E learning module BSc part III

Applied Plant Anatomy Lecture series

Plant Anatomy in relation to Environment

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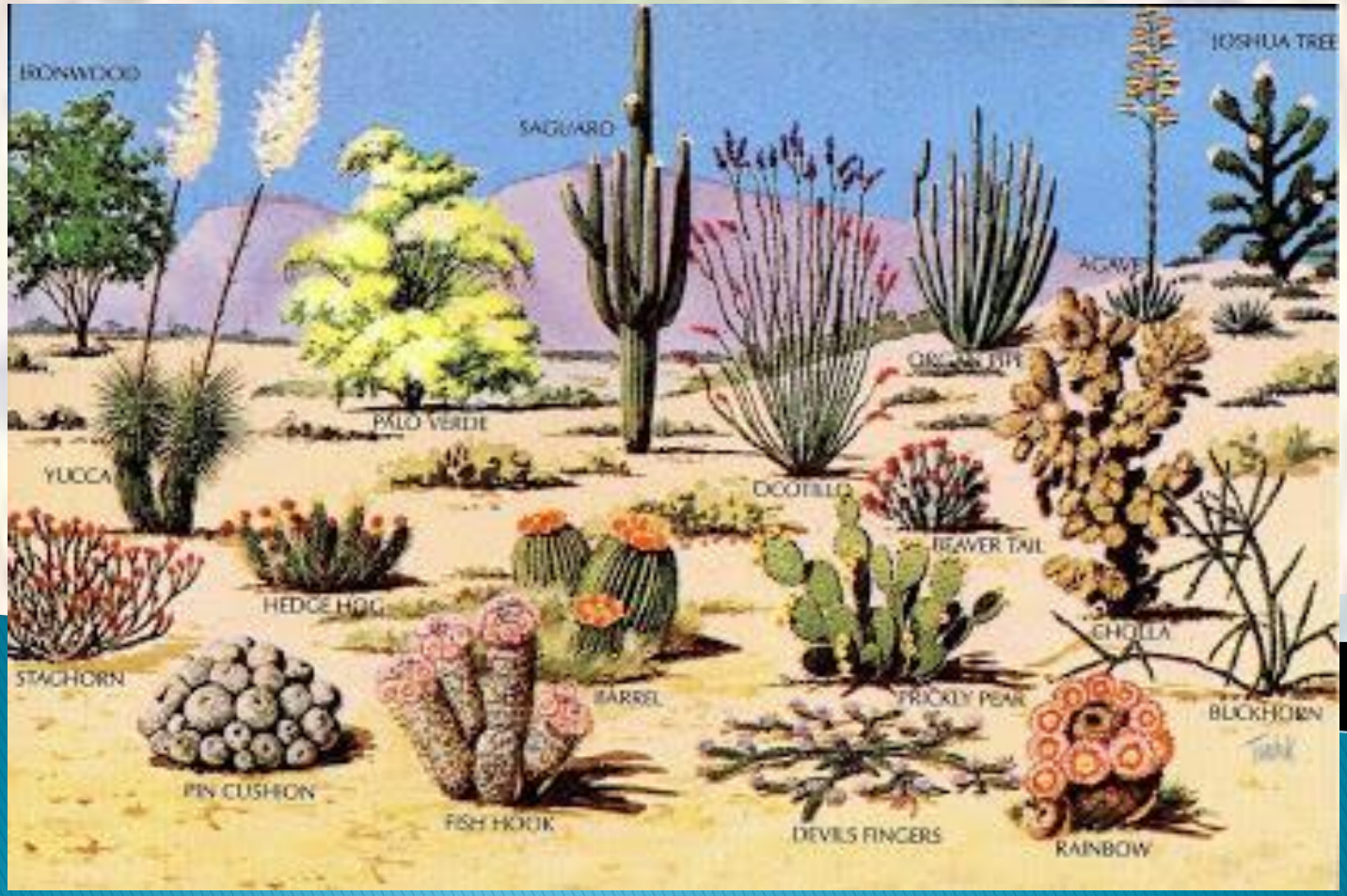


Organism vs Environment

- The living organisms react with their environments and they bear full impression of the environments in which they grow.

- In order to withstand adverse conditions of the environment and utilize to their maximum benefit the nutrients and other conditions prevailing therein,
- the organisms develop certain morphological, anatomical, physiological and reproductive features.

- Any feature of an organism or its part which enables it to exist under conditions of its habitat is called adaptation.

Why do plants adapt

- Adaptations of survival value comprise such features as prevent destruction of vital vegetative tissues and help in large production and efficient dissemination of reproductive bodies.
- This explains why certain plants are found in one area, but not in another.
- For example, you wouldn't see a cactus living in the Arctic. Nor would you see lots of really tall trees living in grasslands.
- **Warming** (1895) had realized for the first time the influence of controlling or limiting factors upon the vegetation in ecology.
- He classified plants into several ecological groups on the basis of their requirements of water and also on the basis of nature of substratum on which they grow.

