's largest cities are located on large rivers, lakes or estuaries that serve as afree sewers".

It has been estimated that the total volume of water present on our planet is roughlyalJout 1460 million cubit kilometers. About 97.41% of the total VOlume is salt water present in the oceans and seas. Of the remaining 2.59% of freshwater, 1.984% is frozen in the form of glaciers and polar ice caps: 0.59% water is un~erground; 0.001% is present in atmosphere. Thus the total amount of freshwater present in our streams, rivers, lakes, ponds, reservoirs, etc. amount to 0.13% only.

II. TYPES OF FRESHWATER HABITATS

The freshwater habitats can conveniently be divided into two groups, namely. a) Lentic or Standing water habitats, and b) Lotic or Running or Flowing water habitats. Both can be considered on an environmental gradient.. The lentic involves gradient from lakes to ponds to swamps to marshes. The lotic follows a gradient from springs to mountain brooks to stream to rivers.

Q. What is Ecesis?

e lotic habitats differ from lentic ones in the following features:

Cl,Jrrentsare present in the lotic habitats while they are absent in the lentic habitats.

The reaction between water and land is greater in the lotic environmentand lesser in lentic environment..

Oxygen tension iSffiore uniform in the streams and rivers and there is HttletMrmal or chemical stratification as compared to lentic waters.

lentic types: Lentic water include all standing water habitats, such as, lakes, ponds, swamps, marshes, meadows, etc. These maybe defined as under:

i. **Lakes:** It is very hard to distinguish a la.kefrom a pond. The term pond is frequently used interchangeably with lake since the question where a body of water ceases to be a lake and becomes a pond has never been settled. A small lake can be termed as a "big pond", and vice versa, a big pond can be spoken .of as small lake. Generally, according to leading limnologists, large expanses of standing waters having considerable depth are considered as lakes while small and shallower ones as ponds. The lakes, in addition to being larger in size also show some important ecological differences. for example. a) in lakes, the limnetic and profundalzones are. relatively large (Fig. 3.6) as compared to littoral zone, Whereas in ponds reverse is true and profundal zone is literally absent (Fig. 3.4). In lakes there is generally a wave action which plays a dominant role in mixing of water whereas pond isa quiet body of water, c) in lakes, there is generally a stratification of temperature and oxygen (particularly in temperate regions) whereas ponds being shallow water bodies do not show any stratification. and d) since profundal zone is usually absent in ponds, most of .its bottom is covered with rooted vegetation.

Ans: Successful establishment of the migrant to an area.

Thus; a lake may be defined as a large body Of standing water with a distinct profundal zone and in which wind plays an important role in mixing water.

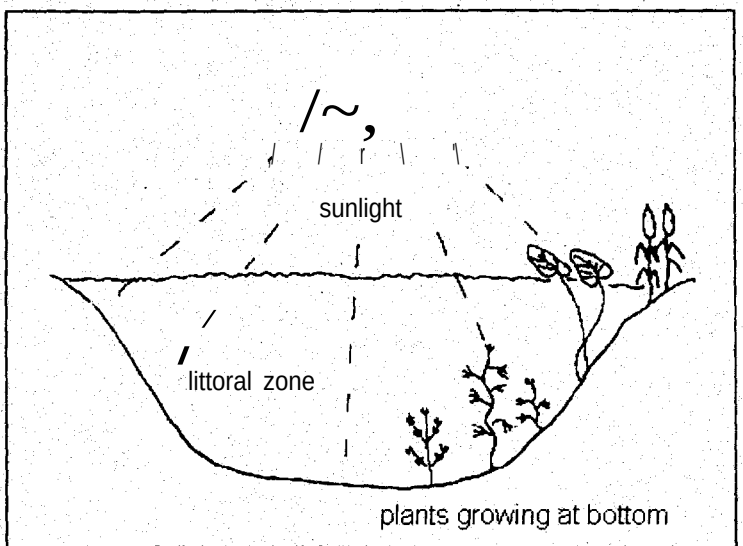

Fig. 3.4 A small pond showing an exclusive littoral zone.

ii. **Ponds:** A pond may be defined as a small, shallow, quiet body of standing water usually filled with rooted vegetation.

iii. **Wetlands:** Wetlands are ecosystems i[1which the land surface is saturated or covered with standing water, at least part of the year and the vegetation is adapted for growth und.er saturated conditions. There are specific names for spedfickinds of wetlands. but we can group them in four categories, namely, 1) **Swamps** are wet lowlands' which support m'osses and shrubs together with large trees; covered with 15 - 30 cm of water.. The swamps tend to be associated with flowing water. 2) **Marshes** are treeless wetlands with abundant grass, rushes and sedges;. often covered with 20cm or more water. These also tend to be associated with flowing water. 3) **Meadows** are areas without

standing water during growing season; water-logged to within few centimeters of surface; grasses short and abundant; serve as pasture ground. 4) Bogs and Fens are areas that mayor may not have trees; soil water-logged that tend to accumulate peat.. Fens are fed by ground water and surface run oft Whereas bogs are fed solely by rainfall.

Lands covered with freshwater and located awayfrbm coastal areas are called **Inland wetlands** whereas the ones covered with saltwater are called **Coastal wetlands.** Wetlands perform following important services:

1. They support a great diversity of-life forms.
2. Wetlands act as traps and filter for water that flow through them.
3. Runoff water is slowed as it passes through the shallow plant-filled areas, reducing flooding.
4. The loads of sediments are deposited in wetland instead of travelling into rivers, and eventually, the oceans. In this way, wetlands clarify surface waters and help in accumulation and formation of fertile lands.
5. Chemical interactions in wetland ecosystems neutralize and detoxify substances in water.
6. Water in wetland seep in the ground, helping to replenish underground water reservoir.s called Aquifers.
7. Wetlands serve as nesting and breeding sites for a variety of migratory birds.

Wetlands have suffered severe losses'in many parts of the world. About half of all theorig'inal wetlands have been degraded or completely lost over the past 250 years. In countries like Indonesia, Philippines. Thailand, New Zealand, Portugal as well as 60 - 90% wetlands have been destroyed.

iv. **Reservoirs:** Reservoirs are -normally large, deep, man-made bodies of standing freshwaters. Reservoirs store - water for domestic, irrigation, industrial- or power generation purposes. Reservoirs are also used for recreation such as, swimming, angling and boating.

The size and shape of reservoir vary according to the region and design of the dam. Often artificial reservoirs are wrongly called as lakes.

b. **Lotie types:** Lotic waters include all types of running waters, such as mountain brooks, springs. streams and rivers.

