4 INTERACTION AMONG ORGANISMS AND ECOLOGICAL ADAPTATIONS

Members of the biotic community in an area are dependent on one another. The interdependence is reflected in their interactions, mainly for food, space, reproduction and protection. These interactions are important for survival of different species and the community as a group. Food interactions are reflected in Tophic structure (food chains), which comprises plants, animals and micro-organisms.

Plants and animals have well established interdependence for reproduction. It is best illustrated by the role of insects in the community. The insects are flower-specific and have structures suitable for nectar sucking and pollination. On the other hand, flowers may also be insect-specific. Snapdragon flower, for example, has lip-like petals to facilitate insect entry and landing. Both flowers and insects have developed and %evolved in a way leading to their nterdependence. Flowers offer nectar to msects as a reward for pollination. The fluctuations in insect population of a zommunity would affect pollination, thereby effecting plant reproduction. The use of nsecticide in a crop field may kill bees, and consequently crop pollination, may be reduced. Birds and mammals help in the dispersal of seeds aind fruits: The .nterdependence in the community can be further demonstrated with the example of ; uckoo laying eggs in the nest of other birds, ind gall wasps embedding their eggs deep into the tissues of plants to ensure hatching and protection.

Some members of the biotic community, rarticularly the animals, develop certain: rotective mechanisms to avoid or to check the fnemies. The weaker members sometimes: amouflage to avoid detection. You will find that butterflies and moths have colours matching the flower colours to make their detection difficult. The camouflage can be easily observed in praying mantis and leaf insect which even mimic the shapes of leaves and branches.

You can also observe orchids mimicking the butterflies, as far as colours are concerned. It has been observed that generally, weaker members, especially among the animals, mimic the strong, fast moving species and those having a fewer natural enemies. For example, non- poisonous snakes mimic the poisonous ones to scare away the enemies. Birds mimic voice or song of other animals. The nature of mimic action could be both defensive as well as offensive.

INTERSPECIFIC INTERACTIONS

The interactions between species may have positive or negative results. Following six general types of interactions have been described:

A. Positive interactions
  1. Mutualism;
  2. Commensalism;
  3. Protocooperation.

B. Negative interactions
  4. Exploitation ;
  (i) Social parasitism ;
  (ii) Parasitism ;
  (iii) Predation.
  5. Amensalism and antibiosis;
  6. Competition.

SPECIES INTERACTIONS

The interactions between populations of species in a community are broadly categorised into **positive** (beneficial) and **negative** (inhibition) **interactions,** depending upon the nature of effect on the interacting organisms.

Possible combinations of 0, + and - to give different kinds of interactions (Burkholder, 1952):

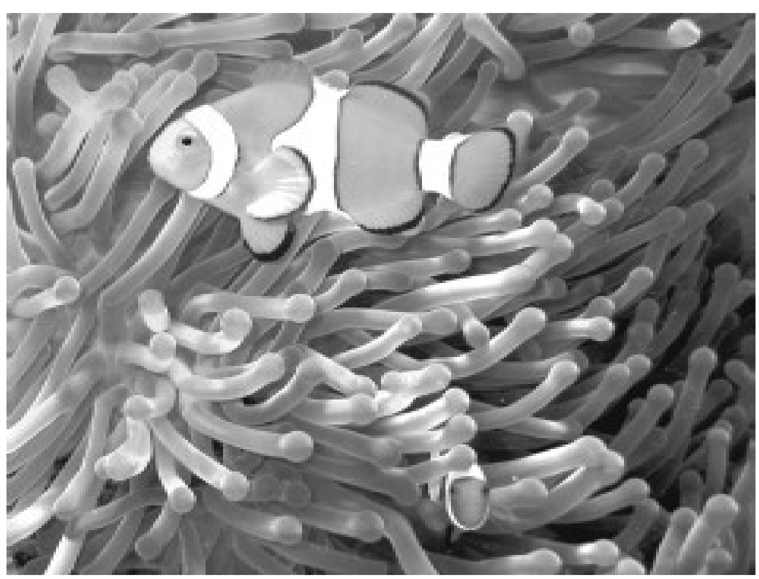
Combinations	*Detailed effect(s)*	*Interaction type*
0 0	Neither population affects the other	Neutralism
– –	Direct-inhibition of each species by the other.	Competition (Direct interference type)
– –	Indirect inhibition where common resources is in short supply.	Competition (Resource use type)
- 0	Population 1 inhibited, 2 not affected.	Amensalism
+ –	Population 1, the parasite, generally smaller then 2, the host.	Parasitism
+ –	Population 1, the predator, generally larger then 2, the prey.	Predation
+ 0	Population 1, the commensal,benefits while 2, the host, is not affected.	Commensalism
+ +	Interaction favourable to both but not obligatory.	Protocooperation
+ +	Interaction favourable to both and obligatory.	Mutualism