Plants in varied environment

- Plants of acidic soil (Oxylophytes)
- Plants of saline soil (Halophytes)
- Plants growing on the sand (Psammophytes)
- Plants growing on the surface of rocks (Lithophytes)
- Plants growing in the crevices of rocks (Chasmophytes).

Xerophilous plants are further classified on the basis of their habitats as follows:

- Oxylophytes (on acid soils)
- Halophytes (on saline soils)
- Lithophytes (on rocks)
- Psammophytes (on sand and gravels)
- Chersophytes (on waste land)
- Eremophytes (on deserts and steppes)
- Psychrophytes (on cold soils)
- Psilophytes (savannah)
- Sclerophytes (Forest and bushland)

Halophytes plants growing in saline environment

- Salt accumulators, such as
- Saltbush (Atriplex),
- smooth cordgrass (Spartina alterniflora),
- saltgrass (Distichlis spicata),
- Tamarisk (Tamarix petandra),
- have specialized cells called salt glands located on the surfaces of their leaves, used for storing excess sodium chloride.

Angiosperm Halophyte Types

- Marine angiosperms
- Mangroves
- Coastal strand
- Salt marshes

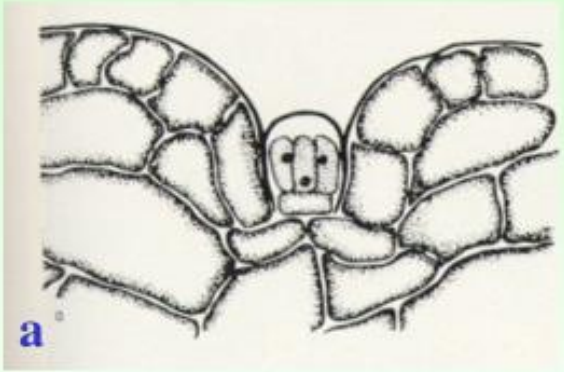
Physiological Response in Halophytes

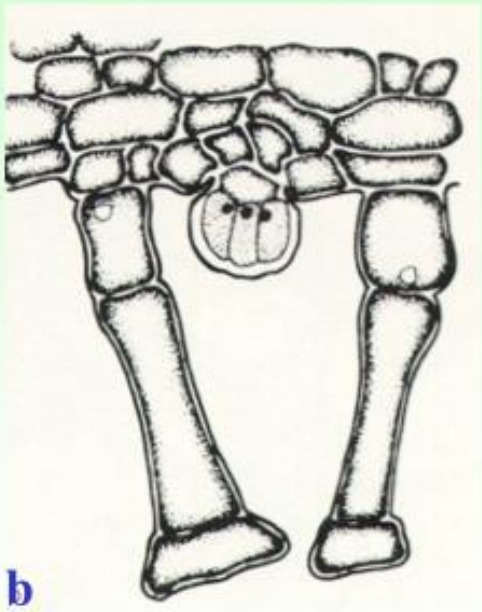
- Switch from Carbon-3 photosynthesis to CAM (crassulacean acid metabolism)
  - Stomates closed during the day
  - CO_2 fixation during the night
  - Sugars accumulate in cells

- Decrease osmotic pressure with organic ions (proteins)

Anatomical adaptations in halophytes

Salt Glands in Black Mangrove (Avicennia marina)



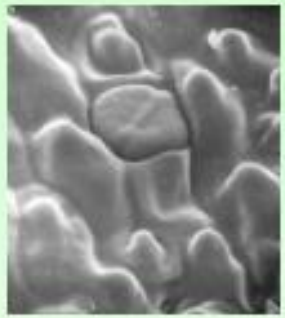


(a) sunken gland on upper epidermis; (b) elevated gland on lower epipermis

Concentrations of secreted salts is typically so high that under dry atmospheric conditions, the salts crystallize

Regulation of Salt Content in Shoots

- Secretion of salts
  - Salt exported via active transport mechanism
  - Excretion includes Na+ and Cl- as well as inorganic ions

