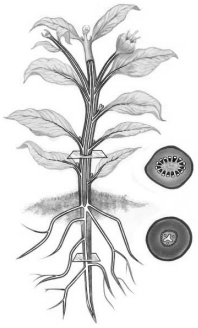
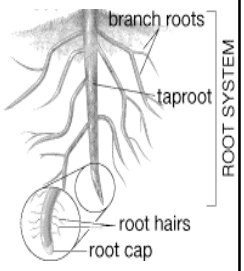
Chapter 43:
Plant Form and Function



Gross Anatomy of a typical plant
(Angiosperm = Flowering Plant):

Root System

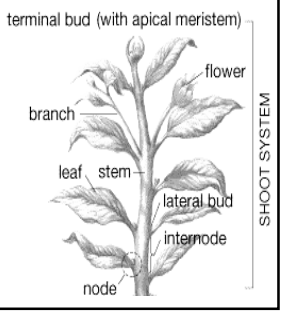
- Anchor plant
- Absorb water / nutrients
- Store surplus sugars
- Transport materials from / to shoot
- Produce hormones (minor site)
- House soil fungi / microorganisms



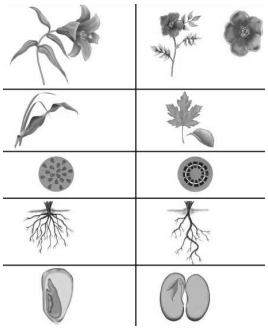
Gross Anatomy of a typical plant
(Angiosperm = Flowering Plant):

Shoot System (leaves, flowers, fruits)

- Photosynthesis
- Transport materials
- Reproduction
- Hormone synthesis (major site)



Groups of Flowering Plants:



1) Monocots	2) Dicots
• Flower parts in multiples of threes	• Flower parts in multiples of fours & fives
• Leaves smooth, narrow (parallel veins)	• Leaves oval (net-like veins)
• Vascular bundles scattered	• Vascular bundles form ring
• Fibrous root system	• Taproot system
• Embryo has one seed leaf	• Embryo has two seed leaves

(Figure 42.2)

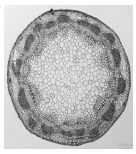
Codyledon = seed leaf

Alright, a quick quiz!

- Form groups if you want, or work alone.
- Get out a sheet of paper
- Tell me what each of the follow pictures are: monocot or dicot?

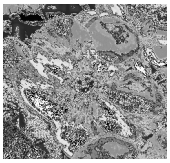
Monocot or dicot?

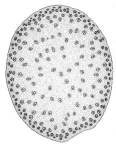
1. 

2. 

3. 

4. 

5. 

6. 

Plant Growth:

1) Indeterminate Growth: Grow throughout life (no stable size)

2) Growth occurs at tips of roots / branches

Growth patterns due to cell distribution in plant:

1) Meristem Cells: Embryonic cells capable of mitosis
   - Cell division results in plant growth
   - Located at tips of roots / branches

2) Differentiated Cells: Cells specialized in structure and function
   - Form stable, permanent part of plant

Forms of Plant Growth:

1) Primary Growth:

- Apical Meristems: Mitotic cells located at the ends of roots / stems

Responsible for:

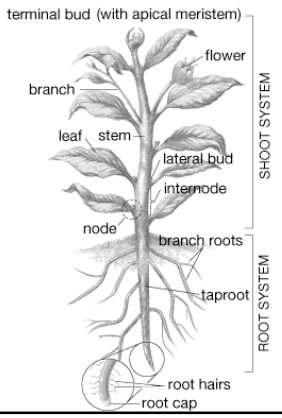
1) Increased length in roots/stems

2) Development of specialized structures (e.g. fruits)

2) Secondary Growth:

- Lateral Meristems (Cambia): Mitotic cells lining stems and roots

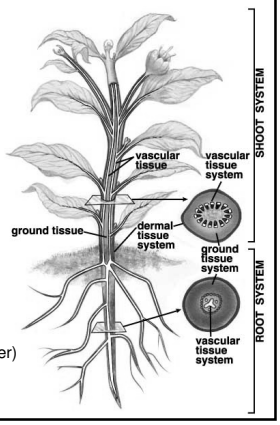
Responsible for increases in stem/root diameter



(Figure 42.1)

