Plant adaptations to habitats

Plants in different habitats possess different adaptations:

Mesophytes: plants adapted to a habitat with adequate water

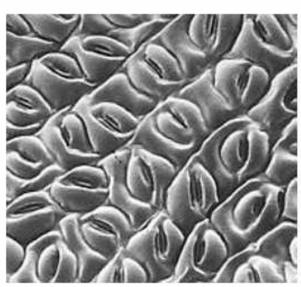
Xerophytes: plants adapted to a dry habitat

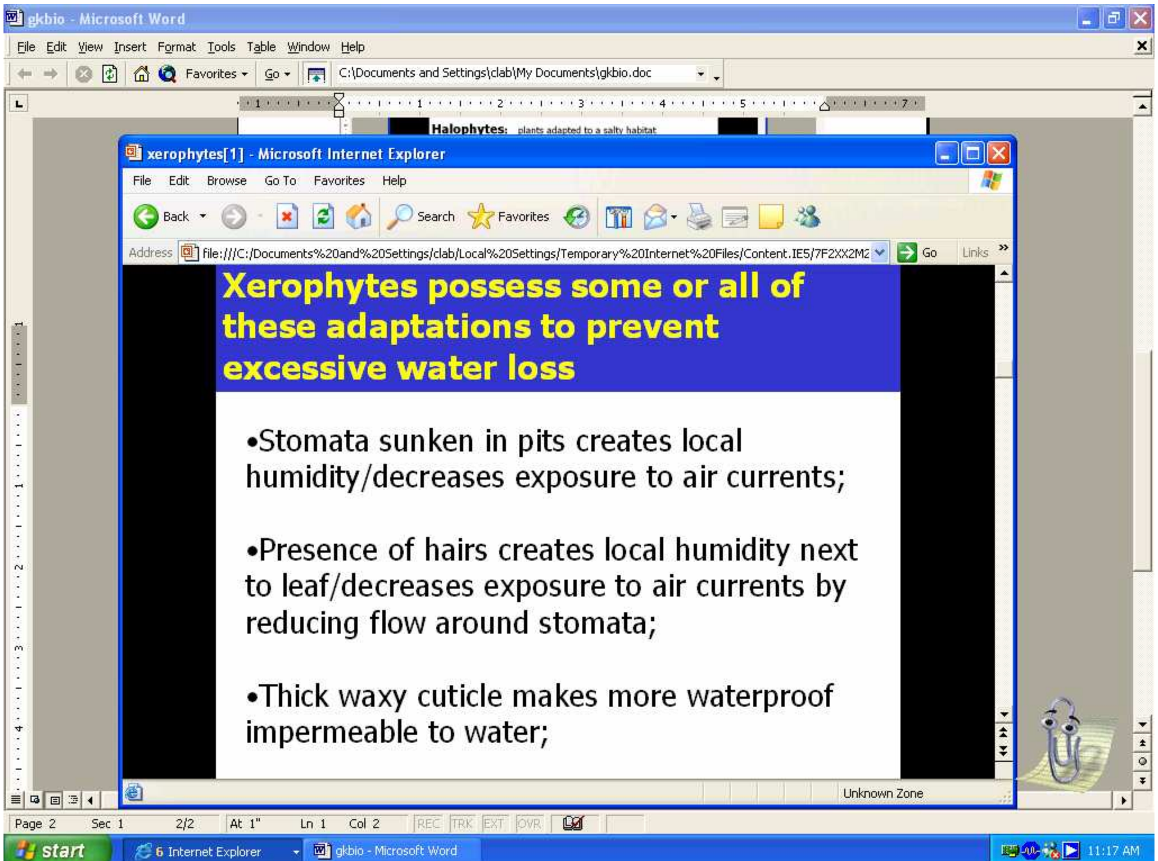
Halophytes: plants adapted to a salty habitat

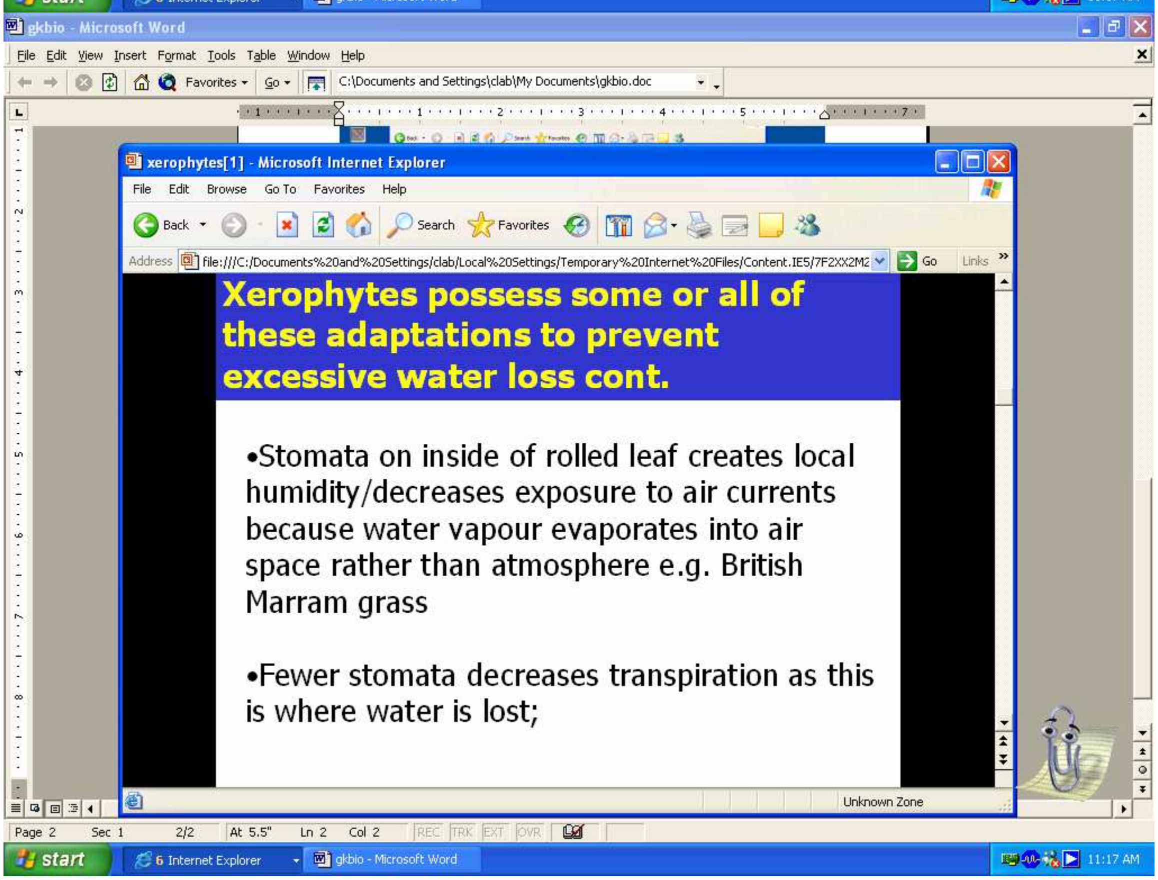
Hydrophytes: plants adapted to a freshwater habitat

Hydrophyte:

Leaf undersurface of the tree fern. Extremely high number of stomata per unit in a species living in tropic cloud forests where is is very moist.