Of the water that falls on earth, some evaporates,some is absorbed by the soil and percolates downwards to form groundwater,and some flows over the ground as "run off" in the form of streams or rivers which eventually drain into the sea. Because of inequalities in the nature of surface rock forms and soil and because land areas have a slope, the run off of melted snow is accumulated in smaller gullies, these join to form mountain brooks, which converge to give rise streams and finally rivers. The river at its mouth divide into a number of channels or creeks before draining into the sea (Fig. 3.5). The various flowing waters maybe defined as:

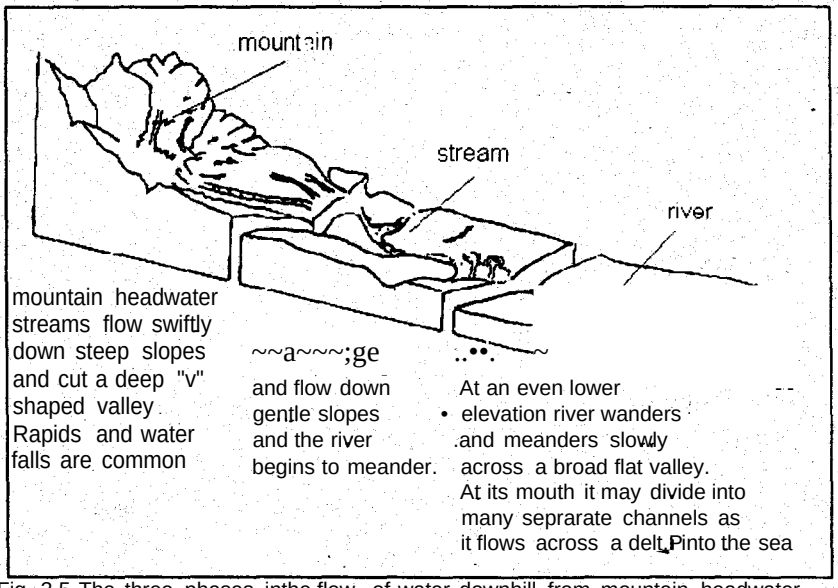

Fig. 3.5 The three phases inthe flow of water downhill from mountain headwater streams to wider lower elevation streams to riverS,which empty into the sea

i. Brooks: Small channelS in mountain or marshy are~s along the seacoast..

ii. Springs: A spring may be defined as concentrated flOW of groundwater issuing from the opening in the ground. Springs may range from tiny seep holes to large fissures in rocks. If the rate of flow is great enough, the runoff water forms a big Channel *or* stream.

iii. Streams: A stream may be defined as smaller, shallower and cooler body of flowing water. The current is comparatively slow and bottom consists of gravel stones.

iv. Rivers:. A river may be defined as a larger, deeper. and warmer body of flowing water: The current is more rapid in upper reaches :md water is muddy.

III. CHARACTERISTICS OF FRESHWATER ENVIRONMENT

Freshwater environments, unlike the marine, are subject to variations in the environmental factors such as, salinity, dissolved gases, light, turbidity and others.

Salinity is one ofthe most important factor that limits the abundance and distribution of many organisms directly or indirectly. It affects organisms mainly through changes in osmotic pressure and the density of water. The salinity of sea water i$ fairly constant, averaging 35 ppt. Freshwater have on average a salinity of 0.065 ppt for soft waters and upto 0.3 ppt for hard water.

Temperature fluctuations both diurnal and seasonal, are more evident in freshwater habitats. As diurnal variation of as much as 5° C has been observed in some tropical ponds having a depth of 3.0 meters. Flowing waters, however, lack such wide fluctuations in temperature. Temperature exerts a tremendous influence, directly or indirectly, on various limnological phenomena such as, stratification of water, solubility of oxygen, pH, and metabolic activities of plants and animals. Temperature often acts as a limiting factor for freshwater organisms since freshwater animals are mostly steno-thermal in nature i.e. have narrow

tolerance of temperature. According to temperature relations, lakes have been classified as a) Tropical lakes, in which surface temperature is always maintained above 4° e, b) Temperate lakes, in which surface temperature vary above and below 4° e,and c) Polar lakes,in which surface temperature never go above 4" C.

Dissolved gasses are. often limiting factors in freshwater habitats. Streams and' lakes contaminated by sewage or decaying vegetation show an abundance. of hydrogen sulphide gas, which is highly toxic to living organisms. likeWise, methane and carbon-monoxide are also tOXic gases. Lotic water comparatively has a high percentage of oxygen. Oxygen contents of a freshwater body are depleted in numerous ways. In stagnant pools with a lot of decaying vegetation, oxygen level often reaches a stage of complete depletion. For best growth of aquatic life, the oxygen leliel should be above 5 mg/liter but should *not* exceed 15 mg/liter. High saturation level of respiratory gases have also been found to have detrimental effects on aquatic biota (e.g. in fishes, it causes gas-b~bble disease).

Light in water is a factor of profound importance for its role in photosynthetic process. It is often a limiting factor in the distribution of organisms, particularly, the plankton.

Turbidity of water. depends upon the kind and amount. of suspended material like, silt, clay particles, and the planktonic organisms. Turbidity is inversely proportional to the penetration of .light. Hence, turbidity is often a limiting factor in the development of animal and plant life in freshwaters.

Since water is dense, the direct action of current is a very important limiting factor, especially in streams. Also, currents often largely determine the distribution of vital gases, salts and small organisms.

Concentration of bio-genic salts, chiefly as nitrates,. phqsphate, etc. appear to be limiting factor to some extent in the distribution of organisms in freshwaters. Freshwater being efficient solvent contains many soluteS in solution, but even then its salt contents remain under 0.5 ppt compared with 35 ppt of seawater. Different dissolved salts reach water by erosion, inflow and decay of aquatic organisms. Dissolved salts have peculiar significance forfloatingaquatic vegetation (rootS of which hang freely in water) and phytoplankton; as these organisms do not depend on the substratum for the supply of nutrients.

Q. What are Lichens?

Nitrates· and ammonia salts are· essential for the aquatic vegetation. Ammonia salts in excess have lethal effects on fauna. All freshwater environments also contain small amounts of phosphorus which more often acts as alimitingfactor. Utilization of phosphorus by phytoplankton during periods of their abundance (or bloom forming period) may result ina total elimination of other plants thatrequire phosphorus.

IV. ECOLOGICAL CLASSIFICATION OF FRESHWATER ORGANISMS

On the basis of their life form or life habitat, freshwater organisms may be classified as follows:

a. Plankton: Plankton may be defined· as those tiny organisms that live, because of their immobility and microscopic size, at the mercy of water movement Plankton community may be divided into two groups, 1) Phytoplankton,the plankton of .plant origin,such as unicellular algae, desmids, diatoms, etc. and 2) Zooplankton, the plankton of. animal origin such as, protozoans, rotifers,. copepods, cladocerans and larval stages of many invertebrates and fish.

b. Neuston: Organisms· resting or swimming at the sUrface of water are called asneuston. They may include floating algae, macrophytes like "duck-weed", as well as many types of animals. Animals that spend their lives on the upper surface of the water are called Epineuston e.g. *Ranatra, Corixa, Notonecta, Hydrometra,* etc. Those animals that live beneath the surface water film 'are called as Hyponeuston e.g. .snails, larvae and pupae of mosquito, *Arcella,* etc.

c. Periphyton: The German' word "aufwuch:' proposed by Ruttner in 1953 is more appropriate than the English term Periphyton. The term aufwuch ~efersto any community that. develops on the surface of some· subrnerged substrate; the community •developing on rocks, stones or bricks is called Epilithic; that developing on plants as Epiphytic; that on sand Epissamic; while the one ,developing on shells and hard parts of living animals (for example, on the carapace of turtles or tortoise) is called Epi%ooic; that developing <;>nwood Epixylic; while the one developing on objects other than these is called Epihalotic.