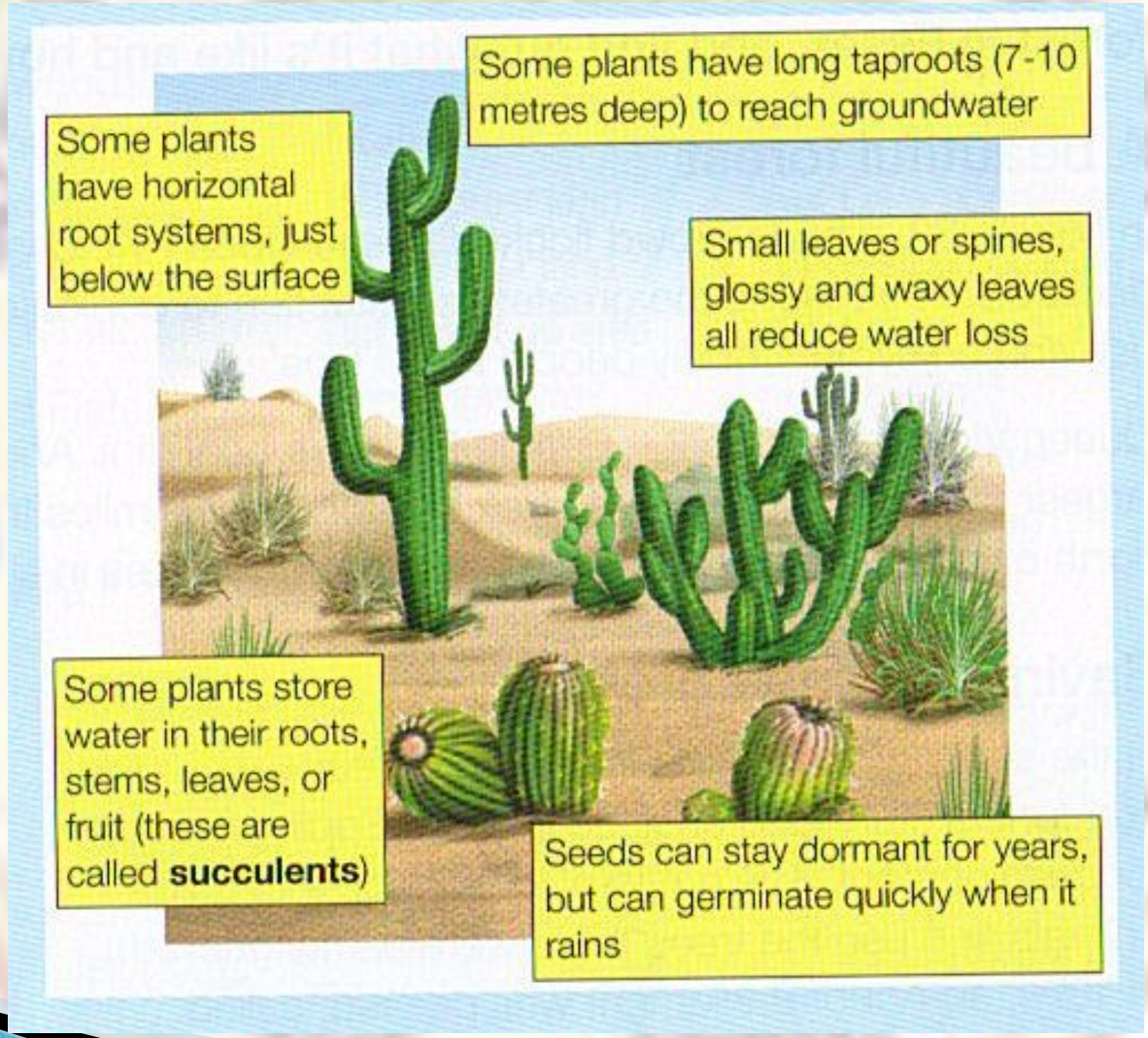


Leaf surface containing salt gland of Saltcedar (Tamarix ramiosissima)

Photograph and schematic diagram of salt gland of Aeluropus litoralis

Two celled salt gland of Spartina

Dessert environment



Desert conditions

- The desert is very dry and often hot.
- Annual rainfall averages less than 10 inches per year, and that rain often comes all at the same time.
- The rest of the year is very dry.
- There is a lot of direct sunlight shining on the plants.
- The soil is often sandy or rocky and unable to hold much water.
- Winds are often strong, and dry out plants.
- Plants are exposed to extreme temperatures and drought conditions.
- Plants must cope with extensive water loss.