Key : 0 = Neutral
– = Harmed
+ = Benefitted

INTERACTIONS WITH POSITIVE EFFECT

Some of the interactions between species in the community benefit one or both the species. Mutualism and commensalism are examples involving beneficial interactions.

Mutualism : An association of two species, in which both species are benefited, is called mutualism. Mutualism may or may not involve close physical association between the individuals of pairs of species. The condition in which there is a close physical association between the individuals of a pair of species is also called symbiosis (= living together). Mutualism is a functional association, not merely living together. Mutualism may be obligate (species are completely dependent upon each other) or facultative (one species may survive even in the absence of the other partner species). Mutualism is exemplified by the nitrogen fixing bacteria *(Rhizobium)* living in root nodules of legumes, where the bacteria, deriving nutrition from the host plant, fix atmospheric nitrogen and make it available to the plants. Algae and fungi exhibit mutually beneficial relationship in lichens. The fungi provide protection to algae, and the latter prepares food for the fungi. In the case of coral reef, coelenterates and algae live in obligate



relationship. Mycorrhizae are mutualistic relationship between fungi and roots of about 80 per cent of higher plants. The fungus helps in mineral nutrition of the plants with which they are associated and obtains, in turn, carbohydrates from plants. Bacteria in the gut of some animals (cattle) help in cellulose digestion.

LICHENS

These are examples of mutualism where contact is close and permanent as well as obligatory. Their body is made up of a matrix formed by a fungus, within the cells of which an alga is embeded. The fungus makes moisture as well minerals available, whereas alga manufactures food. Neither of the two can grow alone independently nature. Lichens grow abundantly on bare rock surfaces.

SYMBIOTIC NITROGEN FIXERS

This is a well known example of mutualism, where the bacterium Rhizobium forms nodules in the root, of leguminous plants, and lives symbiotically with the host. Bacteria obtain food from the higher plant and in turn fix gaseous nitrogen, making it available to plant. Similarly, root nodules of *Alnus Alopecurus, Casuarina,* Cycadacease, *Myrica Podocarpus* etc., and leaves of about 400 species of non-legumes are examples of such association.

MYCORRHIZAE

This is also an example of similar nutrition in fungi that form mycorrhizal structures either inside the roots, or on outside surfaces of plants. Ectotrophic mycorrhizae are very common in nature on pines, oaks, hickories and beech, and endotrophic ones occur in red maple and are common in roots and other tissues of many orchids and members of Ericaceae. In ectotrophic mycorrhizae, the fungal hyphae are the natural substitutes of root hairs absorbing water and nutrients from the soil. In some cases, the plants are restricted in their distribution to acidic soils which suit to the fungus partner. In endotrophic mycorrhizae, fungi occur internal to the root tissue.