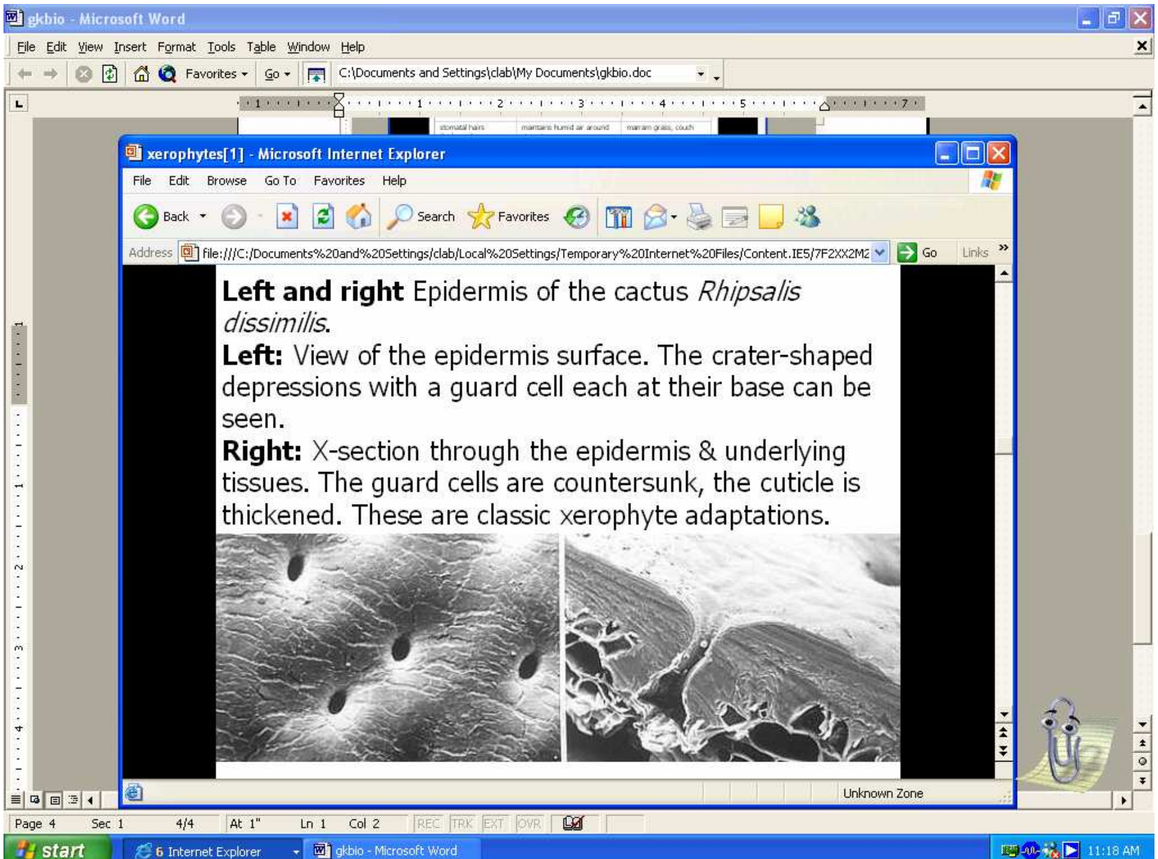

Xerophytes possess some or all of these adaptations to prevent excessive water loss
•Stomata sunken in pits creates local humidity/decreases exposure to air currents;
•Presence of hairs creates local humidity next to leaf/decreases exposure to air currents by reducing flow around stomata;
•Thick waxy cuticle makes more waterproof impermeable to water;


Xerophytes possess some or all of these adaptations to prevent excessive water loss cont.
•Stomata on inside of rolled leaf creates local humidity/decreases exposure to air currents because water vapour evaporates into air space rather than atmosphere e.g. British Marram grass
•Fewer stomata decreases transpiration as this is where water is lost;

Xerophyte adaptations summary:

Adaptation	How it works	Example
thick cuticle	stops uncontrolled evaporation through leaf cells	
small leaf surface area	less surface area for evaporation	conifer needles, cactus spines
low stomata density	smaller surface area for diffusion	
sunken stomata	maintains humid air around stomata	marram grass, cacti
stomatal hairs (trichores)	maintains humid air around stomata	marram grass, couch grass
rolled leaves	maintains humid air around stomata	marram grass,
extensive roots	maximise water uptake	cacti

