Chapter 29

Plant Diversity I
How Plants Colonized Land

- **Concept 29.1: Land plants evolved from green algae**
- ***Charophyceans*** closest relatives of land plants

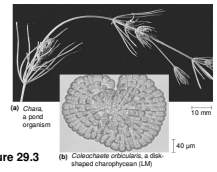


Figure 29.3

Morphological and Biochemical Evidence

- There are five key traits that land plants share only with charophyceans
  - Similarities in cell wall synthesis
  - Peroxisome enzymes
  - Structure of sperm
  - Similarities during cell division
  - Homologous chloroplast

Adaptations Enabling the Move to Land

- In charophyceans
  - *Sporopollenin* prevents exposed zygotes from drying out

Derived Traits of Land Plants: Figure 29.5

- Five key traits appear in nearly all land plants but are absent in the charophyceans
  - Apical *meristems*
  - *Alternation of generations*
  - Walled spores produced in *sporangia*
  - Multicellular *gametangia*
  - Multicellular *dependent embryos*

Apical Meristems

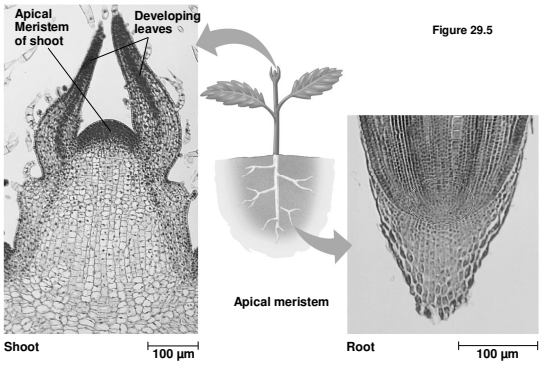
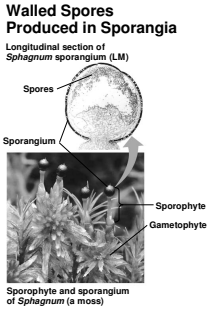
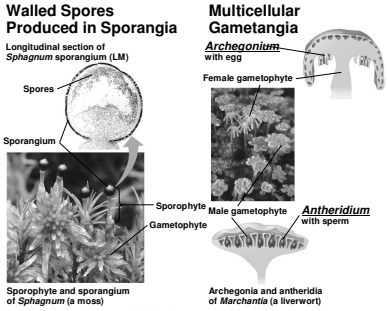


Figure 29.5

Walled Spores

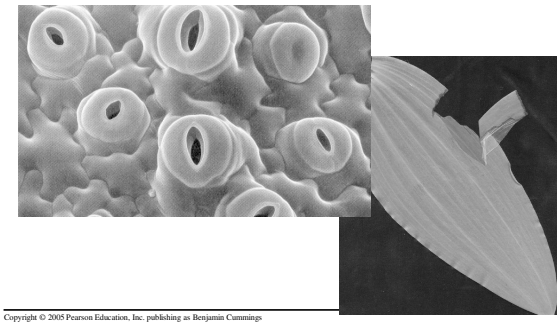


Muticellular Gametangia: gamete producing organs



Additional derived units

- ***Cuticle*** and secondary compounds, evolved in many plant species



Land plants can be informally grouped

- Based on the *presence* or *absence* of vascular tissue
  - *Vascular tissue*- cells joined in tubes to transport water and nutrients
  - *Byrophytes*- non vascular plants
    - Liverworts, Hornworts and Mosses
  - *Vascular plants*
    - Seedless vascular plants
    - Seed vascular plants

What makes vascular plants vascular?

- Vascular plants have two types of vascular tissue
  - Xylem and phloem

Vascular tissue

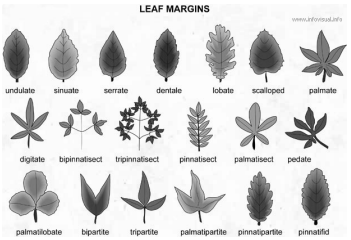
- Xylem
  - Conducts water and minerals
  - Dead cells called *tracheids*
- Phloem
  - Distributes sugars, amino acids, and other organic products
  - Consists of living cells

Evolution of Roots

- Roots
  - Are organs that anchor vascular plants
  - Absorb water and nutrients from the soil

Evolution of Leaves

- Leaves
  - Increase surface area to capture solar energy



Chapter 30

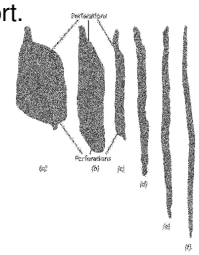
Plant Diversity III: The Evolution of Seed Plants

Characteristics of Angiosperms

- The key adaptations
  - Specialized xlyem for water transport
  - ***Fiber*** is second specialized cells in angiosperms for support.