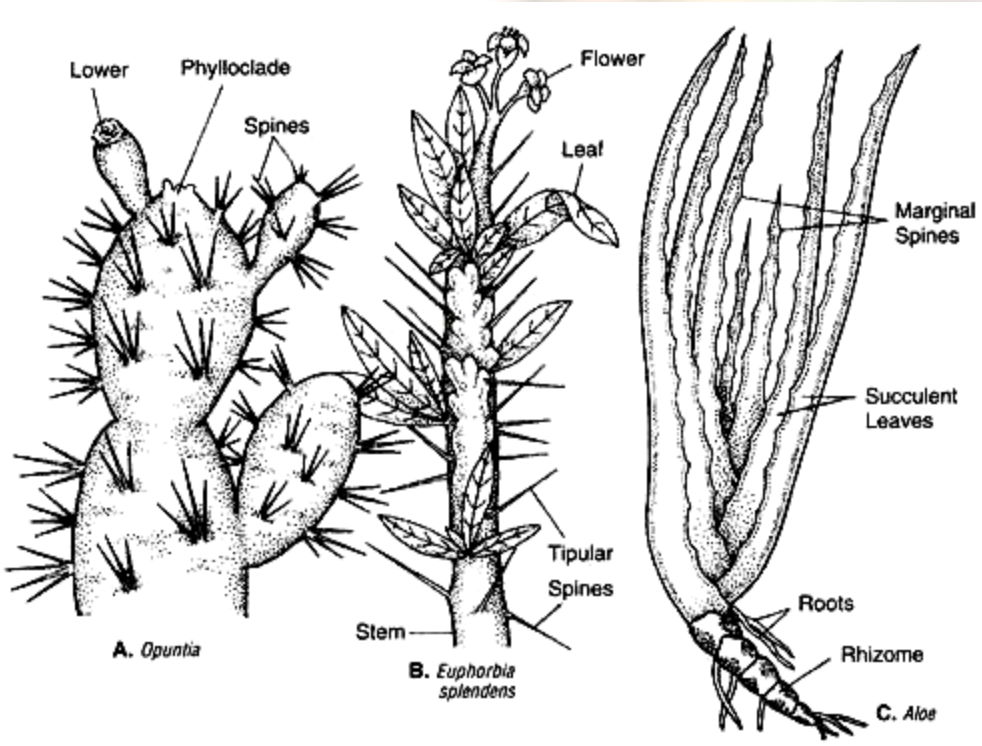
Desert Plant Adaptations

- Some plants, called succulents, store water in their stems or leaves;
- Some plants have no leaves or small seasonal leaves that only grow after it rains.
- The lack of leaves helps reduce water loss during photosynthesis.
- Leafless plants conduct photosynthesis in their green stems.
- Long root systems spread out wide or go deep into the ground to absorb water;

Some plants have a short life cycle, germinating in response to rain, growing, flowering, and dying within one year. These plants can evade drought.

Leaves with hair help shade the plant, reducing water loss.

Other plants have leaves that turn throughout the day to expose a minimum surface area to the heat.



Cactus plant

-It has soft tissues that hold water like a sponge.
- It also has a thick, waxy cover to keep the water inside.
- It has sharp spines that protect it from being eaten by animals.

Spines to discourage animals from eating plants for water;

Waxy coating on stems and leaves help reduce water loss.

Flowers that open at night lure pollinators who are more likely to be active during the cooler night.

Slower growing requires less energy. The plants don't have to make as much food and therefore do not lose as much water.

Anatomical adaptations Xerophytes

- Reduction in the evaporating surface area, leaves modified into needles e.g. *Pinus* or reduces to spine e.g. Cactus.
- The epidermal cells of leaf and other delicate parts develop thick cuticle. In addition some xerophytes also possess a coating of wax and silica.
- Wax is imbermeable to water while silica protects against solar radiations.
- Number of stomata are more in compared to the mesophytic leaves but are restricted to lower surface of leaves only
- Presence of sunken stomata.
- Well developed hypodermis made up of sclerenchymatous tissue
- Well developed mechanical tissue system
- Well developed water conducting system i.e. xylem tissue.
- Mesophyll is differentiated into palisade and spongy parenchyma with small intercellular space.
- Presence of Bulliform cells in leaf epidermis help in rolling of leaves in dry weather

Types of xerophytes

- **Xerophytes are recognized into three major types;**
  - **Ephemerales** also called drought escapers or draught evaders-These are annuals which complete their life cycle within a short period and usually pass the period of draught as seeds. **E.g.** ***Solanum xanthocarpum, Euphorbia prostrata***
  - **Succulents are xerophytic perennials** having fleshy leaves and stem. Fleshy parts store water. The cells have least intercellular spaces and cells have large vacuoles. **E.g.** ***Opuntia*** **has succulent stem; succulent leaves found in-** ***Bryophyllum, Agave, Aloe*****; Succulent roots are present in-*** ***Asparagus, Pelargonium, Oxalis.***
  - **Non-succulent perennials** are true xerophytes which are capable of successfully enduring the dry climate and can withstand low humidity, high temperature, increased wind velocity etc. They adapt anatomically to survive under dry and extreme climate. **E.g.-*** ***Calotropis, Nerium, Casurina, Zizyphus, Salix, Acacia*** **etc**