PROTOCOOPERATION

However, in some cases the association is ahead of commensalism, where both the populations are benefited. But the association, although benefited to both, is not obligatory i.e.... not essential for the survival of either population (cf mutualism, where survival depends mostly on each other), Such associations are referred to at *protocooperation or non-obligatory mutualism.* One good example is of a coelenterate, sea anemone — *Adamsia palliata* attached to the shells of hermit crab - *Eupagurus prideauxi.* The sea anemone is carried by the crab to fresh feeding sites and crab in turn is said to be protected from its enemies by sea anemone. Some ecologists prefer to include this association under commensalism.

Facultative mutualism can be illustrated with the example of sea anemone, which gets attached to the shell of hermit crab The sea anemone grows on the back of providing camouflage and protection (the sea anemone has stinging cells) and, in turn, the sea anemone is transported for reaching new food sources. This type of mutualism is also called protocooperation.

Commensalism : It,is a relationship between two species-where one species is benefited, while the other neither gets any benefit, nor is adversely affected under normal conditions. Some organisms live inside the Dodies of larger animals in order to protect themselves from the enemies and adverse environment.

LIANAS

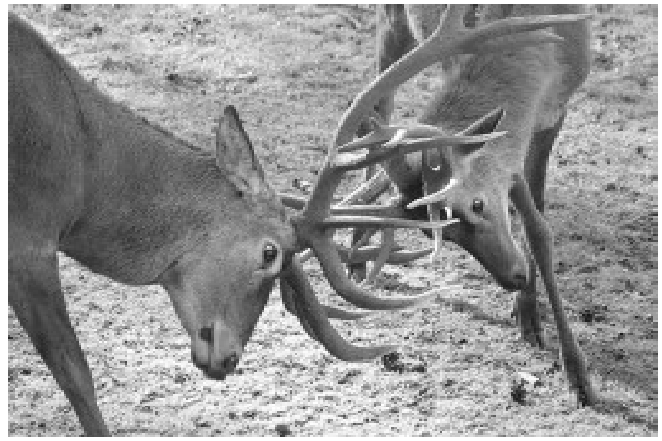
These are vascular plants rooted in the ground and maintain erectness of their stems by making use of other objects for support. Thus, with much economy of mechanical tissues they are able to get better light. Lianas are common in dense forests of moist tropical climates. They maintain no direct nutritional relationship with the trees upon which they grow. On the basis of the type of device used for climbing their supports, lianas may be leaners, thorn lianas, twiners or tendril lianas. Common lianas are species of Bauhinia, Ficus and Tinospora.

Commensalism can be illustrated with the example of sucker fish and shark. The sucker fish attaches to shark surface with the help of its dorsal fin, which is modified into a hold fast. The sucker fish is dispersed to ustant areas with better food supply. Besides, iie fish gets protection from predators due to ils association with shark. However, the shark does not get any benefit from sucker fish and it is also not affected adversely.

Epiphytes (e.g., mosses, ferns, orchids, money plant) growing on trees benefit from better light conditions, but generally, they do not harm the tree. Several woody climbers take the support of the trees for exposing their canopy aboveground without doing any harm to the tree itself. These relationships are also considered examples of commensalism. Interactions with Negative Effects Certain interactions between different species result in negative effect on either or both species. Parasitism and predation are interactions when one species gains and the other suffers. But, in the interaction involving competition, both species are harmed.

Competition: Interaction between two species, where both suffer adverse effects, is known as competition. Usually, competition occurs when resources, such as space, light and nutrients, etc. are in short supply. As a result of competition, the growth and seed production of both species is reduced.

Competition is basically of two types: (i) interspecific, and (ii) intraspecific.



Interspecific competition occurs between individuals of two different species occurring in a habitat. On the other hand, intraspecific competition occurs between individuals of the same species. Generally, the intraspecific competition is more intense than interspecific competition. The requirements of individuals of the same species are very similar; hence, they compete more fiercely.