All Cacti are xerophytes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Left and right Epidermis of the cactus *Rhipsalis dissimilis*.
Left: View of the epidermis surface. The crater-shaped depressions with a guard cell each at their base can be seen.
Right: X-section through the epidermis & underlying tissues. The guard cells are countersunk, the cuticle is thickened. These are classic xerophyte adaptations.
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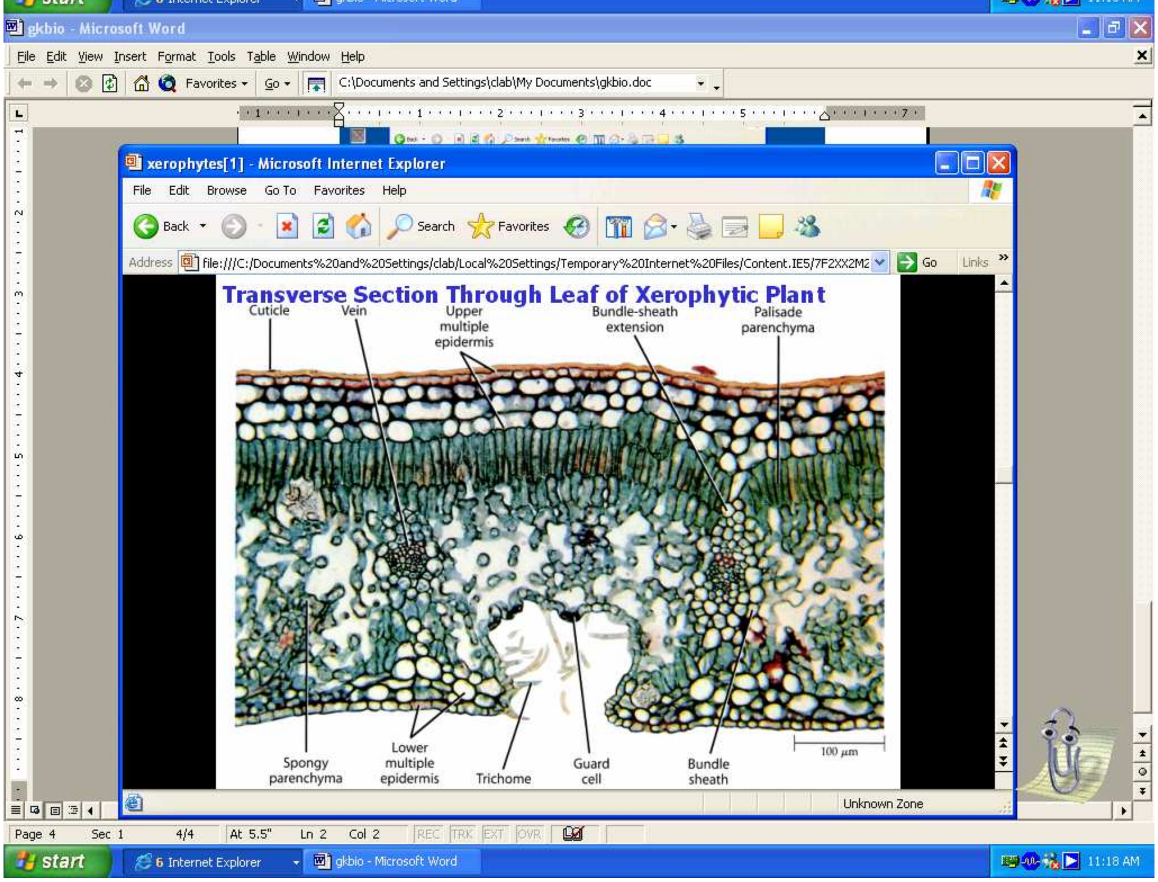
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Transverse Section Through Leaf of Xerophytic Plant
Cuticle
Vein
Upper multiple epidermis
Bundle-sheath extension
Palisade parenchyma
Spongy parenchyma
Lower multiple epidermis
Trichome
Guard cell
Bundle sheath
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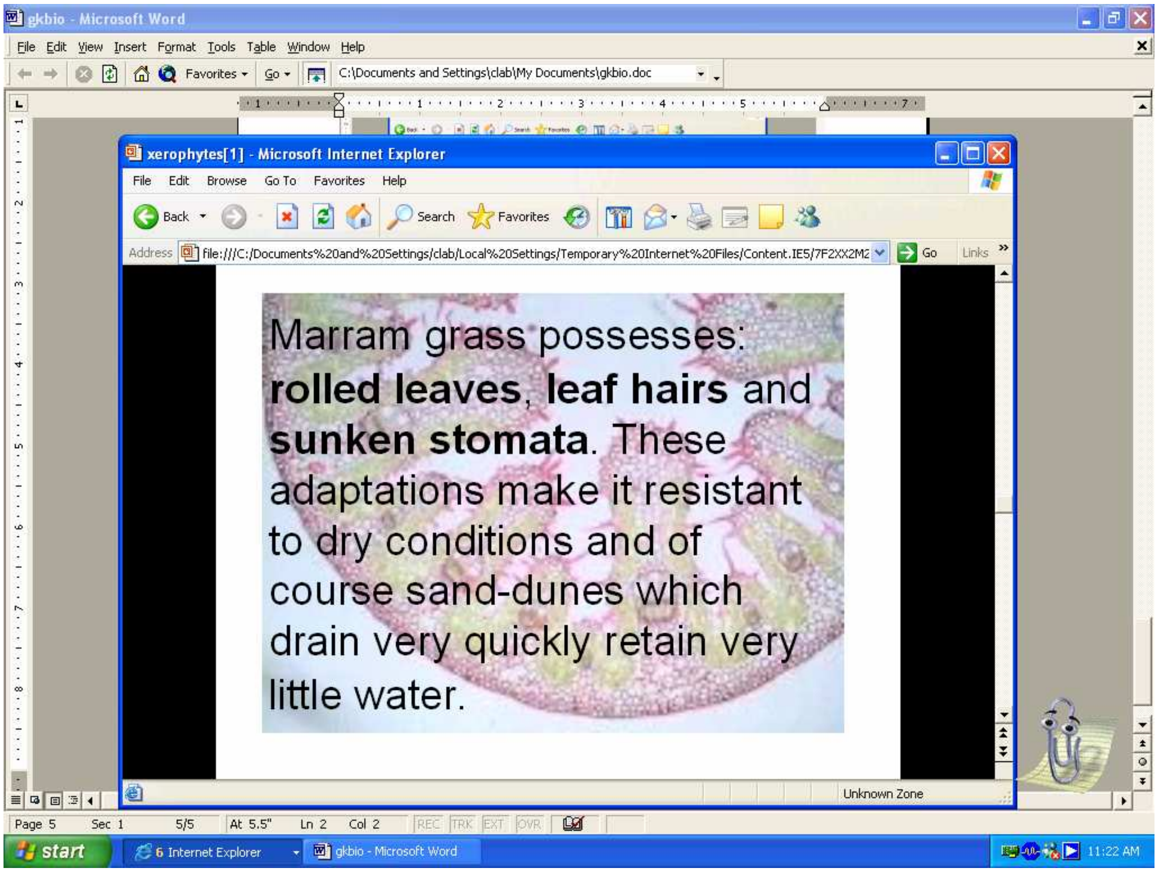
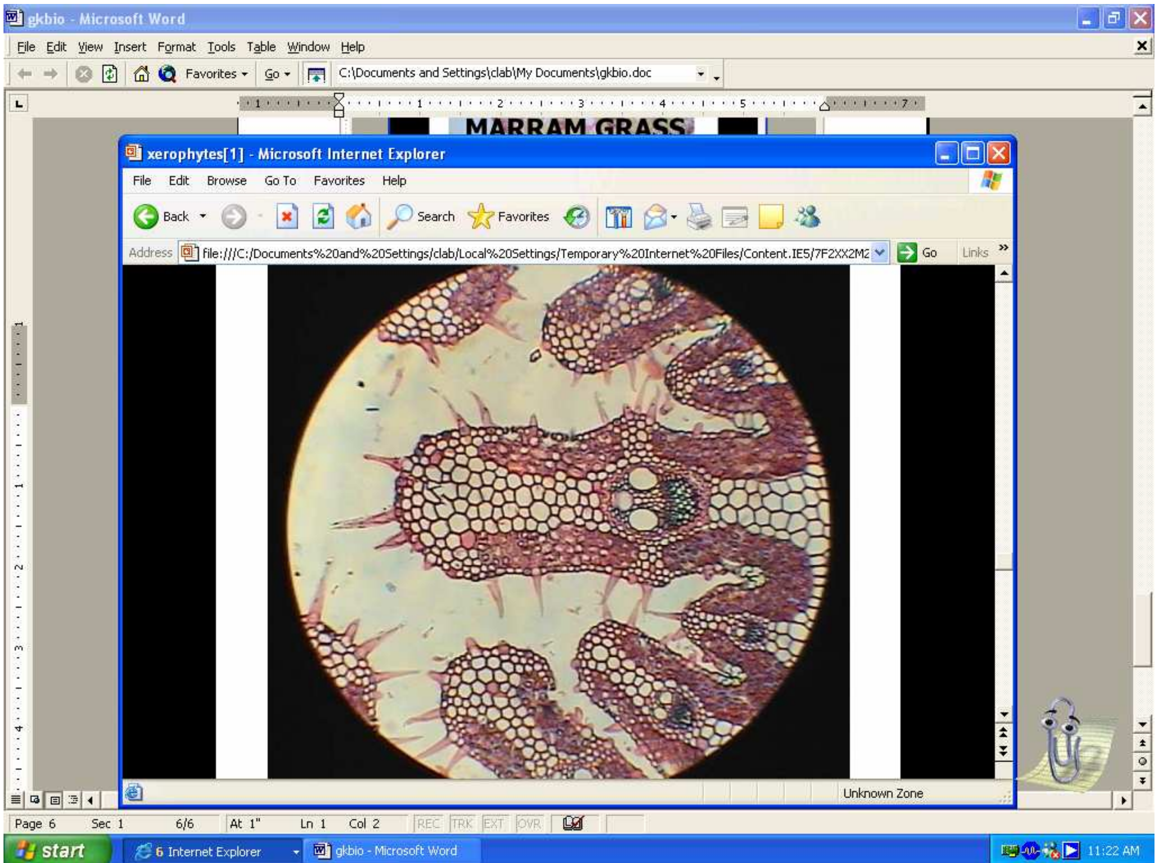
XEROPHYTE SPECIES STUDY: MARRAM GRASS