Hydrophytes

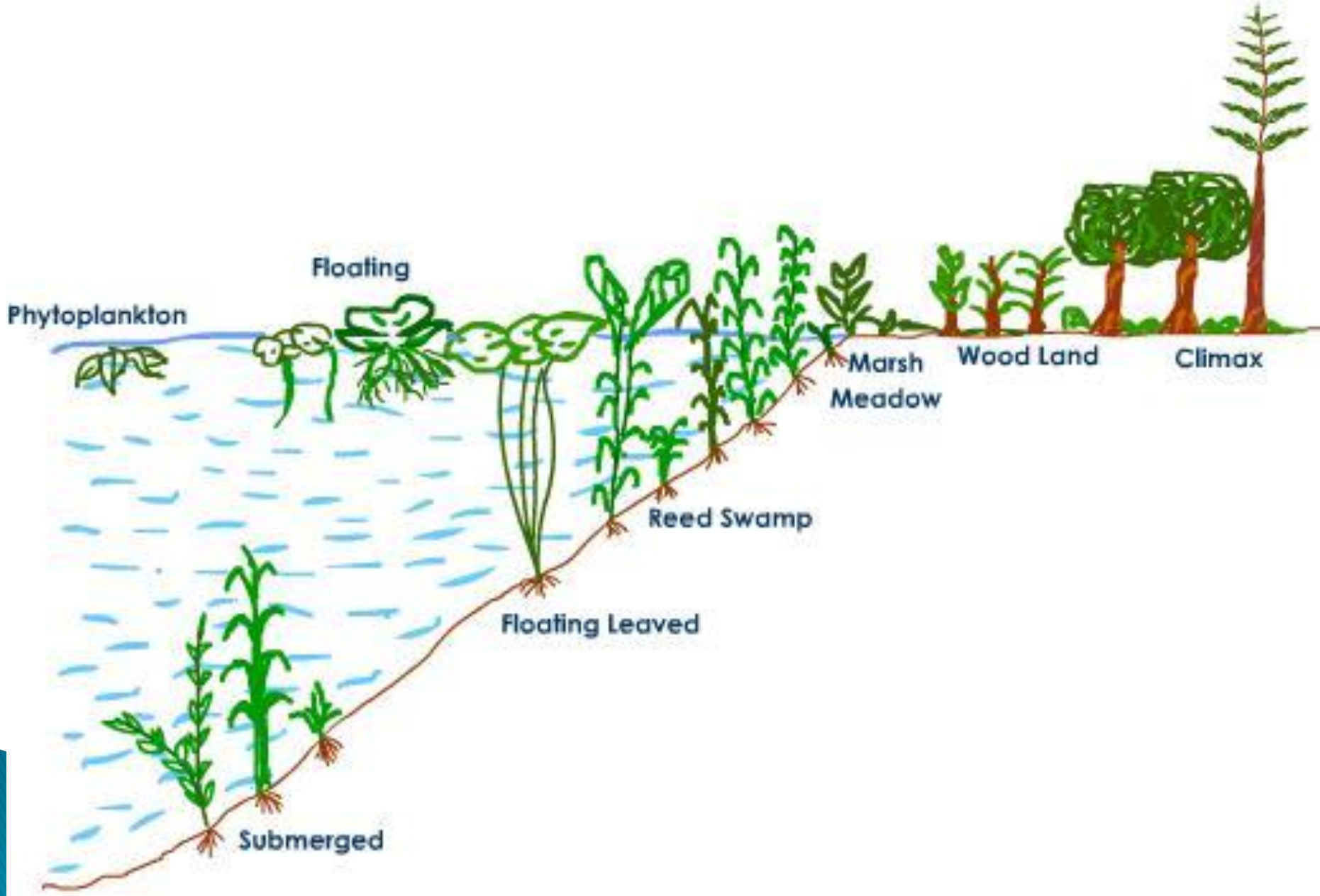
3 types

1) Completely submerged e.g. hydrilla

2) Partially submerged e.g. water lily

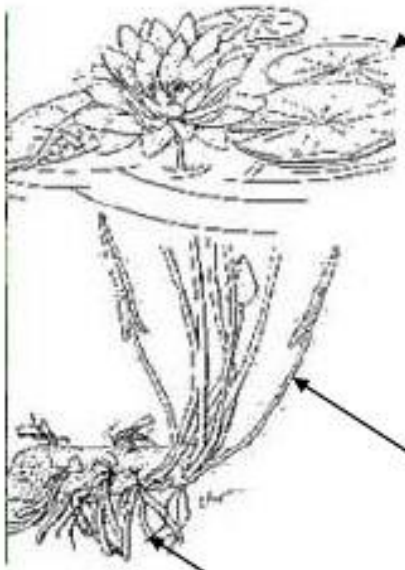
3) Free floating e.g water hyacinth

Water adaptations



Water plant- Water Lily

- Is a species of water lily whose leaves float on the water surface.
- Large air cavities within the leaf, allow it to float.
- Leaves are large and circular with a waxy water repellent on it upper side, this is so it's stomata don't get blocked.
- Leaves are large because they collect sunlight to photosynthesis.
- Roots are in the mud, below the water line. Mud keeps the roots moist and keeps them nourished with nutrients.
- Its roots and long stems collect the oxygen in the water.



- well adapted to resist the shearing and tearing caused by water
- Roots are poorly developed and root hairs are absent or scarcely present
- Stomata is absent in submerged hydrophytes however the leaves of floating hydrophytes bear stomata on upper surface.
- **submerged plants lack strong water transport system (in stems);**
- **instead water, nutrients, and dissolved gases are absorbed through the leaves directly from the water.**

Aquatic Plants

- 1) Floating Plants:
  - These are light, spongy and float on the surface of the water.

