Chapter 30: Plant Nutrition & Transport

Carnivorous Plants

- Capture animals to supplement their nutrient intake
- Venus flytrap lures insects with sugary bait; closes on victim
- Cobra lily lures insects down a one-way passage

Carnivorous Plants

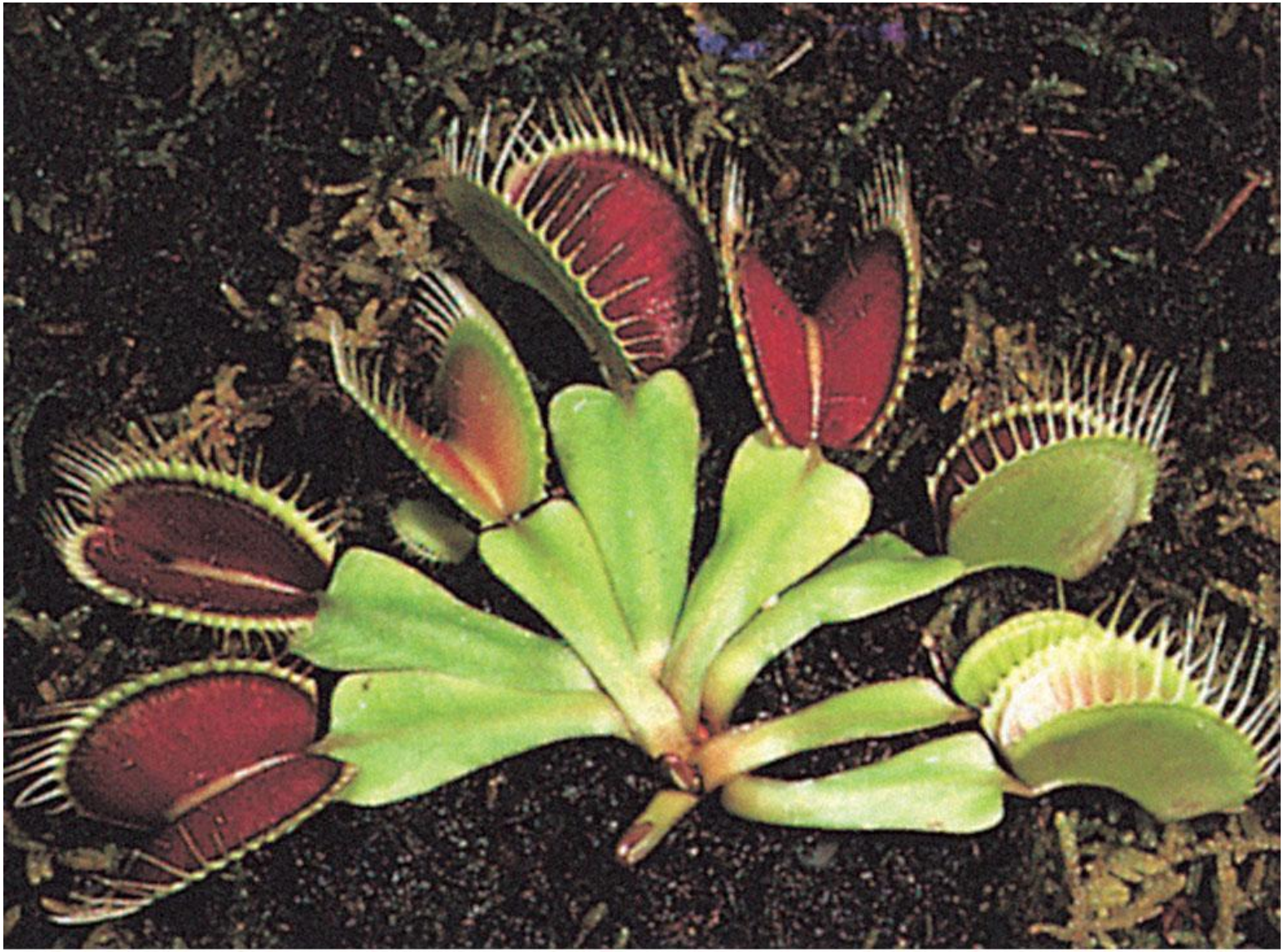


Fig. 30-18a, p.523

Plant Nutritional Requirements

- **Nearly all plants are photoautotrophs**
- **Require carbon dioxide, water, minerals**
- **Many aspects of plant structure are responses to low concentrations of these vital resources in the environment**