Predation**:** Interaction between species involving killing and consumption of prey is called predation. The species which eats the other is called the predator, and the one consumed is termed the prey. Predation is commonly illustrated by the herbivore- carnivore interaction, grass-deer-tiger food chain. For example, tiger, the predator, keeps check on deer (prey) population. If the predator population increases, it consumes more prey, thereby reducing the population of prey. The reduction in prey population may reduce the populationn of predator, resulting from starvation and emigration. The reduction in predator population may lead to increase in prey population, since they are not preyed upon. The increased prey population may over-graze the grasses, and the shortage of herbage may eventually lead to reduction in prey population. It may ultimately affect population of predators. Thus, these relationships stabilise the prey and predator populations in a community.

Parasitism : In the interaction called parasitism, the species smaller in size (the parasite) lives in or on the larger species (host) from which it obtains food. Parasitism also involves shelter, in addition to food obtained by

a parasite. Plants like Cuscuta (dodder), Loranthus Viscum, (Mistletoe) and Rafjlesia are parasitic plants, which live on other flowering plants. Parasites may alter the population growth of hosts, shorten the life cycle, weaken the host, and drastically reduce the reproduction to the extent of causing sterility.

The parasites which remain outside the host are called ectoparasites, or external parasites (e.g., ticks, mites and lice). They generally attach to the skin and hair of the hosts. Some of them use suckers, clamps, adhesive surface, cutting, biting, sucking mouth parts, or root-like outgrowth for consuming host-tissues. Parasites like leeches, lice, ticks, mites, feed on the body fluids of the hosts. The hosts also develop defensive mechanisms to protect themselves from the parasites, as in the case of limbless hosts.

Parasites, like the predators, limit the population of the host species, but they are generally host-specific, and do not have choice or alternatives like predators. They are smaller in size and have higher biotic/reproductive potential compared to the predators. Parasites have poor means of dispersal and require specialised structures to reach or invade the host. Predators, on the other hand, are quite mobile and capable of capturing the prey. The newly acquired predators and parasites are often more damaging than the older ones, since the latter are familiar and the species getting affected have adjusted.

CARNIVOROUS PLANTS

A number of plants as *Nepenthes, Darlinstonia. Sarracenia, Drosera, Utricularia, Dionaea* consume msects~and other small animals for their food. They are also known as insectivorous plants. They are idapted in remarkable ways to attract, catch and digest their victims. Their leaves or foliar appendages produce proteolytic enzymes for digestion of the insects. The carnivorous habit in plants is said to be an incidental feature of their nutrition, since none of them is dependent—upon its animal prey for nitrogenous compound.

To a population ecologist predation is an important interspecific interaction which many determine the population growth. Laboratory studies have been made to derive Lotka-Volterra equations, though less informative. Behavioural aspects of predation as *functional response* have been studied. Such response is affected by *rate of encounter* and *handling time.*

ANTIBIOSIS

The term 'antibiosis' generally refers to the complete or partial inhibition or death of one organism by another through the production of some substance or environmental conditions as a result of metabolic 'pathways. Here none of them derives any benefit. These substances and/or conditions are harmful (antagonistic) to other organism. The phenomenon of antibiosis is much common among microbial world. Production of chemicals that are antagonistic to microbes —the antibiotics is well known. Bacteria, actinomycetes and fungi produce a number of antimicrobial substances which are widespread in nature. Burkholder (1952) reported that about 50% of the species of actinomycetes, and 50% of the lichens as well as large number of higher plants produce substances that inhibit molds and bacteria. Antagonistic substances are also reported in some algae, as for example in cultures of *Chlorella vulgaris,* some substance accumulates which inhibits the growth of the diatom, *Nitzschia frustirulum.* Substances produced by senescent cultures *of Chlorella* and of the diatoms, *Navicula,* and *Scendesmus,* inhibit the filter feeding of *Daphnia* in laboratory. Pond 'blooms' of blue-green algae especially *Microcystis* are known to produce toxins such as hydroxylamine which causes death of fish and cattle. In marine waters, populations of some microbes, popularly known as red tide, cause catastrophic destruction of fish and other animals. There has been accumulating day by day much information on the subject, detailed account of which is beyond the scope of present discussion, for which the reader is referred to books on microbiology and medicine.

