Adaptive anatomical features of Hydrophytes, Xerophytes

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Hydrophytes

Plants that grow in water or very wet places are known as hydrophytes. They can be submerged or partly submerged, floating or amphibious. Their structural adaptations are chiefly due to the high water content and the deficient supply of oxygen.

<u>The various adaptations are as follows:</u>

(i) The reduction of protective tissue (epidermis here is meant for absorption and not for protection).

(ii) The reduction of **supporting or mechanical tissue** (i.e., absence of sclerenchyma).

(iii) The reduction of **conducting tissue** (i.e., minimum evolution of vascular tissue).

(iv) The reduction of **absorbing tissue** (roots chiefly act as anchors, and root hairs are lacking).

(v) There is special evolution of **air-chambers** (aerenchyma) for aeration of internal tissues.

Epidermis:

In aquatic plants, the epidermis is not protective but absorbs gases and nutrients directly from the water. The epidermis in typical hydrophyte has an extremely thin **cuticle,** and the thin cellulose walls permit ready absorption from the surrounding water. Generally the **chloroplasts are found in epidermal cells** of leaves, especially when the leaves are very thin; these chloroplasts utilize the weak light **under water for photosynthesis**.

In submerged plants, **stomata are not present**, and exchange of **gases takes place directly by the cell walls.** The floating leaves of aquatic plants have **abundant stomata on the upper surface**.

Lack of Sclerenchyma:

Submerged plants generally have **few or no sclerenchymatous** tissues and cells. The water itself gives support to the plant, and protects it to some extent from injury. The **thick walls of tissues**, their density and the **presence of collenchyma** in certain plants **give some rigidity**. The strands of sclerenchyma occasionally exist, especially along the leaf margins, and increases tensile strength. A **few star-shaped idioblasts or sclereids** are present, which give **mechanical support** to the body of aquatic plant.

Minimum Development of Vascular Tissue:

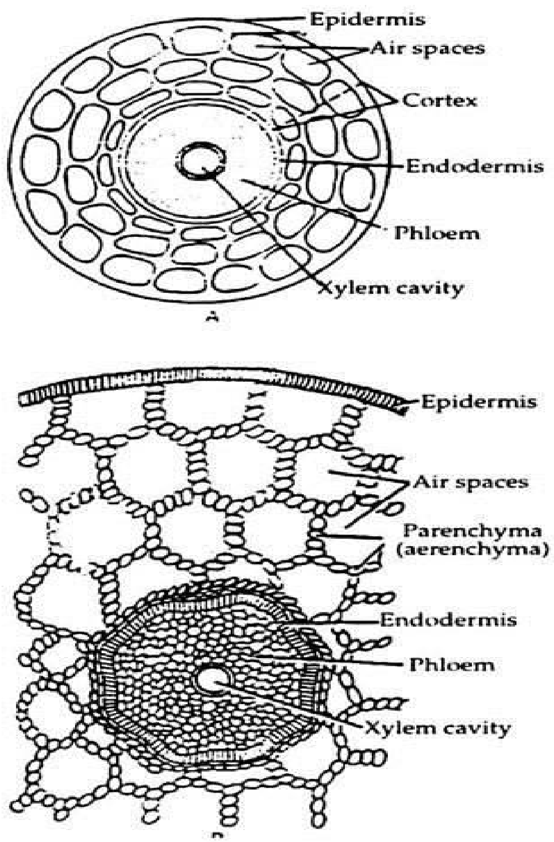
In the vascular tissues, the **xylem visibles greatest reduction** and in many aquatic plants consists of only a few **elements, even in the stele and main vascular bundles**. In certain aquatic plants in the stele and large bundles, and frequently in the **small bundles, xylem elements are lacking**.

In these plants, there is well evolved **xylem lacuna** in the position of xylem. These lacunae resemble typical **air-chambers** (air-spaces). In several aquatic plants, the **phloem is fairly well developed as compared with the xylem**. The endodermis is generally present around the stele, but it is weakly developed.