Table 30.1 Plant Nutrients and Symptoms of Deficiencies

Carbon Hydrogen Oxygen	No symptoms; all three macronutrients are available in abundance from water and carbon dioxide
Nitrogen	Stunted growth; young leaves turn yellow and die (these are symptoms of chlorosis)
Potassium	Reduced growth; curled, mottled, or spotted older leaves; burned leaf edges; weakened plant
Calcium	Terminal buds wither; deformed leaves; stunted roots
Magnesium	Chlorosis; drooped leaves
Phosphorus	Purplish veins; stunted growth; fewer seeds, fruits
Sulfur	Light-green or yellowed leaves; reduced growth
Chlorine	Wilting; chlorosis; some leaves die
Iron	Chlorosis; yellow, green striping in leaves of grasses
Boron	Terminal buds, lateral branches die; leaves thicken, curl, become brittle
Manganese	Dark veins, but leaves whiten and fall off
Zinc	Chlorosis; mottled or bronzed leaves; abnormal roots
Copper	Chlorosis; dead spots in leaves; stunted growth
Molybdenum	Pale green, rolled or cupped leaves

Soil

- Minerals mixed with humus
  - Minerals come from weathering of rock
  - Humus is decomposing organic material
- Composition of soil varies
- Suitability for plant growth depends largely on proportions of soil particles

Three Soil-Particle Sizes

- Sand
  - Largest particles
- Silt
  - Medium-sized particles
- Clay
  - Finest particles

Humus

- **Decomposing organic material**
- **Nutrient rich**
  - Negatively charged organic acids help humus attract positively charged minerals
- Absorbs water and swells; shrinks as it releases water
  - Helps to aerate soil

Table 30.2 What to Ask When Home Gardening Hits a Wall

1. What are the symptoms? (e.g., brown, yellow, curled, wilted, chewed leaves)
2. What is the species? Is part of one plant, a whole plant, or many plants affected?
3. Is the planting soil loose or compact? Were amendments added? Are fertilizers used, and how often?
4. Is watering by hand, hose, sprinklers, drip system? When and how often?
5. Is the plant indoors? Outdoors, in full sun or partial or full shade? In wind?
6. Dig gently to expose a few small feeder roots. Are they black and mushy (overwatering), brown and dry (not enough water), or white with a crisp "snap"?
7. Do you see insects, or insect droppings, webs, cast skins, or slime?
8. Some unique symptoms of infections rather than nutrient deficiencies:

   Viral: Leaves or petals stunted, with mottling, colored rings, distorted shapes.

   Bacterial: Tissues have a soaked, slimy texture, often a rotting smell.

   Fungal: Leaves with dry texture, discolored spots with distinct margins, usually with concentric rings (usually tan at the center, then brown, then light yellow at edge of infection).

Optimal Soil for Plant Growth

- Loam
  - Roughly equal proportions of sand, silt, and clay
- 10 to 20 percent humus

Soil Horizons

- O horizon
- A horizon - topsoil
- B horizon - less organic material, more minerals
- C horizon - no organic material

O HORIZON
Fallen leaves and other organic material littering the surface of mineral soil

A HORIZON
Topsoil, with decomposed organic material; variably deep (only a few centimeters in deserts, elsewhere extending as far as thirty centimeters below the soil surface)

B HORIZON
Compared with A horizon, larger soil particles, not much organic material, more minerals; extends thirty to sixty centimeters below soil surface

C HORIZON
No organic material, but partially weathered fragments and grains of rock from which soil forms; extends to underlying bedrock