EPIPHYTES AND EPIZOANS

Epiphytes are plants growing perched on other plants. They use other plants only as support and not for water or food supply. They differ from lianas in that they are not rooted into the soil. Epiphytes may grow on trees, shrubs, Or larger submerged plants. They grow either on the trunks or leaves. Epiphytes are most common in tropical rain forests. Many orchids, bromeliads, hanging 'mosses', *Usrxea* and *Alectoria* are well known epiphytes. Some of them show intermediate gradations between epiphytes and parasites, as well as between epiphytes and lianas. For example, a fern *Nephrolepis,* in the beginning remains rooted in the soil, later on spreading its rhizome over tree trunk, sooner or later becoming completely separated from the soil, thus becoming an epiphyte. In *Tsuga heterophylla,* seeds germinate on tree surfaces, where their seedlings in the beginning live as epiphytes till they develop their own roots, by which ultimately maintain relation with soil and thus become independent. In epiphytes, there is a special layer - velamen over the root surface. The cells, of the velamen are whitish which can take up abundant water rapidly from the atmosphere.

ECOLOGICAL ADAPTATIONS

The special characteristics of plants and animals that enable them to be successful under prevailing set of environmental conditions, are called adaptations. The organisms in natural world exhibit various types of morphological, physiological and behavioural adaptations. These special features have evolved over a long period of time, through the process of natural selection. The ultimate aim is to seek food and space the organisms need for their survival. The adaptive traits provide mechanism for many organisms to live and thrive in different types of ecosystems and habitats.

Phenotypic Plasticity and Ecotypes

The phenotype is the physical expression of the interaction between genotype of an organism and its environment. The phenotypes show variations due to differences in the environmental conditions within the local habitat. Such variation among individuals, produced by the influence of the local conditions of the habitat, is known as phenotypic plasticity. Usually, species having a wide range of distribution evolve genetically adapted local populations, called ecotypes. Ecotypes differ from each other on the basis of morphological and physiological characters. Although ecotypes of a species differ genetically, they are interfertile.

Strategies of Adaptations in Animals

Like plants, animals also adjust to different environmental conditions to survive and flourish. Carnivores and herbivores have adaptations to eat a certain kind of food. Some animals have adaptations to avoid being eaten by the predators; others have behavioral adaptations to attract a mate. The males of some animals (particularly the plumage of the birds) have bright colouration, which gives advantage in sexual selection and mate attraction. However, a majority of animal adaptations to environmental variations and stress conditions are physiological and behavioural.

Mimicry : Two species resemble each other closely, one species, called the mimic, is palatable to its predators, but resembles another species, called the model, which is distasteful to the predator. In *Batssian mimicry,* the mimic

is defenseless, but has anti-predatory marks, like the model which has a defense against predators; hence, the mimic is able to protect itself from the attack of the predator. Similarly, the monarch butterfly (containing poison, toxic to predator) is mimicked by the viceroy butterfly (containing no poison). *Mullerian mimicry i*s the process when the mimic shares the same defensive mechanism as the model.

Migration: Migration involves long-distance or short distance movement ci animals from one region to anotlier. Many organisms that fly or swim, undertake extensive migrations. Activities . of migration exhibited by some animals are given in Table 16.1. Arctic terns are sea birds that make a round trip of thousands of miles between their North Atlantic and the Arctic breeding grounds to the Antarctica every year. In Africa, wild beasts migrate long distances, following a geographical pattern of seasonal rainfall and availability of fresh vegetation. Locust migrates in search of new feeding grounds from the food depleted areas, in large numbers in the arid regions.

Hibernation and aestivation : In very cold or dry environments, animals incapable of migration shift to a physiological dormant — state. Spending winter in dormant condition is called hibernation. On the other hand, spending the dry-hot period in ah inactive state is known as aestivation.