Reduction of Absorbing Tissue:

The root-system in hydrophytes is feebly evolved and **root hairs and root cap are absent**. In some floating plants such as ***Utricularia, Ceratophyllum,*** etc.**, no roots are evolved,** and in submerged plants such as ***Vallisneria, Hydrilla,*** etc., water dissolved mineral salts and gases are absorbed by **their whole surface.**

In plants like ***Pistia, Eichhorma,*** etc., **no root cap evolves,** but **root pocket is formed** instead. An aquatic plant is, in reality, submerged in or floating up on a **nutrient solution**. In hydrophytes the root system is **functioning mainly as holdfasts or anchors**, and a large apart of the **absorption takes place through the leaves and stems.**



. Anatomy of hydrophytic stem of *Hydrilla* (submerged monocot—T.S. of stem). A, diagrammatic; B, details of a sector and central stele.

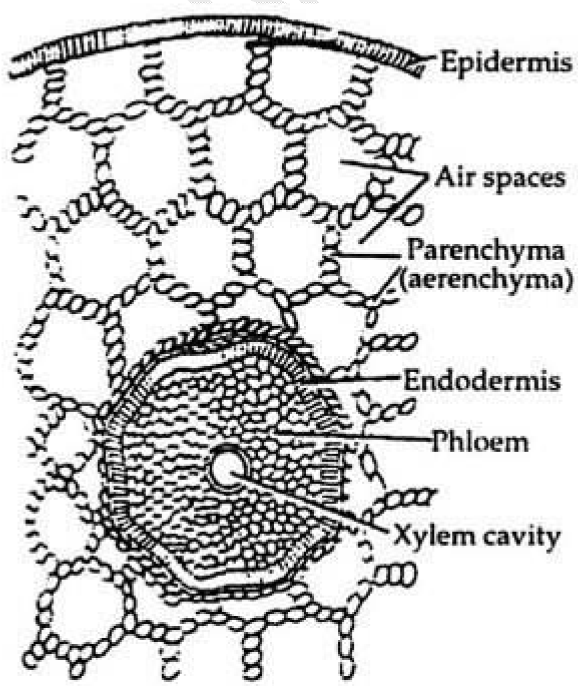
Development of Air-Chambers:

Chambers and passages filled with gases are usually found in the leaves and stems of hydrophytes. **The air-chambers are large, generally regular, intercellular spaces extending** through the leaf and often for long distances through the stem (e.g., ***Potamogeton, Pontederia***).

The spaces are generally **separated by partitions of photosynthetic tissue** only one or two cells thick. The chambers prepare **and internal atmosphere** for the plant. These **air-chambers on the one hand give buoyancy** to the plant for the floating and on the other they serve to **store up air** (**oxygen and carbon dioxide**).

The **carbon dioxide that is given off in respiration** is stored in these **cavities for photosynthesis**, and again the **oxygen it is given off in photosynthesis** during the daytime is similarly stored in them for respiration. **The cross partitions of air passages, called diaphragms prevent flooding.**

The **diaphragms are provided** with minute perforations through which gases but not water can pass. Another specialized tissue frequently found in aquatic plants that **gives buoyancy to the plant part on which it occurs is aerenchyma**. Here, very thin partitions **enclose air spaces** and the entire structure consists of very **feeble tissue. Aerenchyma in phellem** is formed by a typical phellogen of epidermal or cortical origin. At regular intervals individual cells of each layer of phellem elongate greatly in the radial direction which the other cells of such layer remain small. However, the **term aerenchyma** is applied to any tissue with several large intercellular spaces.



. Anatomy of hydrophytic stem. T.S. of a sector of the stem of *Potamogeton* (Monocot.)—detail.