BEDROCK

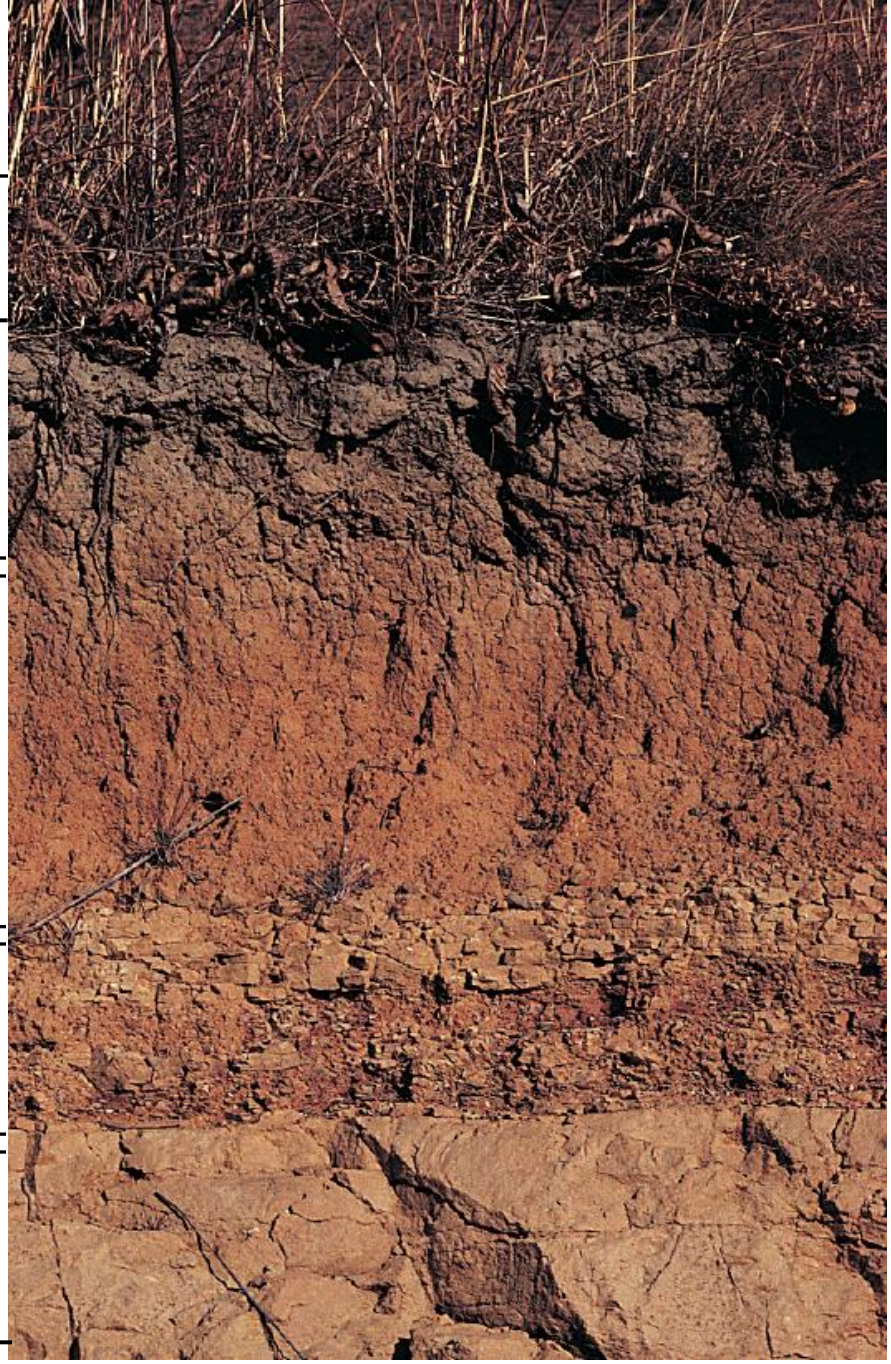


Fig. 30-2, p.513

Macronutrients

Mineral elements that are required above 0.5 percent of the plant's dry weight

Carbon	Nitrogen	Magnesium
Hydrogen	Potassium	Phosphorus
Oxygen	Calcium	Sulfur

Micronutrients

Elements that are required in trace amounts for normal plant growth

- Chlorine
- Iron
- Boron
- Manganese
- Zinc
- Copper
- Molybdenum

Leaching

- **Removal of nutrients from soil by water that percolates through it**
- Most pronounced in sandy soils
- Clays are best at holding onto nutrients