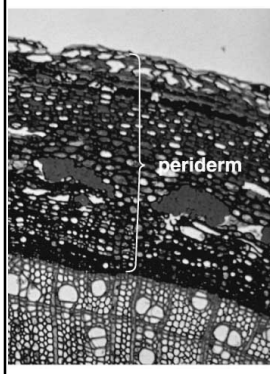
Tissue Systems in Plants:

1) Dermal Tissue System
   - Outer surface covering
   - Protection
2) Ground Tissue System
   - "Body" of plant
   - Photosynthesis; storage; support
3) Vascular Tissue System
   - "Vessels" throughout plant
   - Transports materials (e.g. water)



Dermal Tissue System (Outer Covering of Plant):

1) Epidermal Tissue:
   - Forms outermost layer of herbaceous plants (epidermis)
     - ❖ Cuticle: Waxy covering on above ground structures
       - Reduces water evaporation
       - Inhibits microorganism invasion
     - ❖ Root Hairs: Extensions from root surface
       - Increase absorptive area of root
2) Peridermal Tissue (periderm):
   - Found only in woody plants ("bark = dead cells")
   - Offers protection; support

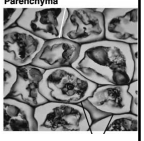


(Figure 42.4)

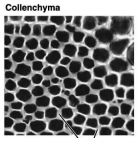
Ground Tissue System ("Body" of Plant):

1) Parenchyma (most abundant):
   - Thin-walled cells; living at maturity
   - Perform metabolic activities:
     - Photosynthesis; hormone secretion; sugar storage
2) Collenchyma:
   - Thick-walled walls (uneven); living at maturity
   - Offers support (flexible but strong - e.g. celery)
3) Sclerenchyma:
   - Thick, hard-walled cells; Dead at maturity
   - Offer support (e.g. hemp fibers; nut shells)

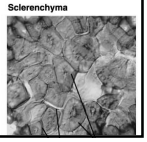
Parenchyma



Collenchyma

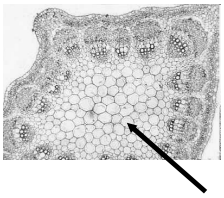


Sclerenchyma

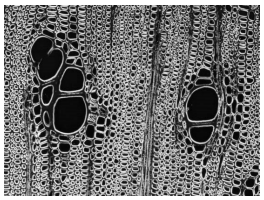


Vascular Transport System (Transport materials in plant):

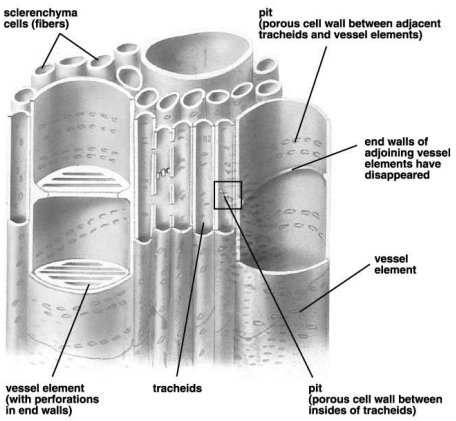
1) Xylem (aka Pith):
   - Conducts water and minerals from roots to shoots:
     A) Tracheids: Narrow, tube-like cells; dead at maturity
     B) Vessel Elements: Wide, tube-like cells; dead at maturity
        - Plants vary in relative number of each cell type



Xylem cross section of a oak tree



Xylem:



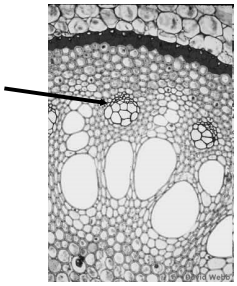
(Figure 42.6)

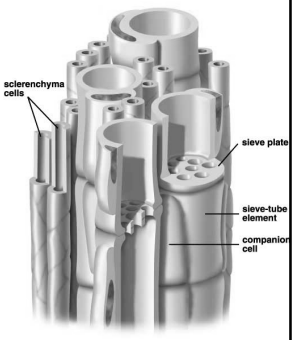
Vascular Transport System (Transport materials in plant):

1) Xylem:
   - Conducts water and minerals from roots to shoots:
     A) Tracheids: Narrow, tube-like cells; dead at maturity
     B) Vessel Elements: Wide, tube-like cells; dead at maturity
        - Plants vary in relative number of each cell type