Ans: Association of autotrophic algae and heterotrophic fungi.

The periphyton community consists of sessile organisms firmly attached to any submerged substrate and various semi-sessile forms within the mat of sessile ones. The sessile members of the community consist of blue-green algae, while the free living members include protozoans,rotiters and other microscopic organisms.

d. **Benthos:** Organisms attached,crawling, or resting on the bottom or liVing in bottom sediment are called Benthos. The bottom fauna includes several species of insects larva.e, bivalves, gastropOds, crustaceans, annelid worms, planarians, etc. Organisms that live on the surface of the substrate are called as **Epifauna,** and those liVing in the sediment or burrowing in the substrate are referred to as **Infauna.**

e. **Nekton:** Nektons are defined as those organisms which are able to navigate at will. These include large, powerful swimming animals, such as, shrimps, prawns, crabs, large insects, fish. and other higher vertebrates.

V. FRESHWATER ZONATION

a. **Zonation of lakes and ponds:** Lakes and large ponds remain vertically stratified (particularly in temperate. regions) in relation to light penetration, oxygen, temperature, etc. In a typical large lake, for example, following zones may be recognized (Fig. 3.6).

1. **Supra-littoral Zone: A** zone just above the edge of water. This zone is not submerged in water but exposed to wave action and splash of water along the margin on a strong windy day. Life is poor in this zone. Among plants are· found *Scripu$, Sagittaria, Typha,* etc. while among animals are found sqme insects, gastropods and annelids.

2. **Littoral Zone:** From the water's edge to a depth of about 6 meters is the Littoral zone.-This zone is well lighted; bottom is coarse; both emergent and submerged plants abundant; oxygen abundant; animals mostly crustaceans, gammarids, annelids, molluscs and insects.

What is Compensation level?

3. **Sub-littoral Zone:** It extends from littoral to a depth of 10 metres. It is called as "shell zone" also, because on the bottom in this area are present large number of molluscan shells. Light is very dim; bottom is made of fine sediments; large plants are rare; pH values considerably lower; animals are mostly bivalve molluscs and chironomid larvae. Generally, the lower limit of sub-littoral zone marks the Compensation Level (Le.it is the depth in lake or pond where the photosynthetic equals the respiratory rate of flora). This is absent in shallow lakes or small ponds. The photosynthetic organisms are limitedto the area above these depths.

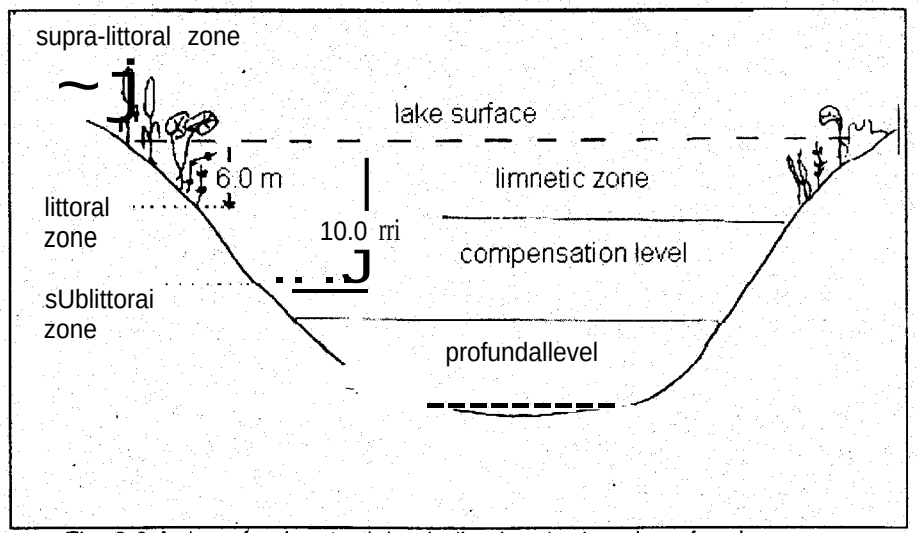

Fig. 3.6 A deep freshwater lake, indicating the location of various zones.

4. **Profundal Zone:** It is the deep water zone beneath the limnetic zone. This is the colder region; temperature nearly uniform: light is absent; oxygen is very poor; carbondioxide abundan:: bottom mucky or consists of fine sediments; plants absent; anirn;:,s rare.

Ans: It is the depth in lake where photosynthesis just balances respiration.

5. **Limnetic** Zone: The open water zone to the depth of effective light penetration is called Limnetic zone. This zone has no shore and no bottom. It is the habitat of phyto and zooplankton, swimming plants, and large animals. The turbidity of water and the absorption of light rays limit the depth to which light penetrates. On this basis, lirrmetic zone can be divided again into Trophogenic and Tropholytic zones. In the upper well-lighted zone, photosynthesis prevails in daylight.. •Since synthesis of organic compounds occur in this zone, •it is called trophogenic. Below trophogenic layer is a very dim-light or darker region called tropholytic zone .where respiration and decomposition predominates. Abundance of bacteria and paucity of macro-organisms characterize this zone. Generally 'animals which are adapted to low oxygen condition are present in this area.

From zonation point of view, ponds differ from lakes,

i. since there is no. wave action in the surface water of pond, supra-littoral.zone is almost absent.

ii. in ponds, littoral zone is larger than limnetic and profundal zones. In fact in shallow ponds, bothlimnetic and profundal zones are absent (Fig. 3.4) and the littoral zone extends completely across the basin, and

iii. in shallow lakes and ponds, the tropholyticzone may be poorly represented or completely absent..

VI. STRATIFICATION IN LAKES

The most important feature of lakes is the occurrence of thermal stratification during summer and winter. The stratification is much more prominent in temperate lakes of sufficient depths (Fig. 3.7);

Q. What is Peat?

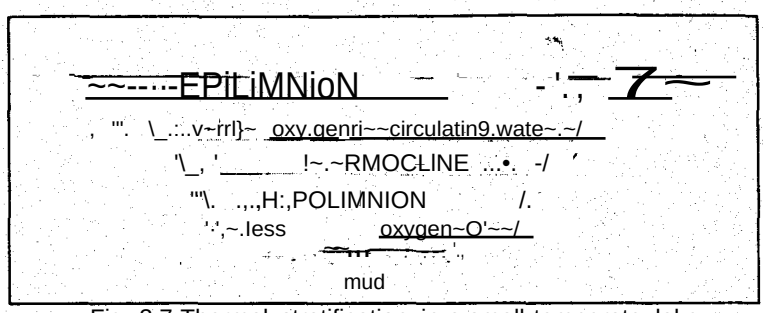

Fig. 3.7 Thermal stratification in a small temperate lake.