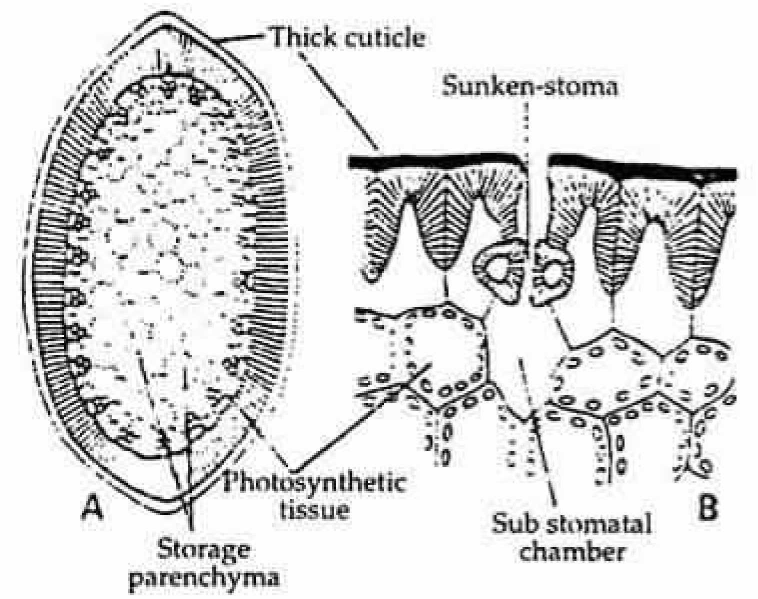
Xerophytes

Xerophytes grow in **deserts** or in **very dry places**; they may **withstand a prolonged period of drought** uninjured, for this purpose they have certain peculiar adaptations. The xerophytic plants have to guard **against excessive evaporation of water**; this they do by **reducing evaporating surface**. Plants form a long **tap root which goes deep into the sub-soil** in search of moisture. To retain the water absorbed by the roots; the **leaves and stems** of certain plants become very **thick and fleshy** (viz., ***Aloe, Agave***). Water tissue develops in them for storing up water; this is further facilitated by **the abundance of mucilage** contained in them. **Multiple epidermis** sometimes evolves in the leaf (viz., ***Nerium***). Modification of the stem into **the phylloclade for storing water and food** and at the same time performing functions of leaves is characteristic of many desert plants (viz. ***Opuntia*** and other **cacti**).

In xerophytes certain structural features are also common. **Leaves are thick** and **leathery**, well evolved cuticle and abundant hairs. **Well differentiated mesophyll is also present**, and there is often **more than one layer of palisade tissue** (viz. ***Nerium***).

The **walls of epidermal** and sub-epidermal cells are frequently **lignified,** and distinct hypodermis may be present. They have a **well-developed vascular system** and often an **abundance of sclerenchyma,** either in the form of sclereids of fibres (***Ammophila***). The leaf is sometimes cylindrical or rolled.

This organization is to **protect the stomata**, which can show **peripheral photosynthetic tissue** and **central water storage issue** (diagrammatic); a portion (detailed) showing **thick cuticle**, thickenings on the radial and outer walls of the epidermal cells and **sunken stomata** exist in furrows. Some **fleshy leaves** (viz., Sedum), contain abundant thin-walled cells, the water storage tissue.



Anatomy of xerophytic leaf—Aloe (monocot). A, T.S., showing peripheral photosynthetic tissue and central water storage tissue (diagrammatic); B, a portion (detailed) showing thick cuticle, thickenings on the radial and outer walls of the epidermal cells and sunken stomata.

The characteristic anatomical features of the xerophytes are as follows:

i. Epidermis and Thick Cuticle:

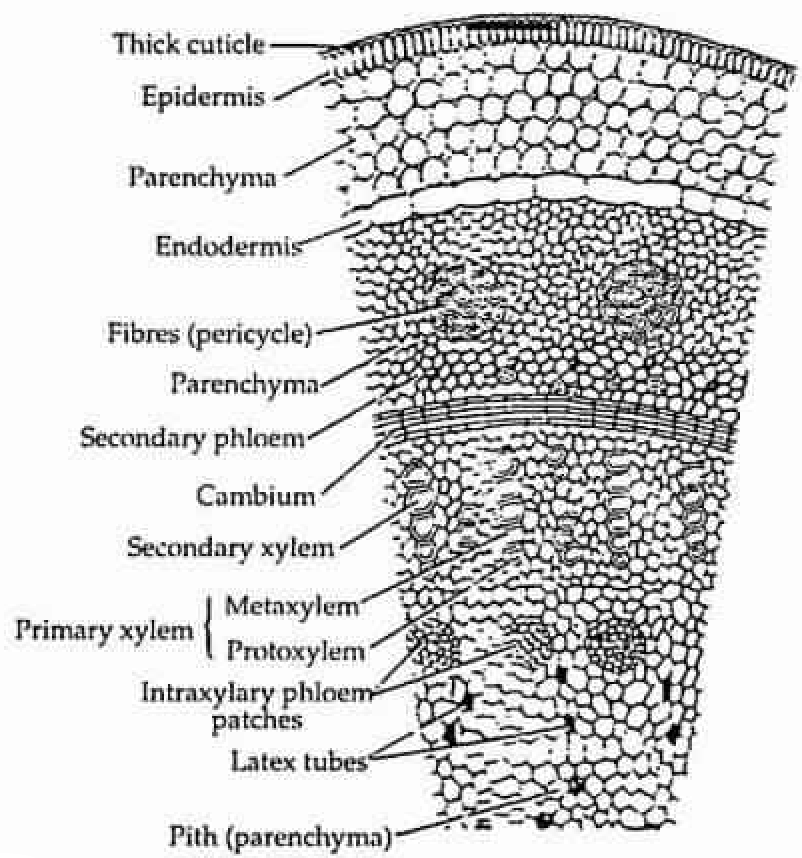
Heavy **cuticularization** and extreme **cutinization of the epidermis** and even of sub-epidermal cells are common in xerophytes. The thickness of the cuticle shows different gradations. In certain cases the thickness of cuticle is only slightly greater than normal, like that of plants of semi-xerophytic habitats. In extreme xerophytes the **cuticle may be as thick as, thicker than**, the diameter of the epidermal cell.

In addition to the presence of thick cuticle, the walls of **epiderml cells become cutinized** and sometimes also those of underlying cell. Along with well-evolved cutinized layers the epidermal and subepidermal cells also become **lignified.** In some cases the **covering of wax** is formed on the epidermis (viz., ***Calotropis***). The epidermal cells are usually **radially elongated.** In the leaves of ***Nerium*** and ***Ficus,*** the epidermis becomes **multilayered.**

In many xerophytes in addition to a cutinized epidermis, single to multi-layered hypodermis is also present. In most plants, the hypodermis of leaves is morphologically mesophyll and can be in the form of a sheet of fibrous tissue or a layer of sclereids. The hypodermis of the stems seems to be a part of the cortex. The hypodermis of stems and leaves can be cutinized to lignified. In many plants, the **mucilage, gums and tanning** are commonly found in hypodermis.

Hairs:

In several xerophytic plants, especially those of alpine regions exposed to strong winds, a covering of matted **epidermal hairs on the underside** of the leaves **prevent water loss**. Hairs can also be abundant over the entire aerial part of the plant. The **thick matting of hairs also prevents rapid evaporation through stomata**. The xerophytes that contain abundant hairs, on their leaves and stems, are commonly called **trichophyllous.**