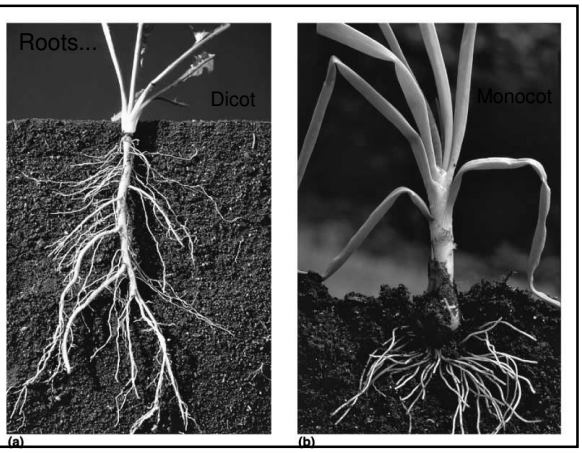
2) Phloem
   - Transports water, sugar, amino acids, and hormones
     A) Sieve Tubes: Wide, tube-like cells; living at maturity
     B) Companion Cells:
        - Sustain sieve tubes
        - Regulate sugar passage into/out of sieve tubes

Phloem:





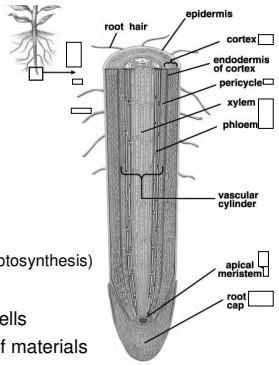
(Figure 42.7)



Roots (Anchorage, Absorption, & Storage):

1) Root Cap
   - Located at tip of root
   - Protects apical meristem
2) Epidermis (dermal tissue)
   - Outermost covering of root
   - Highly permeable to water
3) Cortex
   - Interior of root
     - A) Parenchyma Tissue
       - Store sugars (from photosynthesis)
     - B) Endodermis
       - Ring of close-fitting cells
       - Regulates passage of materials

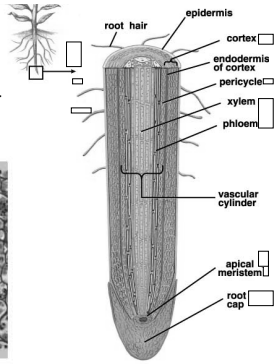
Dicot

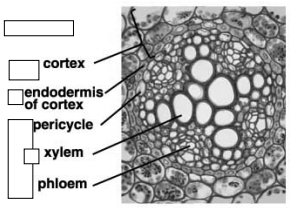


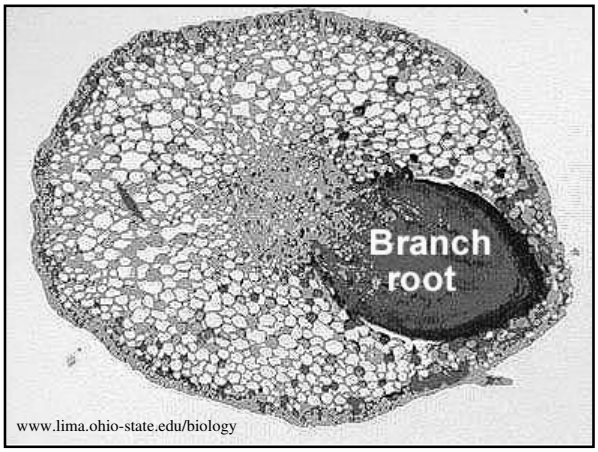
Roots (Anchorage, Absorption, & Storage):

4) Vascular Cylinder
   - Inner portion of root
   - Contains xylem / phloem
   - Pericycle: Outermost layer
     - Forms branch roots

Dicot





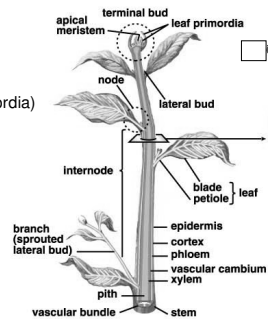


Stem (Extension to Light):

External Anatomy

1) Terminal Bud
   - Apical meristem
   - Developing leaves (leaf primordia)

