**Adaptations in plants**

Like animals plants also show various adaptations. They adapt to different environmental conditions. This is the reason why plants growing in different environmental conditions are of different types. Based on ecological adaptations plants have been classified into four groups:

**hydrophytes**

Hydro means water;phyte means plants.Hydrophytes are plants which are found at places where there is abundance of water. These plants are either completely submerged in water or their some parts such as root, rhizome etc., are present in water. Botanist are of the view that hydrophytes have evolved from mesophytes. Hydrophytes based upon their relationship with air and water have been classified into the following groups:

**Free floating hydrophytes**These plants are in contact with air and water but not soil. Leaves of these plants are very small or very large for example *Lemna, Azolla, Wolffia, Eichhornea*etc.

**Fixed floating hydrophytes**The roots of these plants are embedded in mud whereas leaves due to the long petiole float on the surface of water. Except leaves all other parts of the plant are submerged in water for example *Trapa, Nelumbo, Nymphaea*etc.

**Submerged floating hydrophytes**These plants float in water but remain submerged. Their roots are free and are not embedded in mud. They have small leaves and slender stem example *Najas, Ceratophyllum, Utricularia.*

**Submerged hydrophytes**These plants are completely submerged in water but their roots are embedded in mud. Example *Vallisneria,Hydrilla* etc.

**Rooted emergent hydrophytes**These plants are found in Shallow water. Some part of the plant especially the roots and a portion of the stem remain in mud whereas remaining part of the stem and leaves remain outside water. These are called amphibious plants. Example *Saggitaria, Typha, Ranunculus etc.*

**Factors of aquatic environment which affect plants**

These are as follows:

1. Temperature effect.
2. Oxygen and Carbon dioxide gas dissolved in water.
3. Light
4. Osmotic concentration of water.
5. Salinity
6. Toxicity of water

**Hydrophytic adaptations**Adaptations found in aquatic plants have been classified into the following three categories:

Morphological adaptations

Anatomical adaptations

Physiological adaptations

**Morphological adaptations**

Aquatic plants show the following morphological adaptations:

**Root**

1. Roots of these plants are found surrounded by water.
2. Roots are either less developed or absent.
3. Water is absorbed by these plants by their general body surface.
4. In *Salvinia,*one leaf modifies into root like structure.
5. In place of root cap, root pockets are found.
6. Root hairs are usually absent.

**Stem**

Aquatic plants have tender, thin, long, spongy and flexible stem.In plants in which floating leaves are present such as *Nymphaea* and *Nelumbo*stem forms rhizome.

**Leaves**

1. Leaves in aquatic plants are usually long,ribbon like, thin and slimy.
2. Surface floating plants have peltate leaves.
3. In submerged hydrophytes, the leaves are thin, thread like or they are highly dissected as in*Ceratophyllum*.
4. In*Vallisneria* the leaves are long, thin and ribbon like.
5. In *Nymphaea*and*Nelumbo,* the leaves are large, simple, well developed and have a coating of wax like substance on their surface.
6. In *Eichhornia* and *Trapa* leaves are in a bunch and have swollen petioles.

**Pollination**

1. In most of the aquatic plants, pollination, dispersal of fruit and seeds takes place through water.
2. In *Vallisneria* instead of pollen grains the entire male flower is released and it floats on the surface of the water and comes in contact with the female flower.

**Reproduction**

Reproduction in most of the aquatic plants mainly occurs by vegetative means.

**Anatomical adaptations**

Aquatic plant show the following anatomical adaptations:

1. Cuticle is usually absent or present in the form of a thin layer.
2. Epidermis is thin walled and single layered.Its nature in aquatic plant is not protective.It rather functions as an absorbent layer which helps in absorption of water, gases and Minerals.
3. Hypodermis is less developed or absent.
4. Stomata are absent or rudimentary in leaves.
5. In surface floating leaves stomata are present only on the upper surface.
6. Air chambers are well developed in these plants.
7. Most of the part of the cortex is filled with aerenchyma, which helps in buoyancy.Aerenchymais well developed in aquatic plants and this tissue is present in leaf, stem and roots.
8. In all the aquatic plants mechanical tissues are usually absent. Instead of this tissue aerenchyma is present in all parts.
9. As in aquatic plants, water and minerals are absorbed through entire body surface therefore vascular tissues are not required. Out of xylem and phloem, xylem is least developed.In xylem, vessels are absent. In phloem, sieve tubes are small.
10. Secondary growth is absent in aquatic plants.In submerged hydrophytes mesophyll tissue is not differentiated.