Xylem: Vessel elements and Tracheids

- ***Tracheids***- elongated, tapered cells for support and water movement (gymnosperms)
- ***Vessel elements***- shorter wider cells for water movement and *less* for support. (angiosperms)



Characteristics of Angiosperms

- The key adaptations
  - Are flowers and fruits
  - Specialized for sexual reproduction

Fruits typically consists of a mature ovary

- Ovary wall thickens into ***pericarp***
  - Mature fruits can be either fleshy or dry

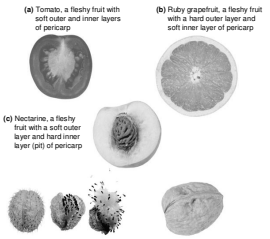


Figure 30.8a–e

Interesting fruits: Kopi luwak **or** civet coffee

- coffee made from the beans of coffee berries which have been eaten by the Asian Palm Civet
- passed through its digestive tract.
- civet eats the berries for their fleshy pulp. In its stomach, proteolytic enzymes seep into the beans, making shorter peptides and more free amino acids. Passing through a civet's intestines the beans are then defecated, having kept their shape.
- After gathering, thorough washing, sun drying, light roasting and brewing, these beans yield an aromatic coffee with much less bitterness, widely noted as the most expensive coffee in the world.

Interesting fruits: Red delicious apples

- The Red Delicious originated at an orchard in 1880 as "a round, blushed yellow fruit of surpassing sweetness".
- Stark Nurseries held a competition in 1892 to find an apple to replace the Ben Davis apple. The winner was a red and yellow striped apple sent by Jesse Hiatt, a farmer in Peru, Iowa, who called it "Hawkeye".

Enhancing seed dispersal

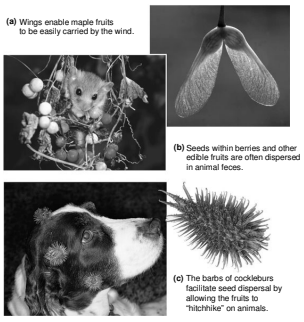
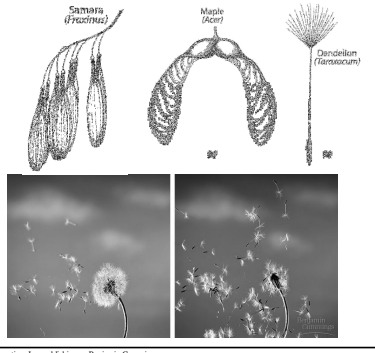


Figure 30.9a–c

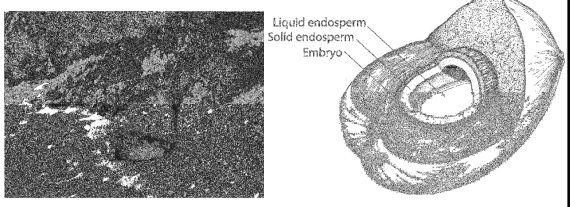
Enhancing seed dispersal

- ***Wind***, water, or animals to new locations.



Enhancing seed dispersal

- Wind, ***water***, or animals to new locations.



Evolutionary Links Between Angiosperms and Animals

- Pollination of flowers and transport of seeds

(a) A flower pollinated by honeybees. (b) A flower pollinated by hummingbirds. (c) A flower pollinated by nocturnal animals.