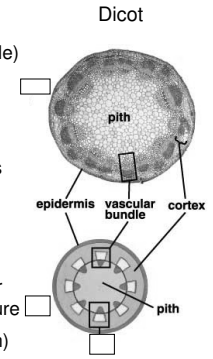
2) Lateral Buds
   - Develop into branches
   - Located at Nodes



Stem (Extension to Light):

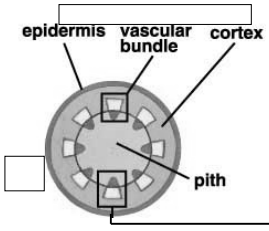
1) Epidermis (dermal tissue)
   - Outermost layer; waxy coating (cuticle)
   - Reduces water loss
   - Stomata present (gas exchange)

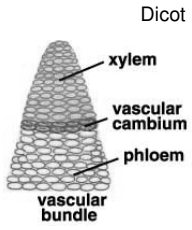
2) Cortex & 3) Pith (ground tissue)
   - Cortex: Located under epidermis
   - Pith: Located central to cortex
   - Functions:
     1) Support
        - Central vacuoles fill with water which increases turgor pressure
     2) Storage (convert sugar to starch)
     3) Photosynthesis (chloroplasts)



Stem (Extension to Light):

4) Vascular Tissue
   - Xylem / Phloem
   - Vascular Cambium: Meristematic tissue that produces new xylem / phloem

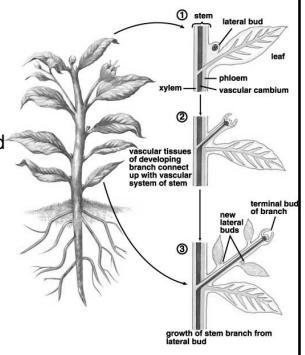




Stem (Extension to Light):

Branch Formation:

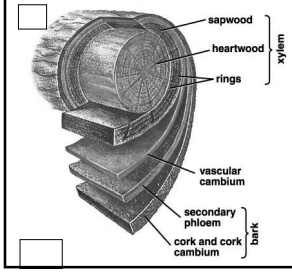
- Develop from lateral buds
  - Located at nodes
- Dormant meristem activated
  - Triggered by hormones
- Development similar to stem



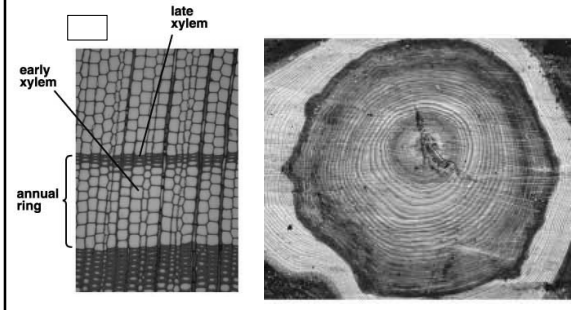
Stem (Extension to Light):

Secondary Growth in Stems:

- Stems thicken due to growth of two lateral meristems:
  1) Vascular Cambium:
     - Located between primary xylem and primary phloem



- Inward growth = Secondary xylem
  - Sapwood = Young xylem
    - H_2O transportation
  - Heartwood = Old xylem
    - Support; metabolic waste
- Growth varies seasonally
  - Annual rings



Stem (Extension to Light):

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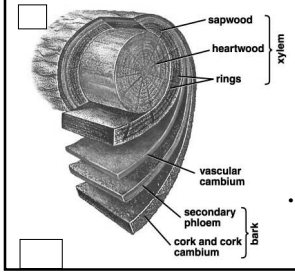
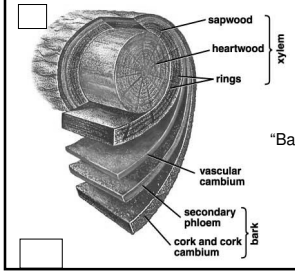


- Inward growth = Secondary xylem
  - Sapwood = Young xylem
    - H_2O transportation
  - Heartwood = Old xylem
    - Support; metabolic waste
  - Growth varies seasonally
    - Annual rings
- Outward growth = Secondary phloem
  - Only functional phloem visible

Stem (Extension to Light):

Secondary Growth in Stems:

- Stems thicken due to growth of two lateral meristems:
  2) Cork Cambium:
     - Located under outer surface; produce cork cells