**Physiological adaptations**

1. In submerged hydrophytes, transpiration is absent.
2. These plants are adapted to perform photosynthesis in low light intensity.

**Mesophytes**

Majority of the plants found on earth belong to this category. These plants are found under normal conditions of temperature, moisture in soil.Mesophytes grow in mesic habitat and develop into forest or grassland community.Under favourable conditions and adequate water availability tropical evergreen rainforest develop.Mesophytic plants have the following morphological and anatomical characters:

1. **Root** system is well developed.The roots are branched, have abundant root hairs and root cap is present at the tip.
2. **Stem** is aerial, thick, erect and branched.
3. **Leaves** are broad, thin or thick and are dark green in colour having different shapes.
4. Aerenchyma is absent in the leaves and are devoid of hairs and waxy coating.
5. Cuticle is present as the outermost layer on the upper surface of leaves.
6. Stomata are usually present on both the surfaces of leaves.
7. Mesophyll is well developed and differentiated into palisade and spongy.
8. Vascular and mechanical tissues are well developed all the physiological processes occur normally in these plants.

**Xerophytes**

Plants found in dry habitats are called xerophytes. Most of these plants face great deficiency of water. The plants can remain alive under prolonged dry conditions. They are well adapted to water deficiency.Even where adequate rainfall occurs such as hillslopes, water is not available to the plants.

The adaptations found in xerophytic plants are as follows:

**Morphological adaptations**

**Root**

1. To obtain water, these plants have extensively developed root system.
2. In these plants, roots are well developed and spread all around.
3. Mostly taproot, penetrating deep in the soil with a network of branches are present.
4. Many annual and small herbaceous xerophytes have surfaced feeding roots. Example of deep rooted xerophytes are *Acacia, Tamarix, Prosopisalhagi.*
5. The growth rate of root is high, sometimes reaching upto 10 to 50 cm/day. Root hairs and root caps are well developed.
6. Due to excessive root growth root and shoot ratio comes between 3 and 10.

**Stem**

1. Stem is mostly short, dry and woody with thick back.
2. Stem may be aerial or underground.
3. In some plants, numerous closely arrange branches are present for example *Citrulluscolocynthis.*
4. Abundant multicellular hairs present on the stem.
5. In some plants stems have spines for example *Euphorbia splendens, Duranta* etc.
6. In many plants due to reduction in leaf size or due to their early fall photosynthetic rate is reduced. To compensate for this, these plants have flat and green photosynthetic fleshy stem. This type of modification is called **phylloclade** example *Opuntia,Ruscus* etc.
7. In *Asparagus* the internodes become flattened and leaf like and the modification is called cladode.

**Leaves**

Leaves in xerophytic plants have the following characteristics:

1. Many xerophytic plants have caducous leaves, i.e., they fall off very early for example *Capparis*.
2. In some plants, the leaf become spinelike or modify into scale, for example *Opuntia, Ruscus,Asparagus.*
3. Leaves are usually smaller in size.
4. Larger leaves have glossy surface which helps in reflecting sunlight.
5. *Pinus* has needle like leaves.
6. Leaves have coating of wax and silica.
7. Tannins and gums may be present.
8. Multicellular hairs cover the leaf surface in many plants.
9. Leaf blade is smaller in size for example *Acacia, Prosopis.*
10. In *Parkinsoniaaculeate,* the leaflets are very small, with thick and flattened rachis.
11. In Acacia melanoxylon in order to avoid excessive water loss through transpiration, the bipinnate compound leaves fall off early. The petiole in these plants becomes flattened and green and perform photosynthesis.This type of modification is called **phyllode**.
12. The leaves are thick, fleshy and leather like in many plants.
13. In some plants,stipules modify into spines for example *Acacia nilotica,Prosopis* etc.
14. In *Poa*and *Ammophila*leaves show rolling movement. The upper epidermis of leaves contains certain specialised cells called the motor cells or bulliform cells. During dry period, exosmosis occurs in the cells leading to rolling of leaves. When adequate moisture is present the motor cells absorb water through endosmosis become turgid and leaves and unroll.

**Flower fruit and seed**

1. In xerophytes, flowering and fruiting occurs only during favourable season.
2. The fruits and seeds are protected by thick hard covering.