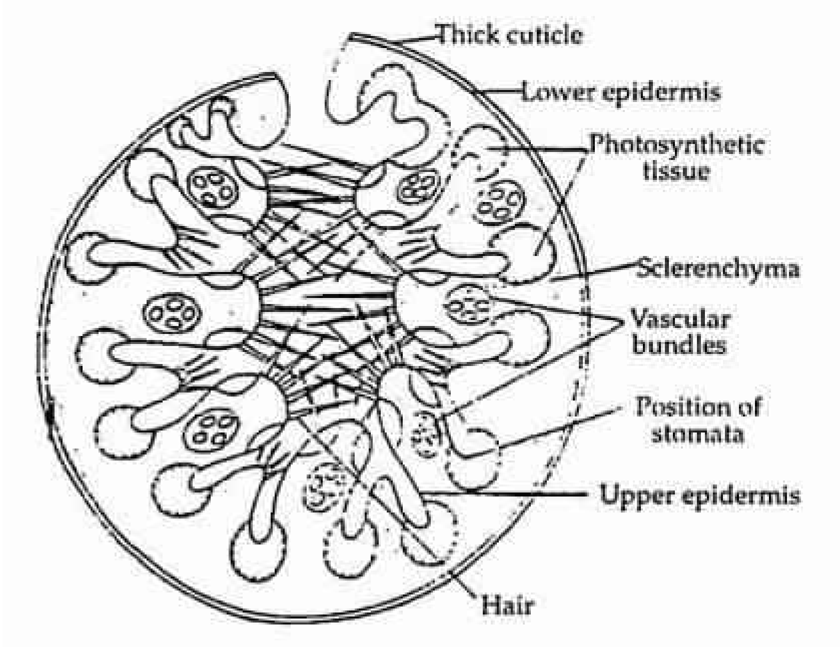


Anatomy of xerophytic stem T.S. of a sector of *Calotropis* stem (dicot.)—detailed structure.

ii. Structure of Stomata:

The stomata are very minute opening produced in the epidermal layer in green aerial parts of the plants. The stomata are essential for intake of carbon dioxide and oxygen and or the passage inward and outward of other gases. The evaporation of the surplus water takes place by the stomata. When the stomata are open, water escapes even when **water loss is harmful to the plant**.

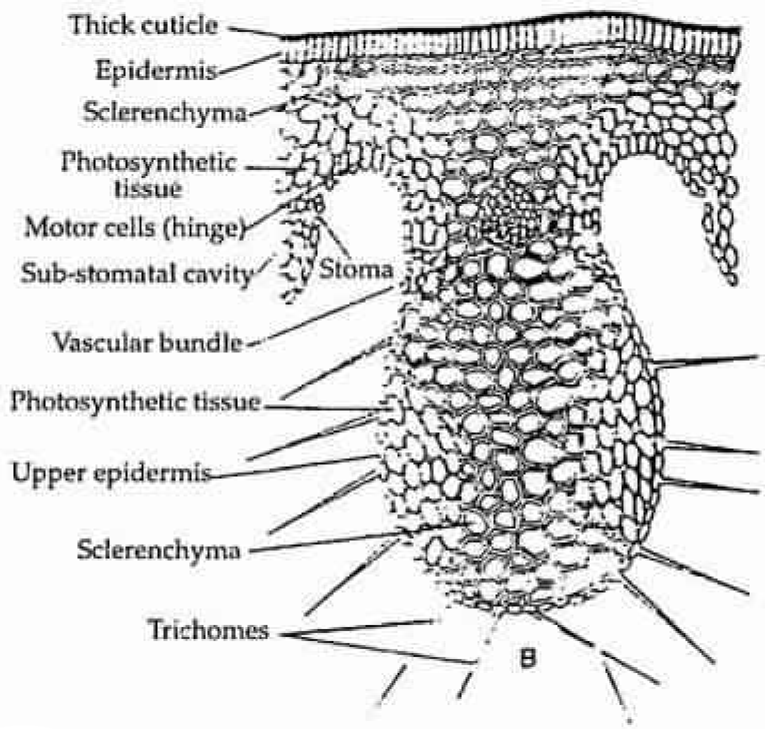
This way, **the reduction of transpiration** is of great importance in xerophytes. The **xerophytes can contain less stomata,** either by reduction of leaf surface or of stomatal number per unit area. To **reduce excessive transpiration** usually the stomata that remain sunken in pits are formed. Such stomata are commonly called **sunken stomata** (e.g. ***Agave*, *Nerium*** etc.). In certain cases the stomata are found in groups and they remain confined to depressions found on leaf surface (e.g. ***Nerium, Banksia***, etc.). Generally the depressions attack of wind gusts.