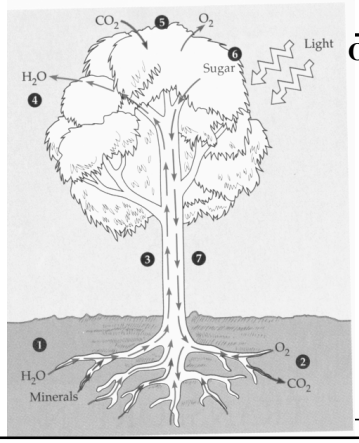
Orchids that mimic insects

- http://www.youtube.com/watch?v=-h8l3cqpgnA

Transport in Plants

Reading: Ch. 36

- Phloem
- Xylem
- Tracheid
- Structure of vascular tissues
- Root pressure
- Water potential
- Transpiration-cohesion-tension mechanism
- Radius of curvature
- Stoma(ta)
- Transpiration
- Cohesion of water
- How stoma close
- Potassium pumping
- Crassulacean acid metabolism



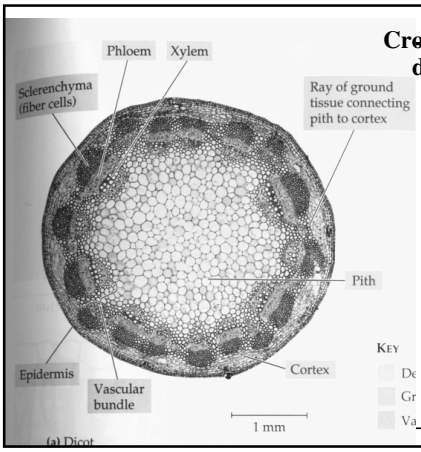
Overview

Broad themes this section illustrates

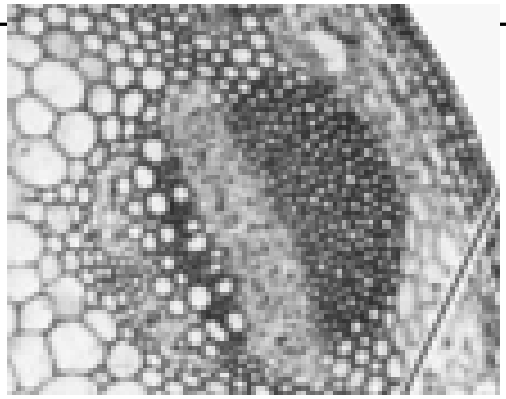
- Organisms must obey physical laws
- Size does matter and surface area to volume relationships
- Organisms have evolved special solutions to deal with environmental challenges

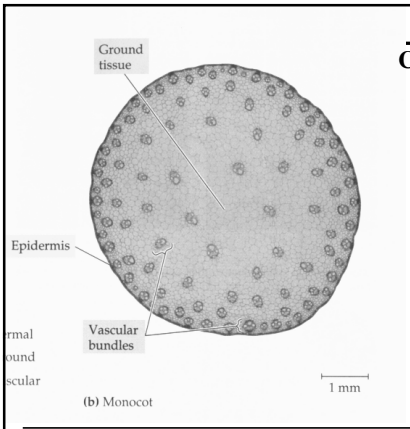
Part A: Plant vascular tissue

- Phloem
  - Sugars, etc. (sap) moving down
- Xylem
  - Water, minerals moving up
  - Tracheids and vessel elements