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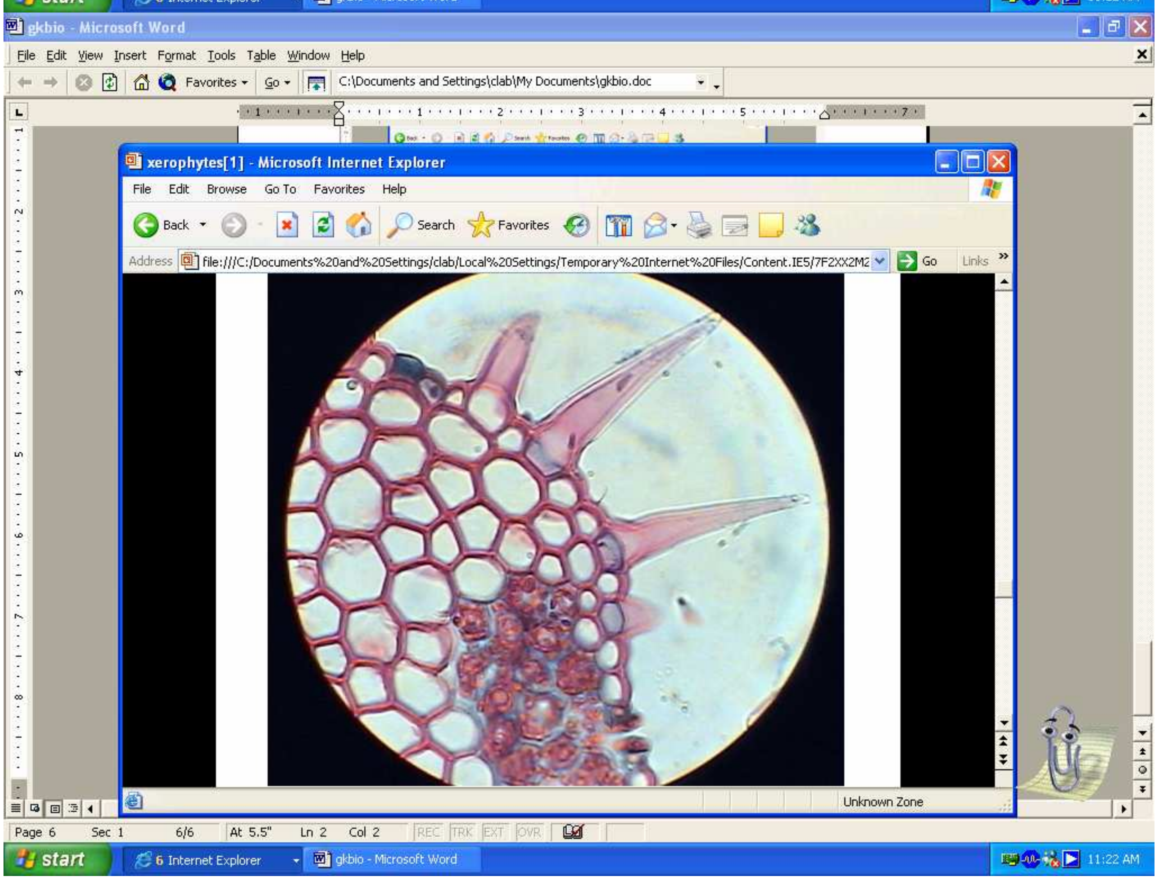
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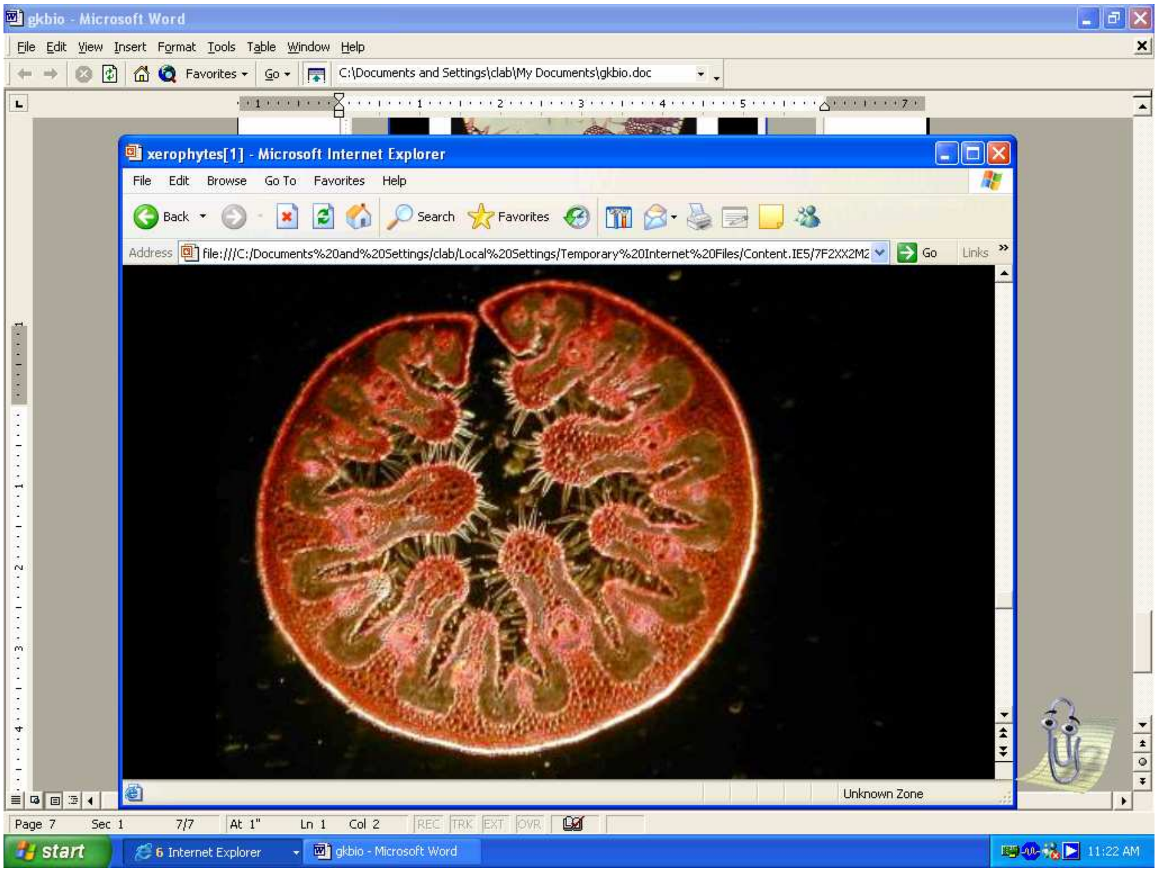