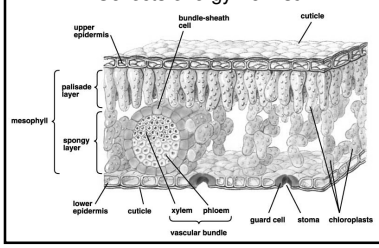
↓
Dead at maturity
Protection

"Bark" = phloem; cork cambium & cork
- Girdling (bark removal) = dead tree

Leaves (Solar Collectors):

Major photosynthetic structure for most plants:

1) Petiole: Stalk connecting leaf to stem
   - Positions leaf in space (towards sun)
2) Blade: Broad, flat surface of leaf
   - Collects energy from sun



1) Epidermis:
   - Secretes cuticle
   - Contains stomata
2) Mesophyll:
   A) Palisade cells
   B) Spongy cells
   - Contain chloroplasts
3) Vascular Bundles (Veins)
   - Branch throughout mesophyll

Nutrient Acquisition:

Nutrient = Elements essential to life

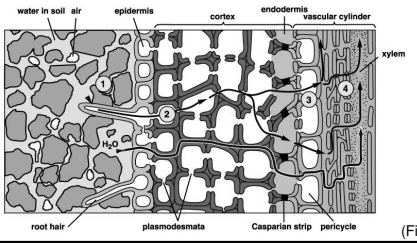
Plants need:

1) Carbon (from CO_2; air uptake)
2) Oxygen (from O_2 & H_2O; air/soil uptake)
3) Hydrogen (from H_2O; soil uptake)
4) Phosphorus (soil uptake)
5) Nitrogen (soil uptake)
6) Magnesium/calcium/potassium (soil uptake)

} Minerals

Process for Acquiring Minerals:

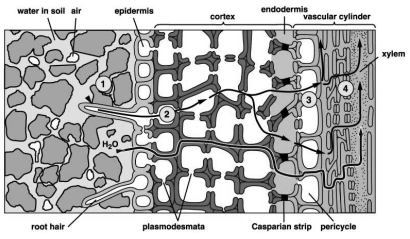
1) Minerals actively transported into root hairs
   - Requires energy (movement against concentration gradient)
2) Minerals diffuse through cytoplasm to pericycle cells
   - Cells connected via plasmodesmata



(Figure 42.19)

Process for Acquiring Minerals:

3) Minerals actively transported into extracellular space of vascular tissue from pericycle cells
4) Minerals diffuse down concentration gradient into xylem
   - Via holes in wall of tracheids / vessel tubes



Nutrient Acquisition via Symbiotic Relationships:

Symbiosis = Close association between two different organisms; usually mutually beneficial

1) Fungal mycorrhizae (Root-fungus complex): Mineral acquisition

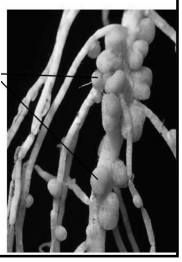
- Fungus = Helps roots absorb rock-based minerals
- Roots = Provides fungus with sugars & amino acids
- Mycorrhizae mats may allow for between plant communication

Nutrient Acquisition via Symbiotic Relationships:

Symbiosis = Close association between two different organisms; usually mutually beneficial

1) Bacteria (Root-bacteria complex): Nitrogen acquisition

- Roots = Provide bacteria with sugar
- Bacteria = Utilize sugar to fix nitrogen (nitrogen fixation)
  - $N_2 \rightarrow$ Ammonium (NH_4^+)
  - Ammonium diffuses into roots
- Bacteria housed in the cortex of the root (nodules)

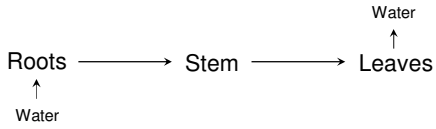


Water Acquisition (via Osmosis):

1) Enters with minerals via epidermis cells of roots
2) Enters between epidermis cells (bulk flow)

Water Transport:

Transpiration = Process which drives the movement of water through a plant



- 99% of water that is absorbed by roots is evaporated through the leaves

How Does Water Move Against Gravity?