In winter (December • February), the upper surface of the lake may be completely frozen and the temperature of water is about 0° e, while that of deeper water is about 4° e (Fig. 3.8 a).

NOTE:

The density of water increases with decrease in temperature and the maximum density is reached when water is at 4° *t. but,* as *soon as, the water cools below 4°* C, *it expands, become lighter, remain on the surface and freezes. It is because of this abnormal property of water that ice is always formed at the top of the water surface and float.*

Thus, in winter, there is an stratification of an upper layer Epilimnion, extending from top to a depth of about 15 meters, and. the temperature range from 0° e to 3° e,and a lower **Hypolimnion** having a uniform temperature of 4° e. Throughout this period many of the organisms hibernate in mud and fishes also retire to deep waters. In winter the oxygen supply is usually not greatly reduced because, bacterial decomposition and respiration of organisms are not sq great at low temperature. Also, water holds more oxygen at low temperature than high ones. However, in exceptional cases, the winter stratification may become severe when snow covers the ice at top. This formation of "snow cover" completely stops light penetration' and prevents photosynthesis, thus resulting in oxygen depletion for entire lake.

Ans: The sediments containing un-decayed organic matter.

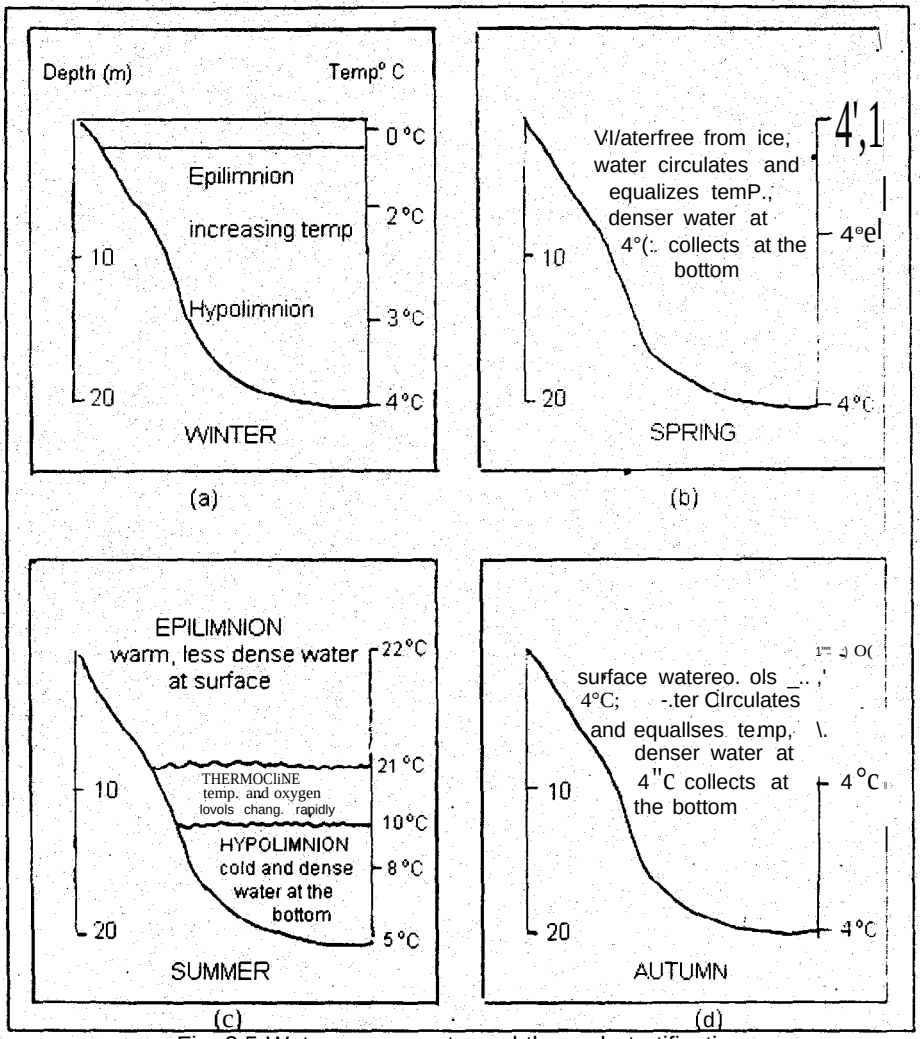

Fig. 3.5 Water movements and thermal stratification in a temperate lake during a year

Q. What is meant by 'fossil fuels' ?

In spring (Marctt. - May) the warming up causes ice to melt and as the surtace water reaches 4° C and becomes more dense, it flows down to the bottom of the lake causing a complete circulation or "over turn". The mixing goes on slowly, helped by winds, till a uniform temperature of 4° C is attained from top to bottom (Fig. 3.8 b). This mixing has been termed as "Spring Overturn". This helps the distribution of oxygen throughout the lake.

In summer (June - August) the surtace water warms up rapidly due. to solar radiations, becomes lighter and floats over the colder denser water which warms up only, slowly. Because of the differences in the density of water, the warm top layer does not mix with more dense cold layer, In summer, three zones can be clearly distinguished in a lake, namely, a) Epilimnion which isagitated by Wind; rich in dissolved oxygen; rich in phytoplankton; good illJmination; usually about·8 - 10 meters deep; temperature difference between its top and bottom layer is minimal,b) Below the epilimnion, there develops a zone of rapid drop in temperature with depth. This' zone, only 2 - 4 meters thick is called Thermocline. In this zone fall in temperature exceeds 1° C per meter. This transitional zone, also known as Metalimnion, constitutes an effective barrier between the epilimnion andhypolimniol1.. This means that heat and. nutrients present in the region of maximum sunlight are prevented from mixing throughout the body of water. In ecological terminology, the thermocline is defined as "the plane of maximum rate of decrease in temperature" and c) there is a deeper Zone of Hypolimnion, extending to the bottom which is poorly oxygenated; with little or no light; temperature is more or less uniform throughout the year (Fig, 3.8 c)

In autumn (September - November)" the water cools to a temperature of 4° G and moves downward to the bottom, causing a second mixing within a year (the first time mixing occurred in spring). An equalization and redistribution of oxygen and dissolved nutrients is attained. This mix!ng in autumn period is called Fall Overturn.

When the temperature at the bottom of. a lake is similar to that at the surtace, water continues to circulate due to the action of wind ahd no thermocline is formed if the temperature at the bottom remains about 4° C there is little circulation and, as a result, the surtace water is rich in oxygen but lacks nutrients while the deeper layers are rich in nutrient salts but lack oxygen. The process of differentiation of freshwater habitat into various layers (i.e. strata) due to temperature is called Thermal Stratification.

Ans: Products of partial or complete decomposition of plants and animals like. oil, gas, coal, etc.