. Structure of xerophytic leaf. T.S (diagrammatic) of *Ammophila arenaria* leaf showing protected stomata.

iii. Sclerenchyma:

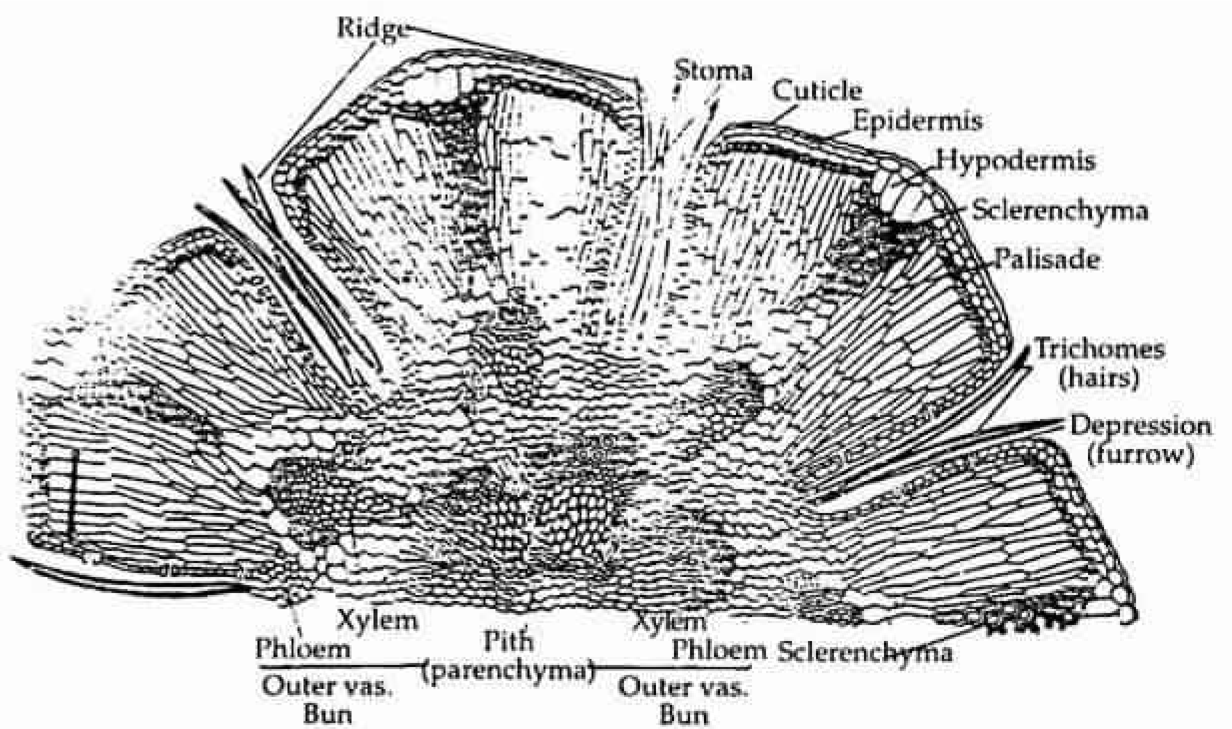
The xerophytes commonly have a **large proportion of sclerenchyma** in their leaf structure than is observed normally in **mesophytes**. The sclerenchyma is either found in groups or in continuous sheets.