Adaptations to dry habitats [back to top]

Plants in different habitats are adapted to cope with different problems of water availability.

Mesophytes	plants adapted to a habitat with adequate water
Xerophytes	plants adapted to a dry habitat
Halophytes	plants adapted to a salty habitat
Hydrophytes	plants adapted to a freshwater habitat

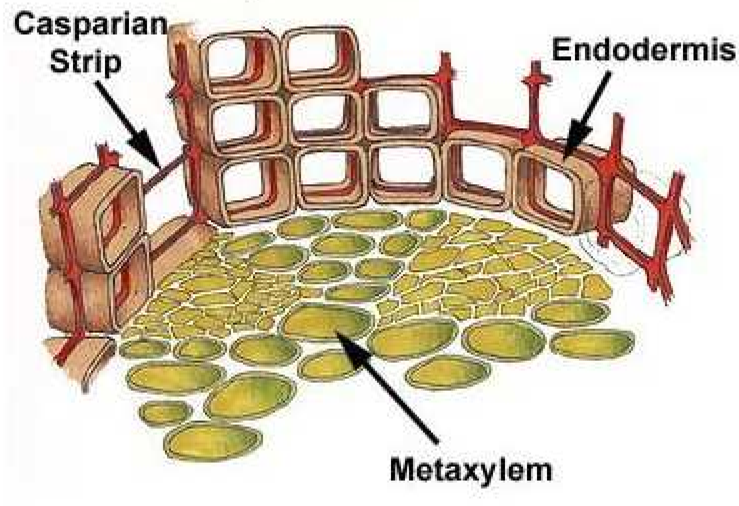
Some adaptations of xerophytes are:

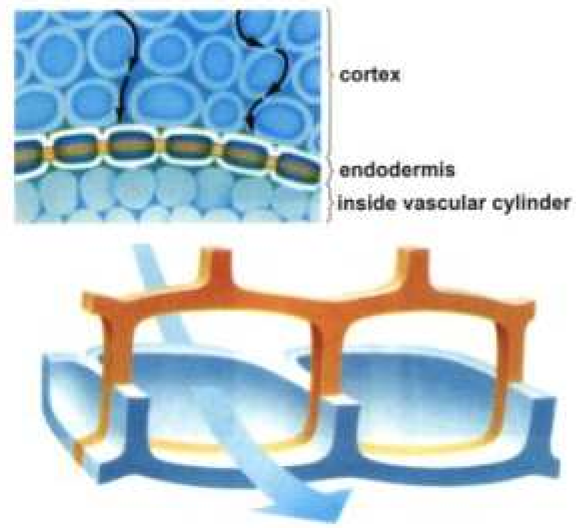
Adaptation	How it works	Example
thick cuticle	stops uncontrolled evaporation through leaf cells	most dicots
Small leaf surface area	less area for evaporation	conifer needles, cactus spines
low stomata density	fewer gaps in leaves	

stomata on lower surface of leaf only	more humid air on lower surface, so less evaporation	most dicots
shedding leaves in dry/cold season	reduce water loss at certain times of year	deciduous plants
sunken stomata	maintains humid air around stomata	marram grass, pine
stomatal hairs	maintains humid air around stomata	marram grass, couch grass
folded leaves	maintains humid air around stomata	marram grass,
succulent leaves and stem	stores water	cacti
extensive roots	maximise water uptake	cacti