Leaching

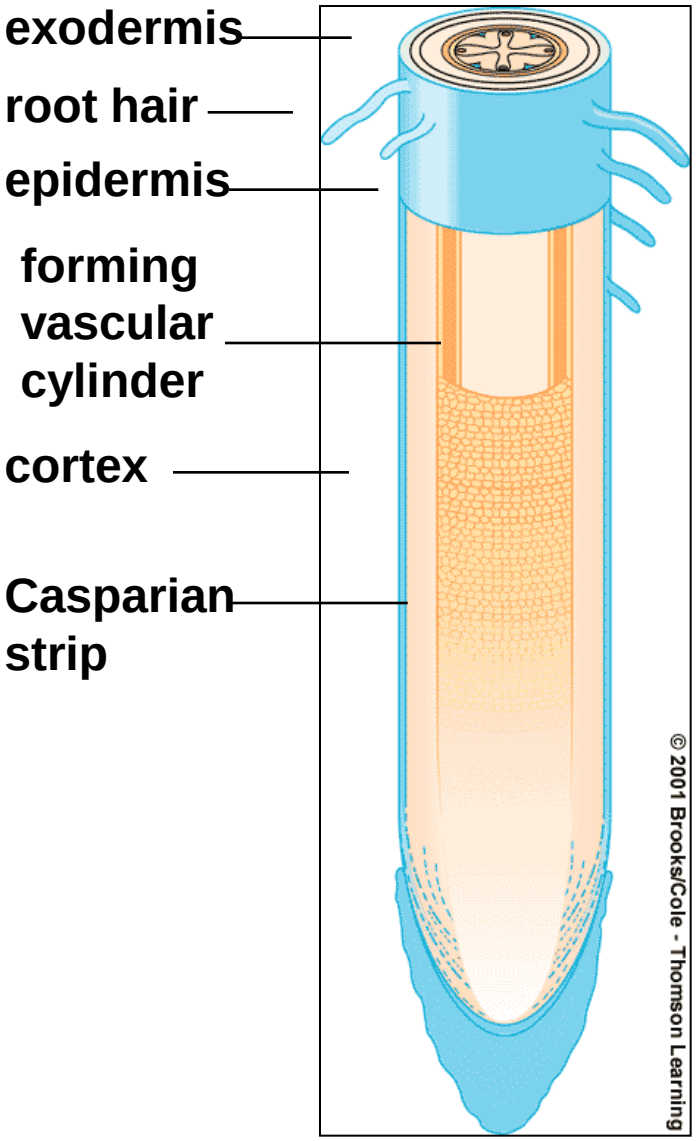
Fig. 30-3a, p.513

Root Structure & Absorption

- Roots of most flowering plants have:
  - Endodermis - surrounds vascular cylinder
  - Exodermis - just below surface
- Both layers contain a Casparian strip
  - Controls the flow of water and nutrients

Casparian Strip

- Prevents water and solutes from passing between cells into vascular cylinder
- Water and solutes must flow <u>through</u> cells
- Transport proteins control the flow



Root Hairs

- Extensions from the root epidermis

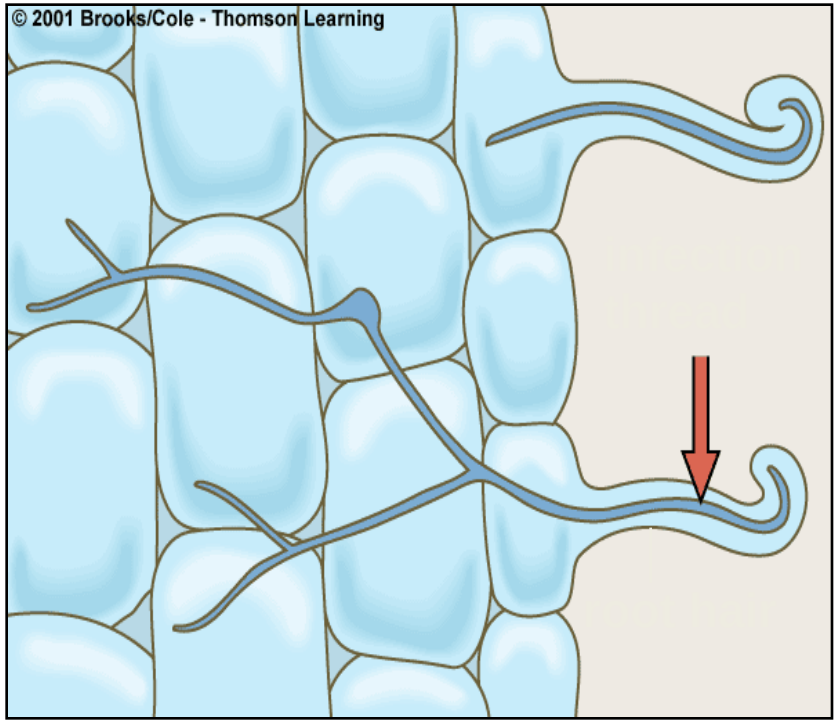
- Greatly increase the surface area available for absorption

Root Hairs

Fig. 30-5a, p.514

Root Nodules

- Swelling on the roots of some plants
- Contain nitrogen-fixing bacteria
- Bacteria convert nitrogen gas to forms that plants can use