Duckweed

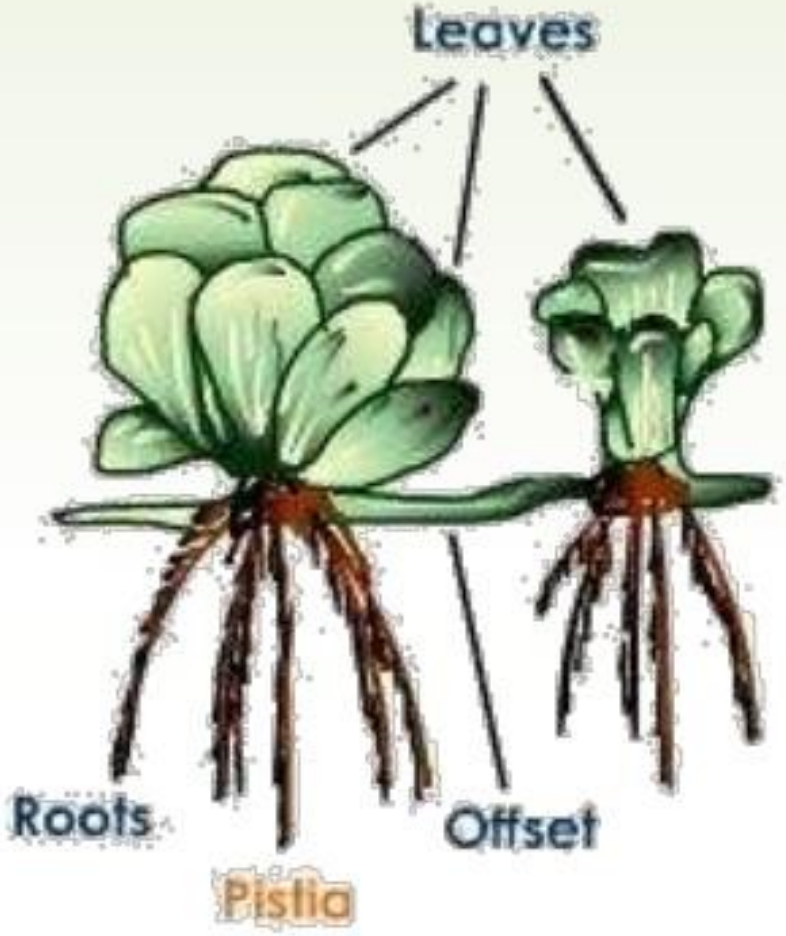
Water hyacinth

Floating plants chlorophyll is restricted to upper surface of leaves (part that the sunlight will hit)

The upper surface is waxy to repel water

Some plants produce seeds that can float

Pistia (Water cabbage)

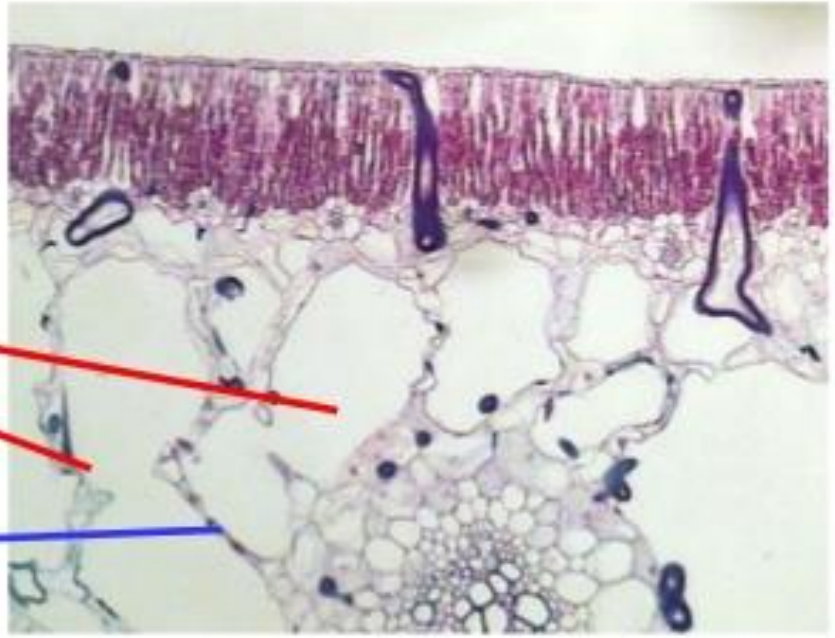


- Free floating aquatic plant
- Leaf are found in rosette manner
- It form cup like structure in nodal portion
- Cluster of adventious root arise from nodal portion

Biggest problem for hydrophytes is: obtaining oxygen for respiration

Mesophyll layer

- has *large air spaces: lacunae*
- is made up of aerenchyma



Lacuna - helps to:

I) allow oxygen to diffuse to the submerged leaves
II) provide buoyancy

Anatomical adaptations in hydrophytes

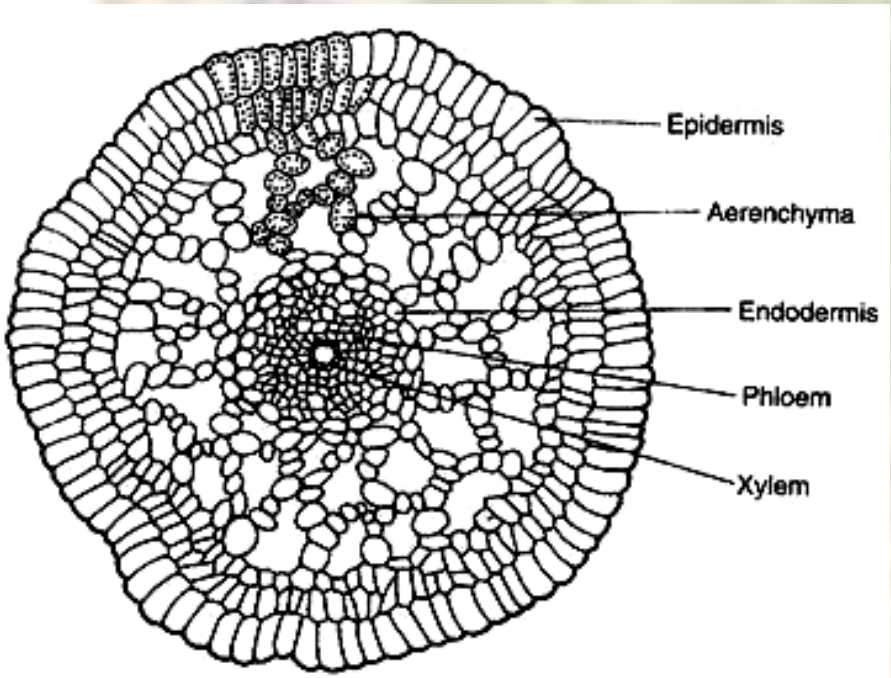


Fig. 8.8. T.S. of *Hydrilla* stem.

- They need not to develop extensive water conducting system (i.e. xylem) to transport minerals and water
- Epidermis do not possess cuticle and epidermal cell absorb oxygen and dissolved salts from water.
- Cortex is wide and possess air spaces
- Hypodermis and mechanical tissue are absent.
- In leaves no differentiation between mesophyll and palisade tissue is seen.
- Leaf mesophyll possess well developed air spaces

Mesophytes

- Grass lands
- Forests temprate
- Forest deciduous

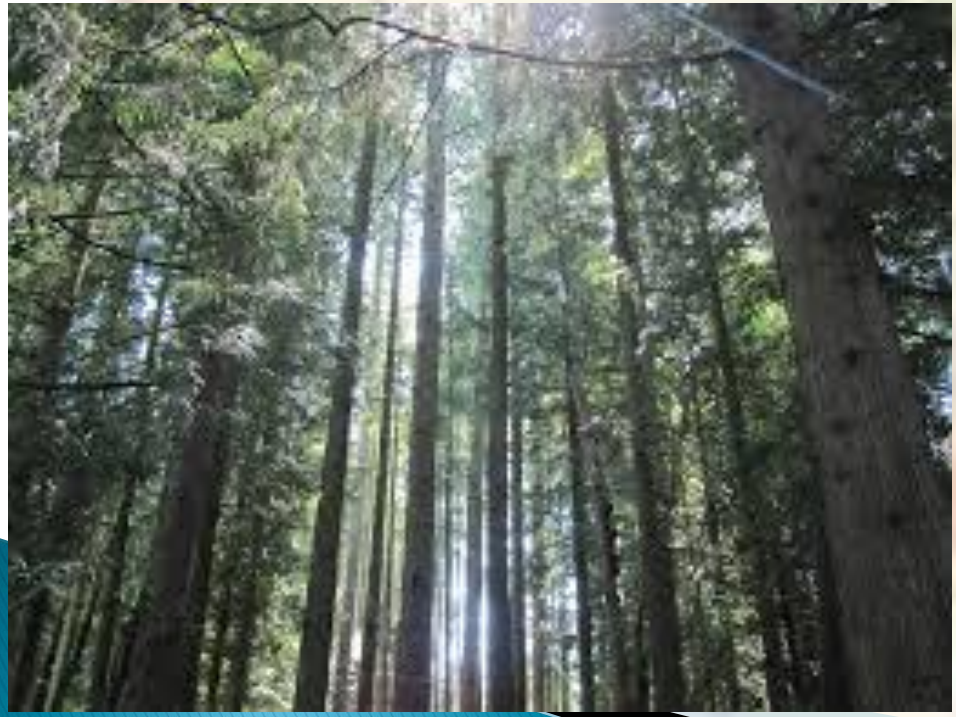
The Temperate Grasslands

- The temperate grasslands, also called prairie, feature hot summers and cold winters.
- Rainfall is uncertain and drought is common.
- The temperate grasslands usually receive about 10 to 30 inches of precipitation per year.
- The soil is extremely rich in organic material due to the fact that the above-ground portions of grasses die off annually, enriching the soil.
- The area is well-suited to agriculture, and few original prairies survive today.