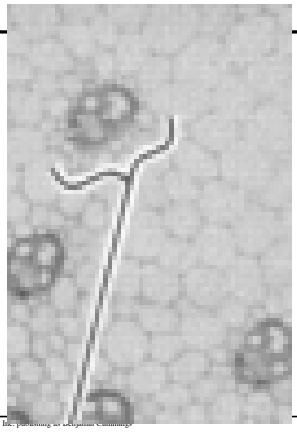


Cross-section of a dicot stem





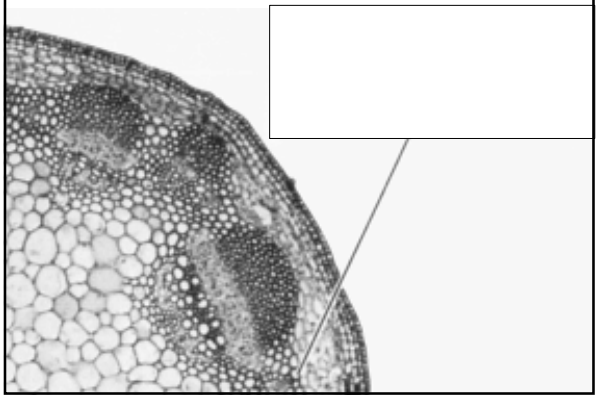
Cross-section of a monocot stem



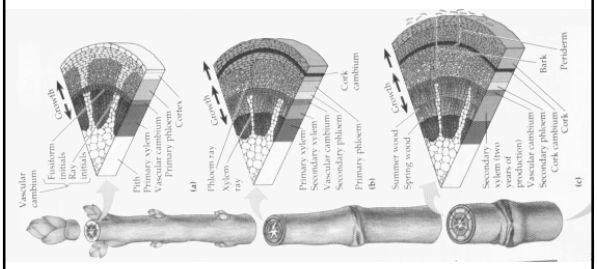
Tracheids and vessel elements

- Water-conducting elements of the xylem

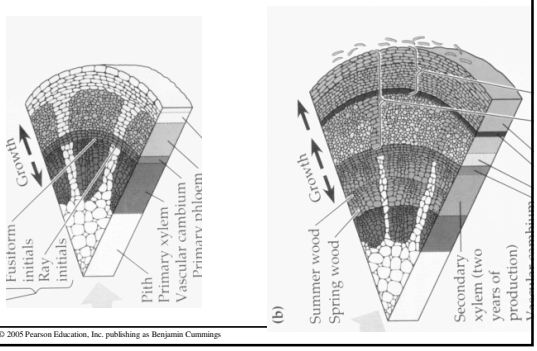
Structure of wood



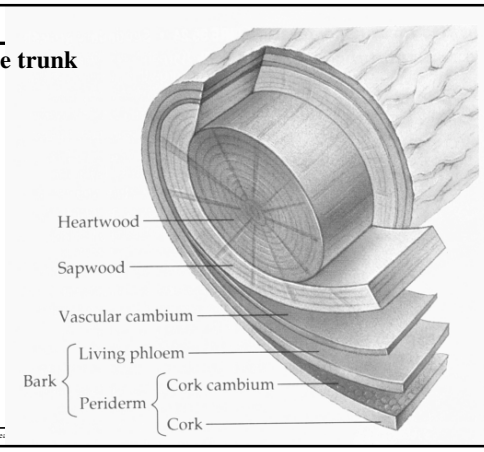
Structure of wood



Structure of wood



Tree trunk



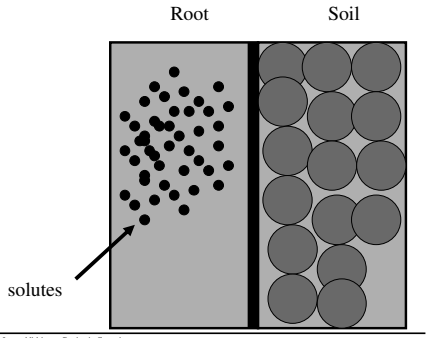
Part B: Some physical principles

The ascent of xylem sap depends mainly on transpiration and the physical properties of water

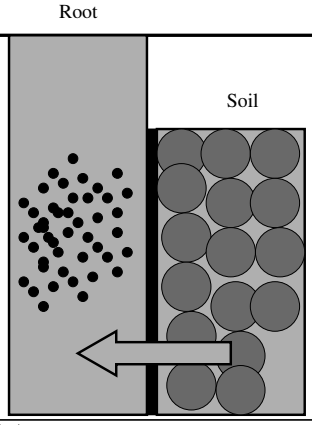
Xylem sap flow

- 15 m per hour or faster
- Maple tree in summer - 200 L of water per hour
- Must travel as high as 100 m
- Is xylem pushed or pulled?

Root pressure



Water flows in forcing fluid up



Water potential (psi, ψ)