**Anatomical adaptations**

The main aim of xerophytes is to reduce water use.The anatomical adaptations in this regard as are as follows:

**Roots**

1. Roots are well developed and vascular tissues are in abundance.
2. Thick deposit of lignin and cuticle on the epidermis.
3. In some plants wax and silica are also deposited.
4. Multilayered epidermis is found in *Nerium.*
5. The epidermal cells are small and closely attached with each other.The glossy layer of cuticle will reflect the incoming solar radiation.
6. In some plants, the outline of thestem has ridges and furrows for example *Casuarina*. In this plant the stomata are present in furrows and they are of sunken type.
7. Bulliform cells are present in *Poa* and*Ammophilla* which help in rolling and unrolling of leaves.
8. Hypodermis is well developed and is composed of mechanical tissues.
9. Cortex is made up of parenchyma in which intercellular spaces are absent. Raisin and latex canals are present in the cortex example *Pinus, Calotropis.*
10. Plants which have small scaly leaves show caducous behaviour i.e. the leaves fall off in early stage.
11. In plants like *Casuarina* and *Calotropis* etc., the cortex of stem has palisade layer. This layer helps in photosynthesis.
12. Cells in these plants are a smaller with very less intercellular spaces. Mechanical tissues are in abundance. Besides,sclerenchyma, different types of sclereidsuch as brachysclereids,macrosclereids and osteosclereids are present.
13. The mesophyll tissue in leaves is differentiated into palisade and spongy parenchyma. Among these palisade tissue is more than a spongy tissue. In*Nerium*, spongy tissue is present between two layers of palisade parenchyma. In*Pinus,* the mesophyll cells have infoldings in order to increase the photosynthetic area.
14. In endodermis, the cells contain starch grains.This layer is also called Starch sheath. The cells also have casparian strips made up of suberin.
15. Vascular tissues are well developed.Xylem is more as compared to phloem.Vascular bundles are more in number. The xylem has broader and longer vessels with the coating of oflignin under cell wall.In phloem, the bast fibres are more in number.
16. Due to secondary growth, cork, bark and annual rings are present.

**Physiological adaptations**

Xerophytic plants develop tolerance and resistance against dry environmental conditions. They can successfully live under dry conditions by reducing the rate of transpiration. Xerophytes show the following ecological adaptations:

1. Stomata are found in cavities that is sunken stomata are found.
2. Stomatal frequency in these plants is less than mesophytes.
3. Most of these plants have higher rate of transpiration but the total water loss is less.
4. These plants can photosynthesize under low moisture conditions but the photosynthetic rate per unit area is high.
5. The sugar-starch ratio is less in these plants.
6. In succulent xerophytes, due to presence of several acids, polysaccharides and other compounds resistance against draught develops.
7. In succulents,stomata open during night and remain closed during day time’
8. The diffusion pressure (DP) of cell sap is high in these plants.
9. As compared to mesophytes, xerophytes have more catalases and peroxidases. The starch hydrolyzing enzyme amylase also shows increased activity in succulents.

**Halophytes**

Halophytes are plants which grow in saline soil containing high concentration of magnesium chloride, magnesium sulphate and sodium chloride.Most of these plants are found around salt lakes and coastal areas. These plants grow in waterlogged soil in coastal areas. Due to high salt concentration these plants experience physiological dryness. Thus halophytes are those plants which are found in physically wet but functionally dry areas. Plants found near salt lake in desert areas are usually succulent halophytes such as *Suaedafruticosa*,*Haloxylonsalicorneum*etc.

The prominent salt lakes of Rajasthan desert are sambhar,Panchbhadra and Didwana. Plants growing in marshy waterlogged saline coastal areas are called Mangrove vegetation. This vegetation mainly includes *Rhizophoramucronata*and *Bruguieragymnorhiza*. In India Mangrove vegetation is mainly found in marshlands of Hooghly river near Kolkata,Sundarban(Bay of Bengal) the shores of river Gomti and Godavari near Elephanta Caves, Andaman and Nicobar Islands etc.

**Adaptations**

Halophytes show the following adaptations:

1. Plants are small size trees, shrubs and herbs.
2. Trees and shrubs show cymose branching and are dome shaped.
3. Roots are less deep.
4. Prop or stilt roots provide mechanical support to plants.
5. Knob like, above ground, pneumatophores are found which help in respiration.
6. Buttress roots are adventitous in nature and provide mechanical support to plant.
7. The stems are short and fleshy.
8. Leaves are thick, fleshy, small sized, Shiny and leathery.
9. Fruits and seeds are light in weight.
10. Viviparous seed germination is found.
11. Air chambers present in roots and stems.
12. Cortex is composed of aerenchyma. Some cells of cortex contain crystals of calcium oxalate.
13. Epidermal cells have thick cell walls.Thick cuticle lies above the epidermis.
14. Sunken stomata are present on the lower epidermis.
15. Many cells of cortex contains tannin and oil.