. Structure of xerophytic leaf. Part of T.S. of leaf a *Ammophila arenaria*, between two ridges (detailed).

iv. Rolling of Leaves:

The leaves of several xerophytic grasses **roll tightly under dry** conditions. In these grasses, the **stomata are confirmed to the ventral surface** of the leaf, so that when the leaf edges roll inward, **the stomata are effectively shut away from the outside air.** As the stomata are situated on the inner surface of the leaf, the air enclosed by **the rolled leaf soon becomes saturated with water arid the outward water diffusion stops.**



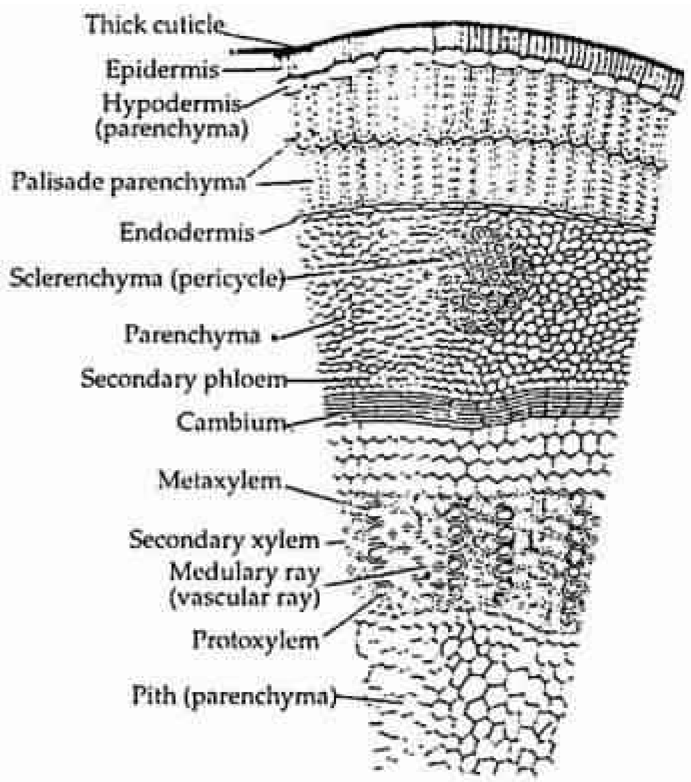
Xerophytes, T.S. of a xerophytic stem *Casuarina equisenfolia*—dicot).

In ***Ammophila arenaria***, there is tight upward folding of the leaf and also the sheltered situated of the stomata in furrows, **greatly reduce air movement over stomatal areas. Special motor cells** (hinge) on the upper surface of the leaf are responsible for the **inward rolling** of leaves. In the xerophytic grasses, the motor cells are well evolved.

v. Reduced Leaf Surface:

In many xerophytes**, reduction of the leaf surface** partly checks water loss because the total exposed surface of the plant body is relatively small as compared with that of normal **mesophytes** (viz., ***Casuarina, Asparagus***, etc.). In such xerophytes the leaves are either **scale-like** or very small in size. Generally they are not found in the mature plant, or they persist as small scales or bracts.

In some plants the photosynthesis takes place in the stem where **assimilatory tissues are well- developed.** The reduction of leaf surface is usually accompanied by **well-evolved sclerenchyma**, **water storage tissue and sunken stomata. Xerophytes, with reduced leaves**, are called **micro- phyllous.**



. Anatomy of xerophytic stem. T.S. of stem of *Capparis decidua* (dicot.)—detail of a sector.

vi. Water Storage Tissue:

Many fleshy xerophytes contain water storage tissue and **mucilaginous substance** in them. In leaves such tissues are situated beneath the upper or the lower epidermis or upon both sides of the leaf and sometimes in the centre too. The storage cells are **visually large and often thin- walled**, as in ***Begonia.*** The **storage tissue can actually serve as a source of reserve water during drought**. The xerophytes, that possess fleshy leaves or stems, are called **malacophyllous**.

vii. Abundant Palisade Parenchyma:

In the stems of several xerophytes, the **palisade tissue is present** (viz., ***Capparis decidua***). In the xerophytic leaves the palisade is abundant and completely arranged.

viii. Latex Tubes:

In many xerophytic stems and leaves the ***laticiferous canals*** are present (viz., ***Calotropis, Euphorbia, Asclepias***, etc.). Because of **vicosity latex** the transpiration is reduced to some extent.