VII. CLASSIFICATION OF LAKES

The German limnologist, Theinmann, classified lakes on the basis of their productivity. Productivity, however, is correlated with zonation. Three types of lakes can be distinguished on the basis of productivity, namely, a) Oligotrophic lakes, which are deep with hypolimnion larger than epilimnion, and have low primary -productivity, b) Eutrophic lakes, which are shallower and have greater primary productivity and c) Dystrophic lakes, also called bog lakes have high concentration of humic acid in water and are characterized by severe poverty of nutrients.

Table 3.1 Comparison of General Characteristics of Three Types of Lakes

Characteristic	Oligotrophic	Eutrophic	Dystrophic
1. Basin shape	Narrow & deep	Broad and shallow	Small and shallow
2. Lake bottom	Stones and organic silt	Fine organic silt	Peaty silt
3. Shoreline	Stony	Weedy	Stony or peaty
4. Water transparency	Hi9t:t	Low	Very low
5. Water colour	Green or blue	Yellow or green	Brown
6. Dissplved solid	Low	High	Low
7. Oxygen'	High	High at surface but low under ice	High
8. Phytoplankton	Poor	Abundant	Poor
9. Macrophytes	Poor; few species	Abundant	Poor
10. Algal blooms	Rare	Common	Rare
11. Zooplankton	Many species but low number	Few species but high number	Few species but low number
12. Zoobenthos	Manysp~cies but low number	Few species but high number	Few species but low number
13. Fish	Few species	Many species	Very lew species

Q. Define Entropy.

Differences in the availability of plant nutrients in the water is the principal criterion upon which the above referred classification of lakes has been made. Although difficulty exists in applying this classification universally, following is the table which shows a comparison of these in their general characteristics and properties.

VIII. ZONATION OF LOTIC WATERS

Lotic or running water environment such as, brooks, creeks and rivers lack well defined zonation as found in lakes and ponds. Very often, the limits of such zones are poorly defined, arbitrary, or of a transitional nature. In other words, the criteria used to designate zones in standing water communities simply do not apply in lotic waters. The three basic zones in running waters or streams maybe designated as a) Flowing water zone, b) Rapid or Riffle zone, and c) Pool zone.

In a flowing water zone, the water depth will vary from extremely shallow water near the shore line to extreme depth in large rivers. Active swimmers, such as, otters, snake.sand fish are common vertebrates inhabiting this environment.. Most of the invertebrates suct) as, annelids, crustaceans, insect larvae, snails and bivalves move along the bottom where currents are not swift or possesses hold fast organs to prevent being swept away many mile* downstream. Some fish move upstream to spawning areas, for example, Ten}Jalosa ilisha, the palla in river Indus.

Rapid or Riffle zones are shallow water zones, with water flowing rapidly over an irregular substrate of "rock or gravel. This typebf zone serves as an ideal environment for many insect larvae for two reasons: the current is relatively rapid and will carry greater quantities of food per unit period of time, and the water is well oxygenated. Most of the living organisms normally found in this zone, where currents are usually rapid, are sedentary forms possessing structures for attachment, or body forms adapted for.life in swift water.

Pool zones are often numerous among older rivers, especially where the downstream gradient is not steep. These zones are frequently referred as river ponds, pools, bayous or swamps, provided they are directly connected to moving streams of water. The velocity of water current in pool zone is extremely slow or practically non"existent as compared with rapid zone. Water depth is greater than that found in riffle areas and the bottom is soft, having a fine sand, silt, or clay suited for burrowing types of animals.

Ans: Energy that is not available for doing work.

IX. BIOTIC COMMUNITIES OF LAKES AND PONDS

The species composition of fauna and flora differ from each other in different zones of standing waters. These are as follows:

a. **Biota of littoral zone:** Lentic aquatic life is most prolific in littoral zone. The producers are of two main types, a) algae and b) macrophytes. The aquatic algae may further be divided into following categories. 1. Planktonic algae, includes diatoms,' desmids simple single celled, or colonial free floating forms. The planktonic algae 01 littoral region includes, diatoms (e.g. *Navicula),* blue-green algae (e.g. *Microcystis, Oscillatoria,* green algae' (e.g. *Cosmarium,* or colonial forms e.g. *Volvox, Hydrodictyon,* etc.) 2. Filamentous algae, consisting· of strands or threads of cells that may either be branched or un-branched and float on the surface forming a scum or mat. Common species are *Spirogyra, Zygnema, Cladophora, Odeogonium.* etc. 3. Macro-algae, are those that grow upward from bottom and have such complex growth forms that they can be mistaken lor vascular plants, for example, *Chara, Nitel/a,.etc.*

Macrophytes, generally referred to as hydrophytes, belong to a number of families and generally form concentric zones within the littoral zone. From shallower to deeper water in ponds or lakes, we generally find, a) a zone of emergent vegetation consisting of rooted plants with principal photosynthetic surfaces projecting above the water. Thus carbondioxide 'for food manufacture is obtained from air but other raw materials from beneath the water surface. These include, species of *Typha, Scirpus, Sagitta ria,* etc., bra zone of rooted submerged plants that remain completely submerged in water. These include species of *Ceratophyl/um, Vallisneria, Hydrilfa, Potamogeton,* etc., c) a zone of rooted plants with floating leaves, such as, *Nymphaea, Nelumbo, Marselia,* etc., d) a zone of free floating forms. The leaves of these plants float freely above the surface of water and the roots hang freely underneath. They have no contact with soil. These include species of *Pistia, Lemna, Eichhornia,* etc.

Q. What are the principle green house gases?

In littoral zone, the consumers are the animals in which vertical rather than the horizontal zonation is more striking. In or on the bottom are various dragon fly nymphs, crayfish, isopods, snails, gastropods and bivalves. Other animals live in or on the plants and other objects projecting up from the bottom. These include protozoans, like *Stentor, Vorticella,* larvae of many insects, rotifers, flatworms, hydra and others. More deeper into the bottom are burrowing nymphs of Odonota and Ephemeroptera, annelids and midges. The free swimming or nektonic fauna of littoral zone is very rich consisting of adult and larvae of diving beetles, adulthemiptera and many dipterous adult and larvae. Among vertebrates, are snakes, frogs, and turtles. Tadpoles of frog and toads are important consumers feeding on algae and ojhet plant material. Pond and lake fish fauna comprises of a variety ofe:arps;catfishes and murrels.

The zooplankton qf littoral region is rather characteristic and differs from that of limneticzone in preponderance of heavier less bouyant crustacea which often ctingto plant orrest on the bottom. Important components of zooplankton are species of daphnia", cyclops. ostraCodsand rotifers.

Finally, the neuston fauna of littoral zone consists of whirling beetles. water striders, water spiders, a variety of bugs and numerous protozoans.

b. **Biota of limnetic zone:** Inlimneticzone, the producers are mainly phytoplanktonic algae. Same species are represented as in littoral region. The limneticzooplankton represent a few species but their number is large. Copeppds, c1adoceransand rotifers are generally of first importance and the species are largely different from' those of littoral zone. Common species are those of *Sida, Diaptomus, Bosmiaa,* etc. The free swimming nektonic fauna consists of mainly a variety offfsh.

c. **Biota of profundal zone:** The deep' profundal life comprises of bacteria, fungi, blood wormS (i.e. chironomid larvae), annelids and small animals which are capable of surviving in a region of low oxygen and no light. In the profundal zone, autotrophs can not produce the food, and the main soutee of energy is "detritus" that fall out of the limnetic zone. All the organisms of this zone are heterotrophs, either as detritus feeders or carnivores.