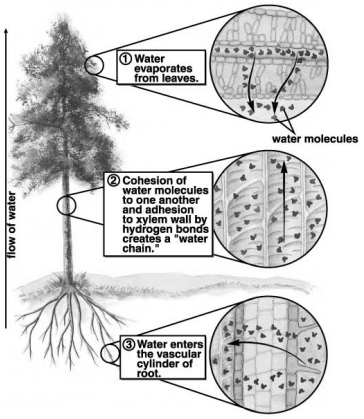
Answer: The Cohesion-tension Theory

1) Cohesion:
   - Attraction among water molecules holds water together in xylem tubes (chain-like column)
     - Water column as strong as steel wire (same diameter)

2) Tension:
   - Water column is pulled up the xylem via evaporation at leaves
     - Evaporation creates concentration gradient (water)

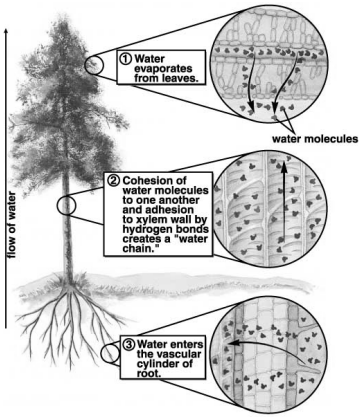
- The flow of water is unidirectional (root to shoot) - only shoots can transpire.

Cohesion-tension Theory:



(Figure 42.21)

Cohesion-tension Theory:



(Figure 42.21)

Stomata Control Rate of Transpiration:

- Open Stomata = ↑ water loss; ↑ CO_2 acquisition
- Closed Stomata = ↓ water loss; ↓ CO_2 acquisition

- Plants need to achieve balance:
  1) Light Reception:
     - Light present = stomata open
     - Light absent = stomata closed
  2) Carbon Dioxide Concentration:
     - [↓] CO_2 = stomata open; [↑] CO_2 = stomata closed
  3) Water concentration (override all else)
     - [↑] water = stomata open; [↓] water = stomata closed

Stomata Control:

- Guard Cells: Control the size of stomata opening

Regulated by potassium (K^+) concentration in guard cell:

↑ K^+ in guard cell

↓

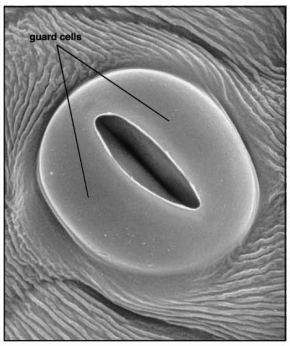
Water enters guard cell

↓

Guard cell swells

↓

Stomata opening increases



Sugar Transport:

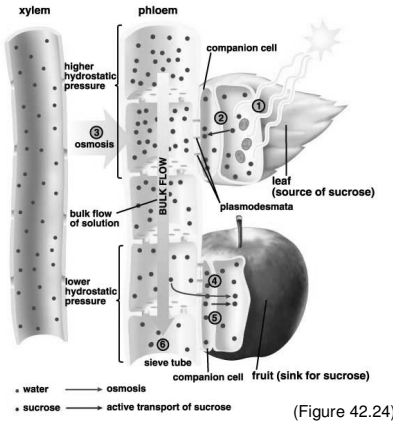
- Sieve tube fluid = ~ 15% glucose and ~ 85% water
  - Source = Location of sugar production
  - Sink = Location of sugar usage/storage

Pressure-Flow Theory:

1) Sucrose synthesized (photosynthesis)
2) Sucrose loaded into sieve tube
   - Active transport (companion cells)
3) Water enters sieve tube (follows sugar)
   - Increases pressure in tube
4) Sucrose unloaded at sink
5) Water exits sieve tube (follows sugar)
   - Decreased pressure in tube

} Hydrostatic Pressure Gradient Drives Flow

Pressure-Flow Theory:



(Figure 42.24)

Specialized Adaptations: Roots

- Food Storage
- Photosynthesis

Carrots

Specialized Adaptations: Stems

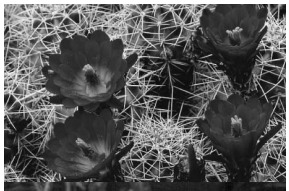
- Food/Water Storage
- Reproduction
- Protection (Thorns)
- Support (Tendrils)

Baobab Tree

Acacia thorns

Specialized Adaptations: Leaves

Desert Cactus



- Protection (Spines)
- Capture Prey
- Food/Water Storage

Venus Flytrap