$$\Psi = \psi_p + \psi_s$$

ψ_p = Physical Pressure

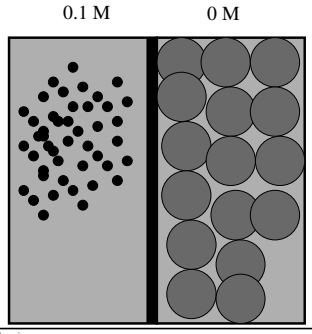
ψ_s = Osmotic Pressure

Quantifying root pressure

Ψ = -0.23 MPa

1 MPa = 147 psi

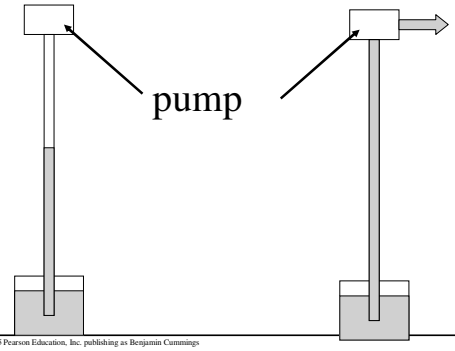
-0.23 MPa = 24 psi



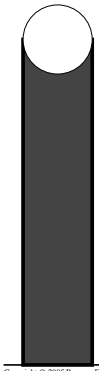
Root pressure is only sufficient to push water up a few meters in most plants

Part C: Transpiration-cohesion-tension Mechanism

The column of xylem sap must be continuous

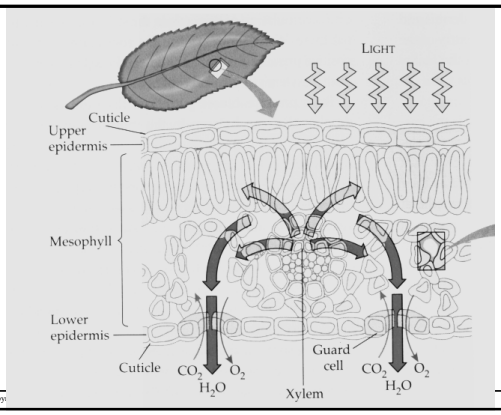


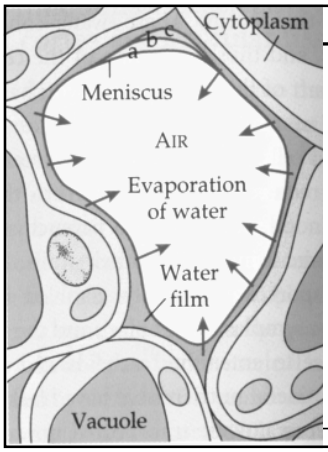
Generation of transpirational pull



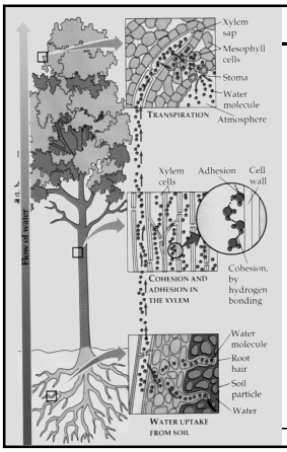
Radius Of Curvature	Hydrostatic Pressure
1 µm	-0.15 MPa
0.1	-1.5
0.01	-15

Where does transpirational pull occur?



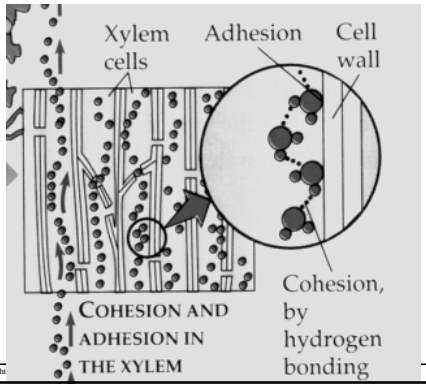


Water evaporates into spaces in mesophyll and exits via stomata. This is transpiration



Transpirational pull is transmitted from the leaves all the way to the root tips

How can a long column of water be pulled up?



How can a long column of water be pulled up?

- Cohesion of water molecules due to hydrogen bonding
- Strong adhesion of water to hydrophilic walls of xylem cells
- Small diameter of tracheids and vessel elements

During transpiration you might expect that there would be tension within the xylem

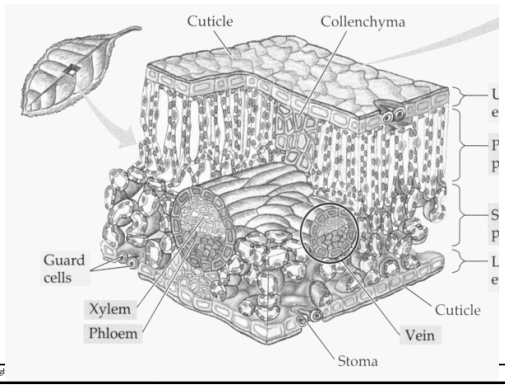
- This would pull on the walls of the xylem cells.
- A decrease in the diameter of tree trunks is actually observed on sunny days
- Walls are strong, preventing collapse. (What structural molecule contributes to this?)