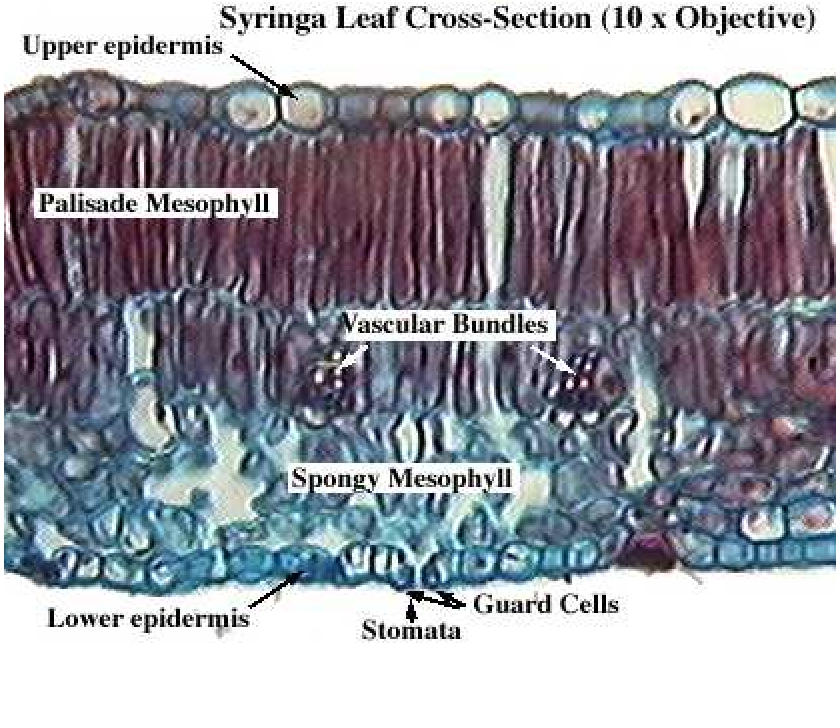
The structure of photosynthetic elements was investigated in leaves of 42 boreal plant species featuring different degrees of submergence (helophytes, neustophytes, and hydatophytes). The mesophyll structure types were identified for all these species. Chlorenchyma tissues and phototrophic cells were quantitatively described by such characteristics as the sizes of cells and chloroplasts in the mesophyll and epidermis, the abundance of cells and chloroplasts in these tissues, the total surface area of cells and chloroplasts per unit leaf area, the number of plastids per cell, etc. The hydrophytes typically had thick leaves (200–350 μm) with a well-developed aerenchyma; their specific density per unit area (100–200 mg/dm^2) was lower than in terrestrial plants. Mesophyll cells in aquatic plants occupied a larger volume ($5–20 \times 10^3 \mu m^3$) than epidermal cells ($1–15 \times 10^3 \mu m^3$). The number of mesophyll cells per unit leaf area was nearly 1.5 times higher than that of epidermal cells. Chloroplasts were present in the epidermis of almost all species, including emergent leaves, but the ratio of the chloroplast total number to the number of all plastids varied depending on the degree of leaf submergence. The total number of plastids per unit leaf area ($2–6 \times 10^6/cm^2$) and the surface of chloroplasts per unit leaf area (2–6 cm^2/cm^2) were lower in hydrophytes than in terrestrial plants from climatically similar habitats. The functional relations between mesophyll parameters were similar for hydrophytes and terrestrial plants (a positive correlation between the leaf weight per unit area, leaf thickness, and the number of mesophyll cells per unit leaf area), although no correlation was found in hydrophytes between the volume of mesophyll cells and the leaf thickness. Phototrophic tissues in aquatic plants contributed a larger fraction to the leaf weight than in terrestrial plants, because the mechanical tissues were less developed in hydrophytes. The CO_2assimilation rates by leaves were lower in hydrophytes than in terrestrial plants, because the total surface area of chloroplasts per unit leaf area is comparatively small in hydrophytes, which reduces the conductivity for carbon dioxide diffusion towards the carboxylation sites.

Keywords
hydrophytes, leaf anatomy, mesophyll, epidermis, photosynthesis, adaptation