Warning colouration : Concealing form and colouration enables a species to avoid its natural predator. The brightly coloured and highly poisonous dart frogi *(Phyllobates bicolour, Dendrobates pumilio)* of the tropical rain forests of South America are easily recognised and avoided by the predators.

Camouflage : In some animals, the capacity to blend with surroundings or camouflage is a common adaptation. Some insects, reptiles and mammals have markings on their bodies, which make it difficult to distinguish them from shadows and branches, or from other members of the group.

Adaptations to water scarcity: Two types of adaptations are prominent in animals living in arid regions, viz. lowering of water loss as much as possible, and adapting to arid conditions. For example, the kangaroo rat conserves water by excreting solid urine, and can live from birth to death without even drinking water. The camels show unique adjustments to desert conditions, being very economical in water use, tolerant to wide fluctuations in body temperature, and are able to maintain blood stream moisture even during extreme heat stress.

Adaptations to cold: Sessile animals, such as barnacles and molluscs, living in very cold inter-tidal zones of northern shores, and several insects and spiders resist the effect of cold spells by a process known as cold hardening. The freeze tolerant organisms have ice nucleating proteins, which induce ice formation in the extracellular spaces at veiy low sub zero temperatures. Some freeze-avoiding animals can tolerate environmental temperatures below 0°C by accumulating glycerol or antifreeze proteins that lower freezing point of their body fluids. Presence of such antifreeze compounds allows the fish in Antarctica region to remain active in sea water.

Strategies of Adaptations in Plants

Plants have special traits that help them to enhance their tolerance limits to light regimes, dry conditions, high temperature, water-saturated conditions and saline environments. In plants, flowers have evolved special structures to ensure pollination by insects or other animals. Plants have developed various mechanisms to deal with stress conditions of the environment.

Adaptations in saline environments: Halophytes are plants of saline environments, which are adapted to grow in high concentration of salt in soil or water. Halophytes occur in tidal marshes and coastal dunes, mangroves and saline soils. The halophytic plants, under hot and dry conditions, may become succulent and dilute the ion concentration of salts with water they store in cells of stems and leaves.

Mangroves are found in marshy conditions of tropical deltas and along ocean edges. Some species of mangroves can excrete salts through the salt glands on the leaves. Some mangroves can exclude salts from the roots by pumping excess salts back into soil. For coping with conditions of high salt concentration and osmotic potential, many mangrove plants have high levels of organic solutes, such as proline, and sorbitol. *Dunaliella* species (green and halophytic algae found in hyper saline lakes) can tolerate saline conditions by accumulating glycerol in the cells, which helps in osmoregulation.

Avicennia and *Rhizophora* (red mangrove) are dominant species in mangrove forests. Since halophytes are exposed to saline and anaerobic conditions in wetlands, they have developed special adaptations, like pneumatophores, prop and stilt roots, and vivipary (seeds germinate while on the tree), etc. The presence of pneumatophores (the respiratory roots) helps to take up oxygen from the atmosphere and transport it to the main roots. Prop and stilt roots, in many species of mangroves, give support to the plants in wet substratum. Vivipary permits plants to escape the effect of salinity on seed germination.

Adaptations to light regime : Individual plants, as well as plant communities, adapt to different light intensities by becoming shade tolerant (sciophytes) or sun adapted (heliophytes). Heliophytes are adapted to high intensity of light, and have higher temperature optima for photosynthesis, as well as have high rates of respiration. The shade adapted plants generally have low photosynthetic, respiratory, and metabolic activities. Plants such as ferns and several herbaceous plants growing on the ground under the dense canopy of trees, are shade tolerant plants.