Ans: Carbondioxide; Chloroflourocarbons; nitrousoxide and methane.

X. BIOTIC COMMUNITIES OF LOTIC WATERS

The lotic communities are entirely different from that oflentic communities and they possess a number of adaptations for maintaining themselves against the fast flowing waters. Some of the important ones are:

a. **Permanent attachment to** a firm **substrate:** The plants and animals are permanently attached to some immovable objects in the substratum, such. as, stones, logs, leaf mass, etc. In this category would be included the chief producer plants of stream. which are:' i) attaCh ed green algae, like Cladophora, ii) encrusting diatoms which cover various surfaces and iii) aquatic mosses of genus Fontinalis and others. Also, a few forms become fixed, sLlch as freshwater sponges and trichopteran larvae.

b. **Hooks and Suckers:** Another method that is commonly seen to gain hold on the substratum .is by the development of hooks and suckers. Hooks and suckers are. well developed in animals inhabiting streams, for example, in dipteran larvae of Simulium and Blepharocera and the larvae of caddis fly.

c. **Sticky Under surface:** Many animals are able to adhere to surfaces by their sticky undersurfaces. Snails and planarians are good examples ..

d. **Streamlined bodies:** Nearly all stream animals from insect larvae to fish, exhibit a definite streamlining which means that the body is more or less egg shaped, broadly rounded in front and tapering posteriolly, to offer minimum resistance to water flowing Over it.

e. **Flattened bodies:** Apart from the streamlined body, many other animals. have extremely flattened bodies which enable them to find refuge under stones and crevice~ etc. thus the body of nymphs of stone-fly and may-fly living in swift water is much flattened when compared with their relatives living in ponds "Orlakes.

Q. How old is earth?

f. **Positive rheotaxis:** Most of the animals inhabiting streams are positively rheotactic. They always move against current. This seems to be, an inherent behaviour pattern. In contrast, many lake animals, when placed in a current of water, merely drift with the current and make no effort to orient themselves or move against it.

g. **Positive thigmotaxis:** Many stream animals have an inherent behaviour pattern to cling close to a surface or to keep the body in close contact with the surface. For example, when a number of stone-fly nymphs are placed in a dish, they seek to make contact with the underside of sticks, debris, or whatever is available, even clinging to each other if no other surface is available.

The producers of flowing water include, encrusting diatoms, blue-green algae, red alga *Lemanea,* water moss of genus *Fontinalis, Hypnum* and the stonewort, *Chara.*

Among consumers, nymphs and larvae of may-fly, dragonfly, caddisfly, blackfly and horsefly predominate. Some animals such as, Gammarus, Helodes, *Cephalopteryx* live among leaves and stems of plants. Animals such as flatworms, annelids, worms, clams, snails live beneath rocks.

In slowly flowing streams, life is abundant. Plant life includes rooted vascular plants such as, pOndweed and grasses, firmly attached mosses and large multicellular filamentous algae. Detritus feeding benthic fauna is predominant. This includes isopods, bivalves, gastropods, nymphs of damsel-fly and may-fly, tubifficids, midges, and nematodes. The surface water animals include water striders, water boatmen and back-swimmers. Zooplankton is abundant.

In slow water streams oxygen is main limiting factor, hence, fishes tolerant of low oxygen levels, such as, carps and catfishes are the most common fishes found in slow moving streams, while species with high oxygen demand such as, trout and mahasheer are found in cold, fast moving streams.

Ans: 4.6 billion years.

3.5 TUNDRA ECOSYSTEM

The word tundra is derived from a Finnish word "tunturi" meaning a treeless plain. In Russian language tundra means a "marshy treeless landscape". There are two types of tundras.

a. **Arctic Tundra:** Some five million acres of Arctic tundra stretches acrosS Canada, Northern Europe, Siberia and. Alaska encircling the North Pole.

b. **Alpine Tundra:** At lower latitudes a similar pattern of landscape "alpine tundra" .occurs in high mountains at altitudes above tree-line (i.e. where trees can grow).

80th types of tundras look· similar, featuring low temperature, limited rainfall, very low precipitation rate and poor vegetation. The vegetatioh (often less than 1Q cmtall) includes mosses, lichens, sedges and grasses. The tundra soils and subsoils are permanently frozen during winter; but in brief summer (which lasts for three months only), the surface layer thaws out. The permanently frozen deeper soil (more than 1500 m thick in some region) is called Permafrost. Alpine tundras, however, have no permafrost layer below the soil surface.

The warmest months during summer averages about 10° C. rainfall is scanty, much of the. precipitation falls in the form of snow. The total annual rainfall is usually less than 25 cm per year but the water is oftef'l trapped near the surface by the widespread permafrost. During winter, thick ice covers the ground and icy winds blow throughout the day. The climatic conditions are thus very' harsh and not conducive to vegetation growth .. Trees are not found in tundra because the growing season is very short and moreover, their roots cannot penetrate the permafrost. During thf3 short summers, however, when there is nearly constant daylight, plants grow quickly and flower in a rapid burst. Lichens, mosses and grasses form the predominant vegetation.

The animals that have 'adapted to survive in such a hostile condition are caribou, reindeer, polar bear, arctic hare, arctic. fox., beavers, lemmings, wolves and others. The important arctic birds are snowy owl, ducks, geese, snowy grouse and ptarmigans. Vast number of migratory birds throng into tundras during summer months. Both Arctic birds and mammals frequently become white in colour in winter. This has been interpreted as protective coloration against predators. In Alpine tundra, mammalian fauns is very poor. During summer months, big swarms of insects, such as, black flies, bumble bees, mosquitoes, dragon flies, etc. have been observed in Arctic tundra. In Alpine tundra, however flies are scarce, but beetles, grasshoppers and butterflies are common.

Q. How long do Chloroflouroca'rbons stay in the atmosphere-

3.6 FOREST ECOSYSTEM

A forest may be defined as a large tract of uncultivated land covered with big trees, shrubs. herbs and grasses. The development of forest is condition by a number of clirnatic factors, important ones being humidity, rainfall, temperature and space. Forests roughly occupy 30 - 40 % of land surface area.

There are three principal kinds of forests:

a. Coniferous ~orests: These are dominated by evergreen conifers (Le. cone bearing trees).

b. Deciduous Forests: Whose trees drop their leave during unfavourable conditions, and

c. Tropical Rain Forests: That grow in a broad belt around equator.