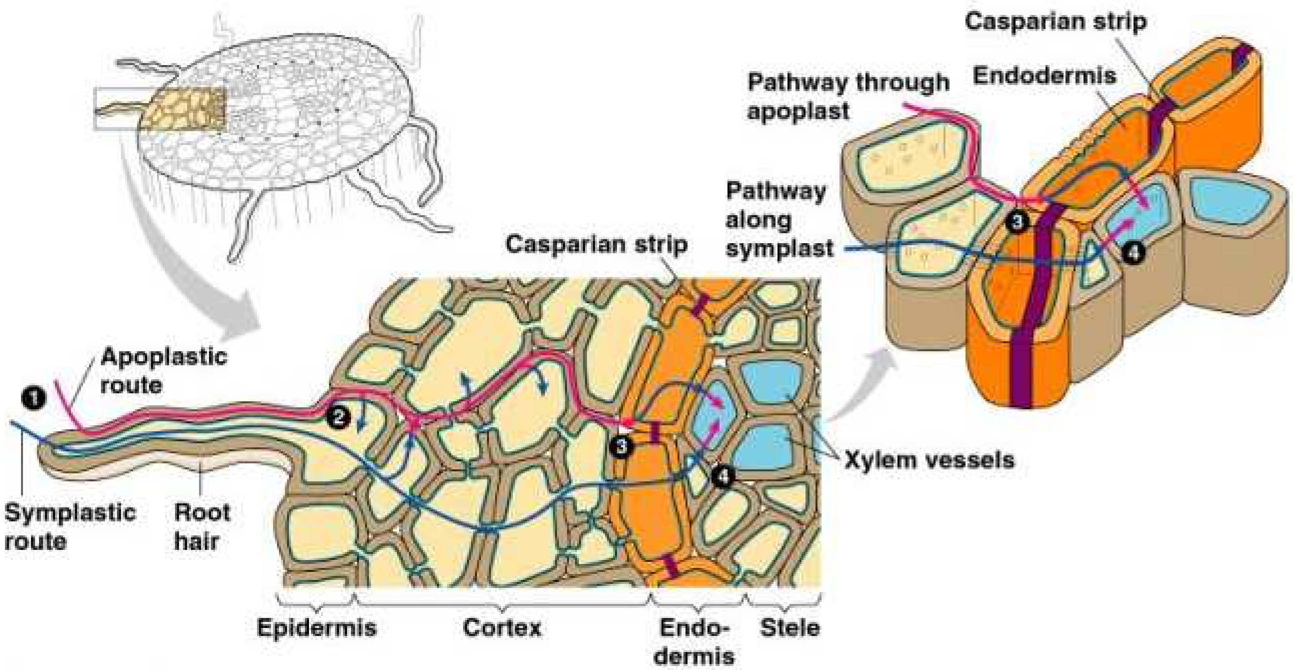


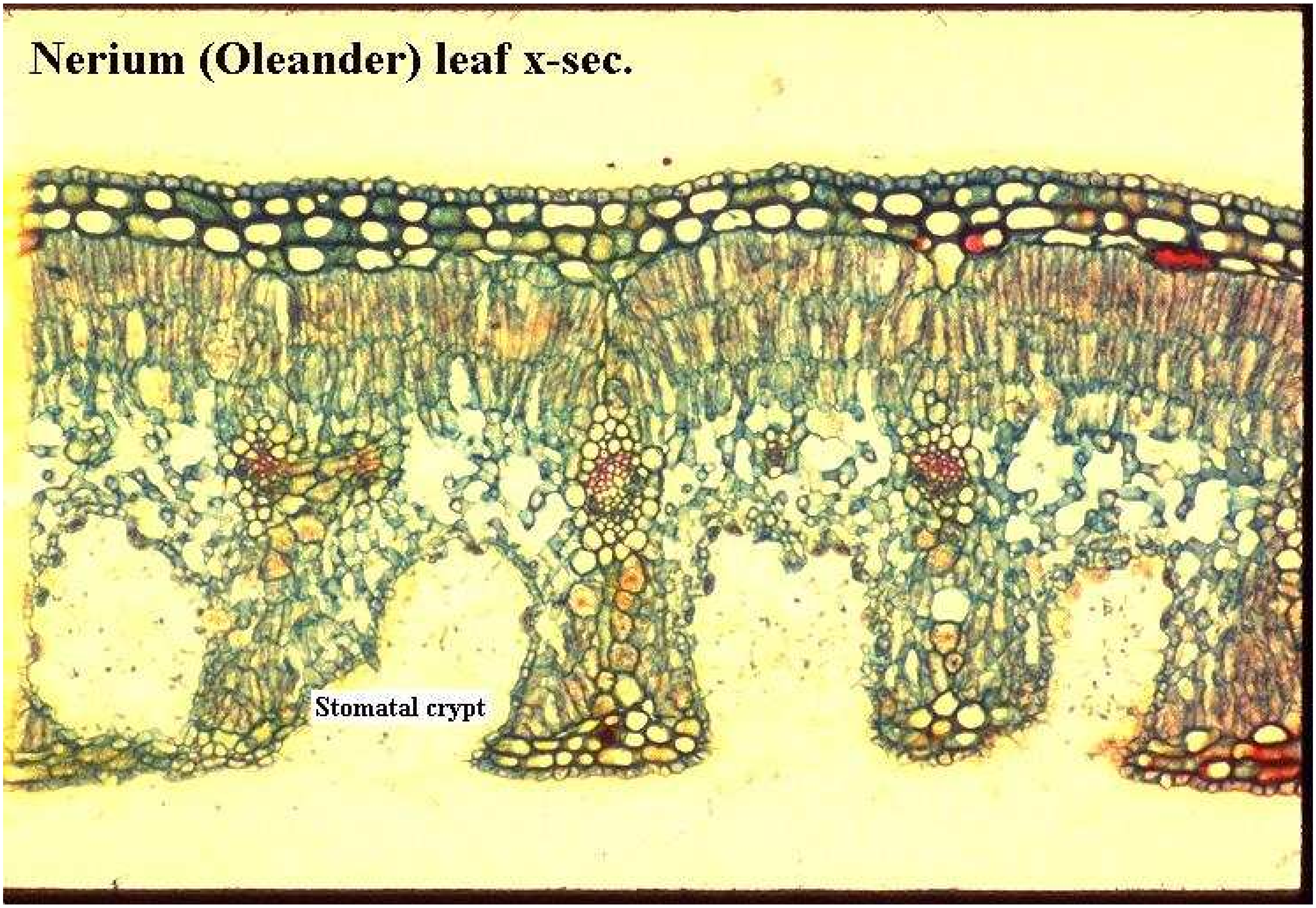


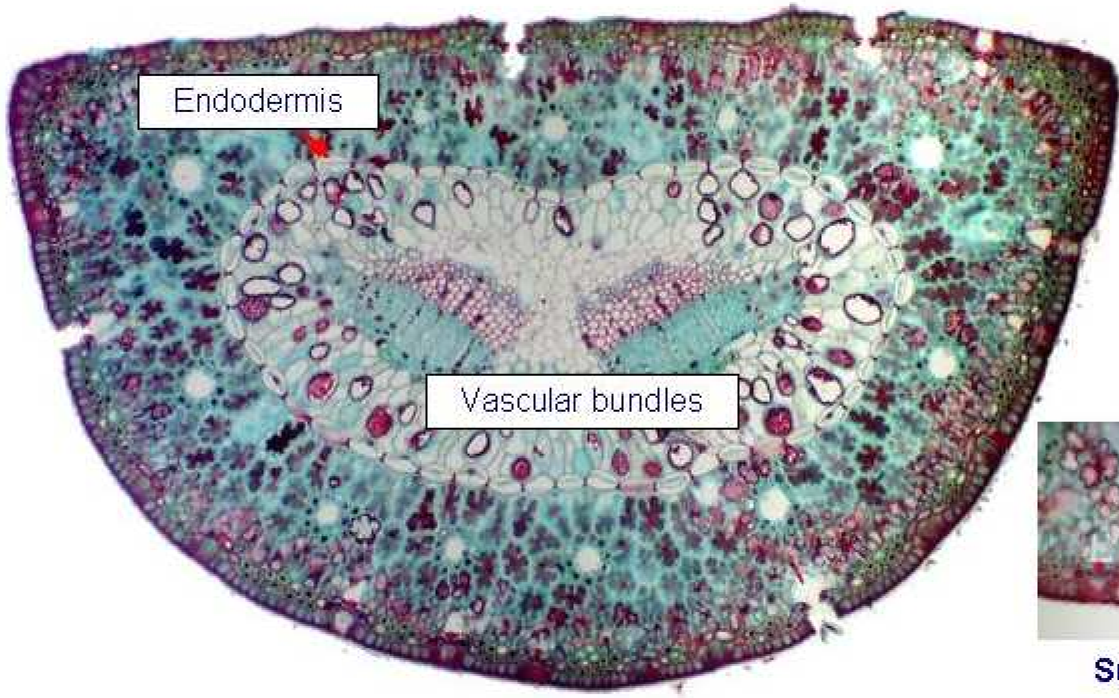
Syringa Leaf Cross-Section (10 x Objective)