Adaptations in aquatic environments: Plants which remain permanently immersed m water are called *hydrophytes.* They may by submerged, or partly submerged and show the presence of aerenchyma (large air spaces) in the leaves and petioles. *Aerenchyma* helps to transport oxygen produced during photosynthesis and permits its free diffusion to other parts. These tissues also impart buoyancy to the plants. Presence of inflated petioles in *Eichhornia* (water hyacinth) keeps the plants floating on the surface of water. Roots are poorly developed or absent in free floating hydrophytes like *WolJJia*, *Salvinia, Ceratophyllum* and *Hydrilla. Nymphaea* is an example of an emergent and rooted hydrophyte, which is seen growing in a pond. This plant, as well as other emergent hydrophytes (having leaves projecting above water surface), have a continuous system of air passages, which help the submerged plant organs to exchange gases from the atmosphere through the stomata in the emergent organs.

Adaptations to water scarcity and heat: Plants of hot deserts are adapted to survive in dry conditions of soil and high temperatures. The plants which have a short life span are known as ephemerals. For example, in desert areas of Rajasthan, many annual plants germinate from seeds, complete their life cycle quickly during the rainy season. Some plants have deep tap roots, which can reach even up to water table, in arid climates, and therefore, are capable of absorbing water from deep soil. Some prominent examples of plants having deep root systems are *Prosopis* (mesquite), palms and some species of *Acacia.*

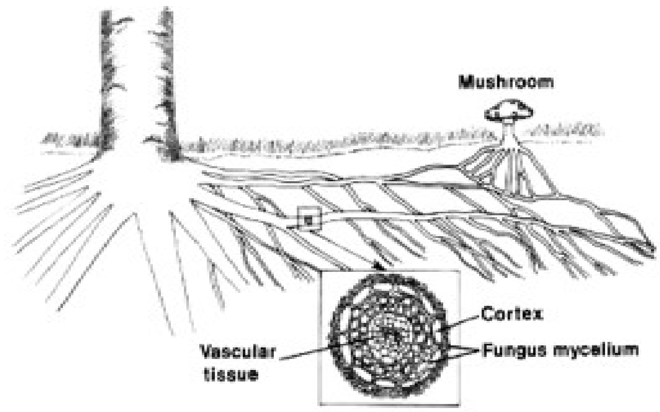
In xerophytes, small leaves, sunken-stomata, leathery leaf surfaces and waxy cuticle help in reducing transpiration.

As in the case of cacti and succulents, the presence of fleshy leaves and stems to store water *(succulence)* is an adaptation to dry environments. In cacti, leaves are reduced to spines, whereas stems are modified into fleshy

and spongy structures. Some cacti have expandable stems for storing water, and have spreading root systems in the surface layer of the soil.

Many tropical plants, particularly grasses which grow in hot and arid climates, possess C_4 pathway of photosynthesis. Such plants, therefore, use less water to achieve higher rates of photosynthesis, particularly at higher temperatures. Many desert plants, such as cacti and succulents, close their stomata during the day and open them in the night to reduce transpiration. Many xerophytes may accumulate proline (an amino acid) in response to stress. The heat shock proteins chaperonins) provide physiological adaptations to plants to high temperatures. These proteins help other proteins to maintain their structure and avoid denaturisation at high temperatures.

Adaptations to oligotrophicsoils : The oligotrophic soils contain low amounts of nutrients. These soils generally develop in old and geologically stable areas, such as soils found in much of the tropical rain forest region. Due to intense weathering and high rates of leaching, these soils have a poor nutrient retention capacity. In nutrient-poor soils,



nutrient accumulation in vegetation is high. Many plants growing in nutrient-poor soils possess **mycorrhizae** which have mutualistic association of roots with fungi. Mycorrhizae help in efficient absorption of nutrients (e.g., phosphorus). Mycorrhizae are of two types, **endomycorrhizae** and **ectomycorrhizae**. In endomycorrhizae, the fungal hyphae dwell inside roots. These types of mycorrhizae are found in many vascular I plants. In ectomycorrhizae, the fungal mycelium forms a mat outside the root. Ectomycorrhizae occur in several tree and shrub species in temperate regions.