I. CONIFEROUS FORESTS

Stands of coniferous forests (also called Boreal forests) are lOCatedsouth of tundra and confined to Northern Hemisphere. These forests that constitute the largest terrestrial biome, extend from Central Alaska across Canada, then sweeps along the northern border of Lake Superior. In Eurasia. this biorne extends across Norway, Sweden, Finland and Siberia.

During spring and summer, melting snow fill the lakes forming wa.tery bogs and marshes within coniferous forests. This i.s why coniferous forests are also called as **TAIGA** (in Russian language. "taiga" means swampy land).

The lands of boreal forests have a cold continental type of climate. Summers are short with long days and winters are long with short days. Only 4 - 5 months have temperature higher tha.n6° C, the temperature below which plant life cannot grow. Precipitation is scanty, about 40 -100 cm per year, and is mostly in the form of heavy snowfall. In winter, the ground is snow covered and soils freezes to a depth of1 - 3 meters. Soil is deficient in minerals. poor in nutrients and acidic in nature.

Ans: 65 to 111 years.

These forests are characterized by needle-leaf cone bearing evergreen plants. Millions and millions of tightly packed conifers covers vast areas of North America and Eurasia. The dominant species are *Picea* (spruce), *Abies* (fir), *Pinus* (pine) and *Larix* (larch). Shorts trees like orchids and shrubs are not common. Mosses and lichens are in abundance. Compared to other forests, taiga is poorer in number of plants and animal species. However, these forests are chief supplier of timber in the world.

Fauna is restricted. Large mammals are represented by Elks, *Caribous, Reindeers, Moose,* etc. Ofthe large mammals, Moose is most conspicuous (it is the largest of living deer, attaining a height of 1.8 meters). Carnivores include bears, wolves, foxes, lynxes, etc. Arboreal animals. include, porcupines and squirrels. BirdS are represented by grouse,crossbills, jays, woodpeckers, etc. Insect life consisting of wood wasps, bark beetles, pine saw flies, etc. is predominant and prolific in summertime. The swarms of insect attract many birds of migratory character.

II. DECIDUOUS FORESTS

The deciduous forests consisting of Oak, Walnut, Maple, Cedar, Cottonwood, Chestnut, Beech and Willow trees, usuaily 40 - 50m height are found in Europe, North America, Japan, Australia and Chile. The most important feature of deciduous forest is falling of leaves during winter. The new foliage appears in spring. This is an adaptation to contrasting conditions of summer and winter. The presence of broad leaves helps the trees to prepare starch and carry ontheir vital activities at a maximum rate because of warm temperature, plenty of moisture and long periods of sunlight during summer. On the other hand, during winter since days are short and cold and air is dry, water loss is greater from the surface of leaves, hence the leaves are shed and trees become naked and dormant.

The deciduous forests are characterized by warm summers (20°C - 27°C) and cold winters (-12° C) coupled with abundant rainfall. The rainfall varies from 75 ~ 150 mm and may be uniform throughout the year. The trees found in deciduous forests are less dense than are those found in tropical rain forest enabling light to reach the floor. As a result, herbs are more numerous and have two blooms i.e. the spring bloom (after winter) and the rainy season bloom. The spring, summer, autumn and winter seasons are distinctly marked.

Q. What is hydroponics?

The invertebrate fauna is represented by the earthworms, millipedes, snails, isopods, wood boring larvae of various insects and leaf-eating insects. Among the. vertebrates,. the salamanders, tree frogs, turtles, ..rattle snakes, horned owl, hawks, thrushes, fly catchers,herons, storks, squirrels, deers, bears, bobcats, pigs, dormice, wolves,. raccoons, antelopes, lynx, porcupine opossum and wild boar are well represented.

III. TROPICAL FORESTS

A variety 9f tropical forests is found within 23.5° latitude of the equator, where the average temperature is around 23° C and length of daylight is around 12 hours. Tropical forests comprise of 43 % thorn forests; 32 % deciduous forests and 25 %. rain forests. Each category has following important characteristics.

a. Tropical Th()rn Forests or Tropical dry forests are found in lowland areas that have prolonged dry season and scarce rainfall. Plants are mixtures of thorny shrubs and trees and succulents. These forests are found in East Africa and North-Western India.

b. Tr()pical Deciduous Forests: In areas that have distinct wet and dry seasons, tropical deciduous forests are common. Deciduous trees and shrubs drop their l.ealieS during the long dry season and re-leaf during the rainy season. The tropical deciduous forests are found in India, Central and South America and Northern Australia.

c.. Tropical Rain Forests: The luxuriant tropical forests are found in areas near the equator where rainfall is abundant (250 - 400 mm per year) and dry season last for no more than few months; high and uniform temperature throughout the Year(average being about 28° C); maximum temperature 32 - 43° C and' minimum being 10- 13° C); rainfall is also uniformly distributed throughout the year. Tropical rain forests are found in Central and South America, Central and West Africa, Malaysia, Indonesia and New Guinea.

The tropical rain forest has the greatest diversity of plants. As many as 300 species of trees, shrubs and herbs can be found in one hectare area. The great plant diversity allows great animal diversity.

Ans: The cultivation of plants without soil in plastic bags containing water and mineral nutrients.

The ground in tropical forest is soggy, the tree trunks are wet and water drips down everywhere. Agreatvariety of epiphytes (plants that grow on tall trees but do not parasitise) are found in these forests. Temperatu re and moisture are. ideal for decomposition; .hence detritus feeders, bacteria and fungi immediately decompose organic matter falling to the forest floor, whereas, the soil of tropical deciduous forest is rich enough for agricultural purposes. The soil of tropical rainforest is very poor in nutrients and is not suitable for farming. Vegetation in tropical rain forest is divided into five layers:

1. trees that emerge above the canopy, about 50 -- 60 m tall.
2. high upper canopy.
3. low tree Substratum.
4. shrub understory, and
5. ground layer of herbaceous plants.

these forests are dense and nearly all plants are evergreen. Those trees that lose their leaves entirely do so at irregular inteNals with no apparent regard to the climatic regime.

Invertebrate density and abundance is very high in tropical forests. The common invertebrates are worms, snails, millipedes, isopOds, centipedes, scorpions, termites, bugs,beetles, leeches, planarians, ants, etc. The vertebrate fauna is represented by a variety of frogs and toads (amphibia) geckos, chameleons, agamid lizards,poisonous and non-poisonous· snakes; crocodiles (reptilia), wood peekers, humming birds, Parrots, fruit eaters,hornbills, cuckoos, sunbirds, owls, hawks (aves) and a great variety of nocturnal,arboreal, herbivore and carnivore mammals. The important mammalian .fauna of various tropical rain forest isas under:

South American tropical rainforests have flat-nosed coloured monkeys, tapirs, sloths, agouties, porcupines,· llamas, anteaters and armadillos.

Q. What three functions are served by human diet?

Central African forests have gorillas, chimpanzees, monkeys, elephants, giraffes, zebras, antelopes, hyenas, wolves, rhinoceroses, hippopotamuses, anteaters, etc.

Indian tropical. rainforests have elephants, tigers, rhinoceroses, monkeys, chevrotains, anteaters, hyaenas, lorises, wolves, etc.