The Path of Water into Roots




Nerium (Oleander) leaf x-sec.
Stomatal crypt



Sunken stom

C.2. Tropical Desert

C.2.1. Adaptations to the environment

Environmental characteristics	Vegetation characteristics
• intense insolation & • high temp. at day • scarce rainfall • (Et>ppt: • Soil moisture deficit) • dry and arid • wind / desert storm	**1) Ephemerals or annuals** (Drought-evaders-they avoid rather than withstand the dry season) which complete the life cycles in a short period (2 or 3 weeks) • form 50%-60% of desert plants; they are rain dependent *Physiological adaptation* • complete an annual growth cycle within a short rainy period of 6-8 weeks e.g. desert plantains and desert fescue. • seeds quickly germinate, grow and flower after occasional torrential downpours arrive • regulate the life cycle

	seeds with thick case can lie dormant for long periods until the next rain produce a large number of seeds produce seeds protected from desiccation by either the seed coating or the remains of the plant *Morphological adaptation* small size, small leaves and shallow roots **2) Perennials** : **Succulent** perennials e.g. cacti, Euphorbia, Saguaro • These plants can enlarge their parenchyma tissues with income of fresh moisture. with water storage devices e.g. stems/ leaves/ roots reserve of water in plant cells as a response to aridity the stomata are closed during the day (to reduce transpiration loss when the evaporation rate is high) and open at night /nocturnally. **Non-succulent** perennials (drought-tolerant or drought-enduring) These are the hardy plants and comprise a variety of morphological forms : herbs, grasses, shrubs, trees, etc. These plants can tolerate the climatic and / or soil aridity. Their growth forms : - evergreen : they are biologically active throughout the years - drought-deciduous : biologically dormant during dry season - cold-deciduous : biologically dormant during cold season commonly found where water is available such as in wadis or depressions, at oases or perennial rivers, e.g. tamarisks, acacias, grasses, palms, etc. *Physiological adaptation* underground water storage organ e.g. tubers, bulbous roots The following features can reduce the loss of water through the cells and prevents the collapse of the plant tissues during wilting. shed leaves at the first sign of dry period no leaves, shedding of foliage, shedding parts of the shoot branches, rolling of leaves , etc **.** heavy cuticularization and cutinisation. Such varnish-like covering / plaster-like layer / cuticle forms a watertight layer, minimizing the loss of water through the epidermal cells and limit the loss of moisture Profuse lignification provides the organs with efficient mechanical support, saving its tissues from collapse, under conditions of wilting (losing freshness) or water deficit in the softer cells Sunken stomata -stomata are arranged in recesses or grooves, an adaptation for water retention. Abundant hairs

	Morphological adaptation development of deep and extensive root system as compared with a lesser shoot e.g. long tap roots to reach the water table, these ***phreatophytes*** can have roots of 50m e.g. acacias and mesquite, tamarisks horizontally extending roots are common in a sandy habitats and in shallow soil overlying harder substrate. Rope-like roots may extend for several meters (5-20m) not far below the sand surface. Low shoot - to - root ratio, e.g. from 1:3 to 1:6 small, spiky, spiny or waxy leaves to reduce transpiration minute leaves with shiny surfaces spikes and thorns to protect against animal attack They are compact in growth , e.g. low rounded shapes like cushion plants and small cacti. They can resist structural damage by winds which are generally strong low stature of plants so as to reduce evaporation and stop damage arising from desiccating desert winds **Other xerophytic adaptations** : Drought-resistant plants thick leaf cells and cuticles small leaves or spines/ tough leaves to reduce transpiration loss pale leaves with reflective surfaces leaves rolled into tubes/ curly stomata are located mainly on the underside of the leaf folded leaves with the stomata inside thick bark to reduce transpiration e.g. thornbush short stem hard and woody tissues to prevent the collapse of plant tissues during wilting high osmotic pressure in their cell saps which can delay wilting and resist toxic saline soil short (low in stature) and small
saline soil	**Halophytes:** salt-tolerant or salt-avoidant by excretion (through glandular cells) and exclusion salt-evaders : regulate their life cycle to germinate and grow in the rainy season e.g. saltbush

C.2.2. Summary for Tropical Desert plants

lowest NPP (____)

- low biomass
- limited species diversity/ few species
- simple structure : no stratification by height
- scarce, scanty vegetation
- sparse, widely-spaced to avoid competition for water, discontinuous
- uneven distribution of veg.- veg. is concentrated at the areas with water supply e.g. oasis, hollows
- thorny, hardy and woody plants e.g. scrubs, grasses, herbs, bushes
- lack of moisture is the major limiting factor for plant growth in desert
- The desert vegetation is a good opportunist with highly developed xerophytic characteristics to encounter the harsh environments including aridity, high salinity of soil, shifting of sand dunes, existence of strong winds. These adaptations include devices to
  - minimise water Loss by transpiration
  - store water
  - obtain maximum moisture
  - avoid drought by reducing the contact between air and the interior tissues of the plants (waxy and hairy cover)

C.3. Tundra

C.3.1. Adaptations to the environments (fig. 12.42)

Environmental Characteristics	Vegetation characteristics
• long and severe cold winter (9 months) with temperature below $0^{O}C$ • very short summers (<3 months) with mean temp. below $10^{O}C$ -thaw period • very short growing season (frost-free period is <50 days) • freeze-thaw action takes place on the active layer which is swampy and muddy in summer • strong and persistent winds desiccate the veg and cause physical	• mosses and lichens ◦ their tissues do not freeze and are capable of taking photosynthesis at temp. as low as $-20^{O}C$ • grasses, heath, dwarf shrubs and sedges dominate in more favourable areas (south-facing slopes) • low-growing herbaceous plants • cushion form • few annuals with short life cycles • woody herbaceous perennial plants with underground storage organs to store food (carbohydrates) in root biomass; and close stomata in time of drought • some herbaceous plants have buds under the soil surface • seed production is opportunistic and dependent upon temp. during flowering and latter half of growing season • seed dormancy • small leaves to limit transpiration • reproduction takes place vegetatively • cellular ice does not form until temp. drops below $-30^{O}C$ lichens never freezes and adjust to rapid and extreme temp. changes • grow near to the ground or in low depressions to get water and avoid extreme wind exposure

damage frozen soils shallow soil above the permafrost waterlogged/ poorly-drained soil in summer boggy areas aspect: south-facing slopes solifluction	very short roots to avoid the permafrost compact and rounded shape to protect against wind attack