- Some prairie trees have thick bark to resist fire
- **Prairie shrubs readily resprout after fire**
- Roots of prairie grasses extend deep into the ground to absorb as much moisture as they can
- Extensive root systems prevent grazing animals from pulling roots out of the ground
- Prairie grasses have narrow leaves which lose less water than broad leaves
- Grasses grow from near their base, not from tip, thus are not permanently damaged from grazing animals or fire
- Many grasses take advantage of exposed, windy conditions and are wind pollinated
- Soft stems enable prairie grasses to bend in the wind

Temprate rain forest

- **The Temperate Rain Forest** The temperate rain forest features minimal seasonal fluctuation of temperature:
- the winters are mild and the summers cool.
- The temperate rain forest receives a lot of precipitation, about 80 to 152 inches per year.
- Condensation from coastal fogs also add to the dampness. The soil is poor in nutrients.
- Large evergreen trees, some reaching 300 feet in height, are the dominant plant species.



Temprate rainforest

- Epiphytes such as mosses and ferns grow atop other plants to reach light.
- cool temperatures lead to slow decomposition but seedlings grow on "nurse logs" to take advantage of the nutrients from the decomposing fallen logs.
- trees can grow very tall due to amount of precipitation.

The Temperate Deciduous Forest

- There are four distinct seasons in the temperate deciduous forest: spring, summer, autumn, and winter.
- The temperature varies from hot in the summer to below freezing in the winter.
- Rain is plentiful, about 30 to 50 inches per year.
- The temperate deciduous forest is made up of layers of plants; the number of layers depends upon factors such as climate, soil, and the age of the forest.
- The tallest trees make up the forest canopy which can be 100 feet or more above the ground.
- Beneath the canopy, the understory contains smaller trees and young trees.
- These understory trees are more shade tolerant than canopy trees.
- Below the understory is a shrub layer.
- Carpeting the forest floor is the herb layer made up of wildflowers, mosses,and ferns.
- Fallen leaves, twigs, and dried plants cover the ground, decompose, and help add nutrients to the topsoil.

Adaptations

- wildflowers grow on forest floor early in the spring before trees leaf-out and shade the forest floor
- many trees are deciduous (they drop their leaves in the autumn, and grow new ones in spring).
- Most deciduous trees have thin, broad, light-weight leaves that can capture a lot of sunlight to make a lot of food for the tree in warm weather;
- when the weather gets cooler, the broad leaves cause too much water loss and can be weighed down by too much snow, so the tree drops its leaves.
- New ones will grow in the spring.
- trees have thick bark to protect against cold winters

The Taiga

- Also know as boreal forests,
- the taiga is dominated by conifers (cone-bearing plants), most of which are evergreen (bear leaves throughout the year).
- The taiga has cold winters and warm summers.
- Some parts of the taiga have a permanently frozen sublayer of soil called permafrost.
- Drainage is poor due to the permafrost or due to layers of rock just below the soil surface, and together with the ground carved out by receding glaciers, lead to the development of lakes, swamps, and bogs.
- The taiga receives about 20 inches of precipitation per year. The soil is acidic and mineral-poor. It is covered by a deep layer of partially-decomposed conifer needles.

Adaptations in taiga plants

- many trees are evergreen so that plants can photosynthesize right away when temperatures rise
- many trees have needle-like leaves which shape loses less water and sheds snow more easily than broad leaves
- waxy coating on needles prevent evaporation
- needles are dark in color allowing more solar heat to be absorbed
- many trees have branches that droop downward to help shed excess snow to keep the branches from breaking

Tundra environment

- The tundra is cold year-round—it has short cool summers and long, severe winters.
- The tundra has a permanently frozen sublayer of soil called permafrost.
- Drainage is poor due to the permafrost and because of the cold, evaporation is slow.
- The tundra receives little precipitation, about 4 to 10 inches per year, and what it does receive is usually in the form of snow or ice.
- It has long days during the growing season, sometimes with 24 hours of daylight, and long nights during the winter.
- There is little diversity of species.
- Plant life is dominated by mosses, grasses, and sedges.

Tundra adaptations

PLANT ADAPTATIONS

- **Functional:**
  - Small shrubs and mosses that grow low to the ground to keep from freezing
  - Grow in clumps to protect one another from the wind and cold
- **Structural:**
  - Dark in color to absorb solar heat
  - Shallow roots to not have to penetrate ice

- Tundra plants are small (usually less than 12 inches tall).
- low-growing due to lack of nutrients, because being close to the ground helps keep the plants from freezing, and because the roots cannot penetrate the permafrost.
- Plants are dark in color—some are even red—this helps them absorb solar heat.
- Some plants are covered with hair which helps keep them warm.
- Some plants grow in clumps to protect one another from the wind and cold.
- Some plants have dish-like flowers that follow the sun, focusing more solar heat on the center of the flower, helping the plant stay warm.