Malayan and East Indies forests have tapirs, elephants, gibbons, orangutan, bears, etc.

North. Australian forests have kangaroos, wallabies, Tasmanian wolves,oppossums, flying phalangers, etc.

3.7 GRASSLAND ECOSYSTEM

At one time,grasslands covered about 42% of the land surface of the world, today, however, much of it is under cultivation and its cover is reduced to 19% of the total land area of the world. There are two main types of grasslands:

a. Grasslands variously known as **Prairies** (in North America); **Veldt** (in South Africa): **Steppe** '(in Asia); **Puszta** (in Hungary); **Pampas** (in Argentina and Uruguay) from one group. These are. tree-less grasslands and are characterized by .the predominance of grasses adapted to dry conditions.

b. Savannas (from Spanish word "Sabana" which means meadow) or Tropical grasslands form other group. These are grasslands with scattered big trees and shrubs. Tropical savannas are found in South Africa, South America, South EastAsia and Australia. Savannas cover about 8% of the land surface of the world.

Grasslands naturally develop in regions with cold winters, hot summers and seasonal. rainfalls (more annual rainfall than desert· but not enough to support forest life). Generally the rainfall lies between 30 - 75 mmper year. Grasslands typically appear in the interior of continents. Grasslands are open land communities with limited moisture conditions, .irregular . rainfall, sharp seasonal and diurnal variations in temperature and high solar radiations, Grassland soils are highly characteristic; dark in colour and contain large amount of humus. The extensive root system of grasses allows them to recover quickly from seasonal drought, occasional fires and grazing by large mammals which occur frequently in··this biome. As the name implies, dominant vegetation consists of grass which can be divided into two groups, the tall grass more than 1.5 meter high found in moist areas and the short grasses, grown in clumps,and found in drier areas.

Ans: It provides energy, materials for 9rowth, and material for regulation of life processes.

Typicalanimals in grasslands tend to be quite small, with the exception of a few very farge herbivore mammals such as *Bison* and *Pronghorn* in North America; Wild horse, Wild ass, Antelope in Eurasia; Antelope, Zebras in Africa; kangaroos and wallabies in Australia. Most herbivores of grasslands characteristically aggregate into herds or colonies; this aggregation provides some kind of protection against predators. *Carnivores* of grassfandsare relatively small, such as badgers, foxes, ferrets, *wolves,* etc. Rodents, such as, rabbits, gophers, sqCJirrels,mice, shrews are predominant.. The characteristic birds of this biome are chicken, hawks, owls, pigeons, etc. Lizards and snakes are common,

Savannas .cover much of Central.Africa, South "Africa, Malaysia,. North Australia, West Indies and parts of South America. *Savanna* is COmparatively rich in number of .plant species. Vegetation is dominated by tall perennial· grasses which may reach 2 meter in height and commonty referred to ~as "Elephant grass". The trees found in association with it are quite distinctive. They are relatively low growing and may be deciduous or evergreen.

Temperature is high, seldom falling below 21° C. rainfall comes in summer and ranges between 38 - 150 mm. Three seaSons are generally recognized, namely, cold dry season, hot dry season and warm rainy season.

The fauna of *savanna* is *very* rich compared to other types of grasslands. The fauna of *savanna* mainly consists of large herbivores. The tropical grasslands of Africa *have* herbivores like zebra, antelope, giraffe, elephant, gazelle, monkey, ape, rhinoceros, hippopotamus, etc. and *carnivores* like lions, tigers, hyaenas, wolves, jackals, etc. The tropical grasslands of Malaya include, gibbons, tapirs, antelopes, elephants, etc. whereas in Australian *savanna,* kangaroos and. wallabies are dominant..

3.8 DESERT ECOSYSTEM

Deserts are defined as lands where evaporation rate is high and rainfall is *very* scanty. Deserts occupy roughly 30% of the land surface area of the earth. Deserts may be classified as under:

a. Low rainfall deserts e.g. Atacama (Chile).

Q. What is a species?

b. Hot deserts e.g. Sahara (Africa); Kalhari (Africa); Thar and Cholistan (pakistan); Arabian (Saudi Arabia); Libyan (Libya); Hajisthan (India) and many others.
c. Cold deserts etc. Ladakh (India), Gbbi (Mongolia); Alps (Italy).
d. Low nutrient deserts e.g. North American deserts.
e. High salt content deserts e.g. Chile, South American and Australian deserts.

Generally. hot deserts have a rainfall of less than 25 mm·per year. The driest deserts of the world are those *ot* Central Australia and Sahara (Africa) where annual rainfall .is less than 2 mm. These deserts have no .or little vegetation. Cold deserts occur at high elevations where temperature is very low but rainfall is very scanty.

Deserts are mostly confined to tropical regions. Deserts arecharacterized by:

a. Lovvrainfall and highevaporatfon rate,
b. High intensity bf scorching sunlight,
c. Wide fluctuation in temperature, from hot day to cool night; the days are hot because of the lack of cloud cover but the nights are cool because heat escapes easily into the atmosphere,
d. Dust storms are of common occurrence, particularly in afternoon; these result due. to lack of moisture and extremes of temperature, causing an increase in the air movement, and,
e. Vegetation is sparse due to scarcity of water.

The desert is a harsh environment.. "Animals and plants in this habitat have evolved ways to circumvent aridity and high temperature. Desert animals avoid heat by becoming nocturnal in their habit; by seeking shady places; or by sleeping daytime .in underground borrows. Vegetation is largely composed of thorny bushes, perennial succulents and rapidly growing herbaceous plants. In most hot deserts, there occurs plant like *Cacti, Acacia, Euphorbis, Prickypeers,* etc. Fauna is very poor. There are few large mammals,' such as, camels, antelopes and sheep, Small mammals such, as, rodents of various kinds are abundant.. Carnivores are represented by wolves, jackals, foxes, etc. Reptilian fauna consists of lizards and snqkes. The avi-fauna include birds like partridges, quails, bustards, sand grouses and vultures.

Ans: Species. is a group of interbreeding animals that do not bread with members of other such groups.

Chapter 4

ENERGY FLOW IN ECOSYSTEM

4.1 INTRODUCTION

Every living organism requires a certain amount of enefgy for growth, survival and reproduction. This energy is used in the folloWing ways.

i. to perform metabolic activity

ii. for repair and renewal of tissues

iii. to allow for the movement of mobile animals i.e. energy expended through activity

iv. a part is used for the growth and formation of new protoplasm

v. to supply the necessary structures for reproduction i.e. embryos, seeds, etc, and

vi. a small part of energy is stored as reserve food, for example. in the form of starch in plants, and fats in animals.

Living organisms take in energy from outside and convert it into some useful form, A portion of that useful energy is then released to perform the above referred life processes, after which it leaves the organisms once again. and is dispersed into environment in the form of heat.

In the following account we shall define. and discuss the kinds, source, behaviour, quality and flow of energy in an ecosystem.

Q. What is the total area of world's land surface?