Part D: The compromise between photosynthesis and water loss due to transpiration

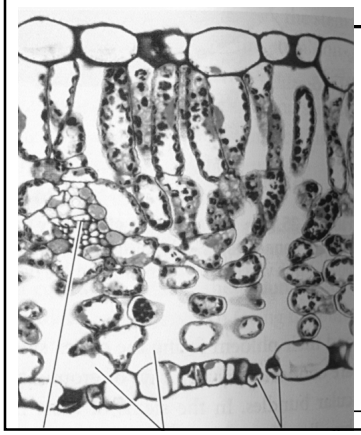
Movement of water to leaves

- Benefits: transports water and minerals, evaporative cooling (10-15 ℃)
- Costs: Water Loss

Leaf structure

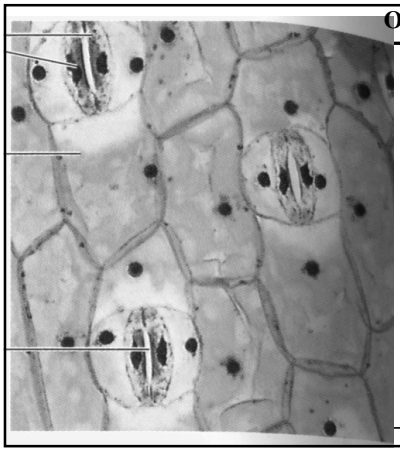


Leaf structure



You could close the leaves but then there would be no carbon dioxide available for photosynthesis

Opening and closing of leaves



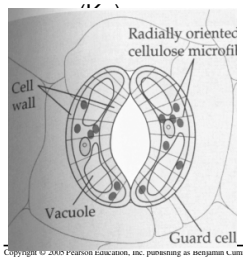
- Controlled by the stomata

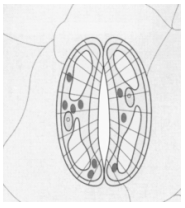
Characteristics of stomata (singular = stoma)

- On underside of leaves
- Where most of the gas exchange occurs
- Open during the day and closed at night

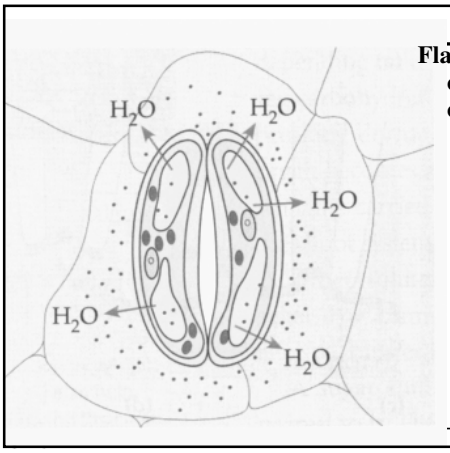
Structure of stoma and guard cells

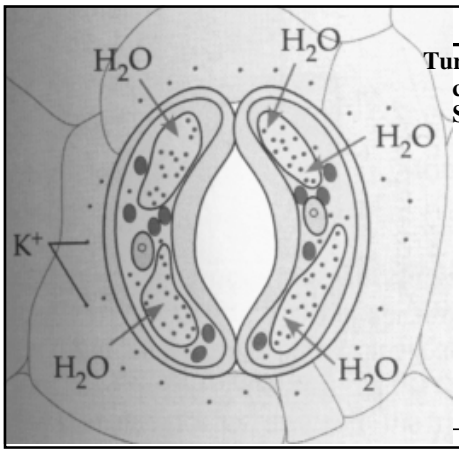
- Guard cells can be turgid or flaccid
  - This is regulated by pumping of potassium





Flaccid guard cell, stoma closed





Turgid guard cells
Stoma open

Regulation of potassium pumping

- Blue-light receptor
- Increased ATP during photosynthesis
- Carbon dioxide concentration
- Circadian rhythms

Plants from arid habitats have an elegant adaptation to avoid water loss

- Crassulacean acid metabolism (CAM)
- Stomata closed during day
- Enzymatic incorporation of carbon dioxide into organic acids at night.