Mycorrhizae

- **Symbiosis between a young plant root and a fungus**
- **Fungal filaments may cover root or penetrate it**
- **Fungus absorbs sugars and nitrogen from the plant**
- **Roots obtain minerals absorbed from soil by fungus**

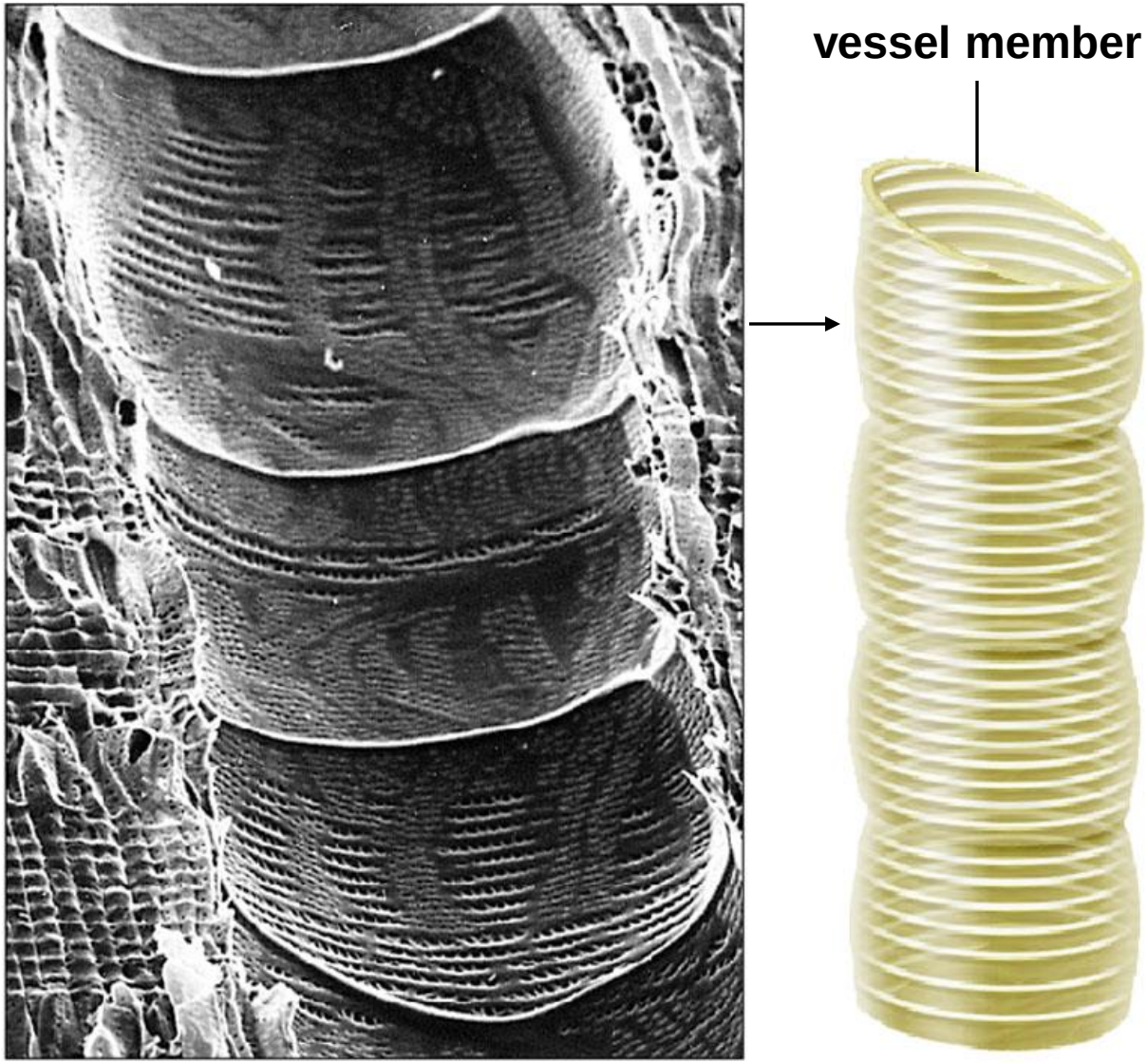
Water Use and Loss

- **Plants use a small amount of water for metabolism**
- **Most absorbed water lost to evaporation through stomata in leaves**
- **Evaporation of water from plant parts is <u>transpiration</u>**

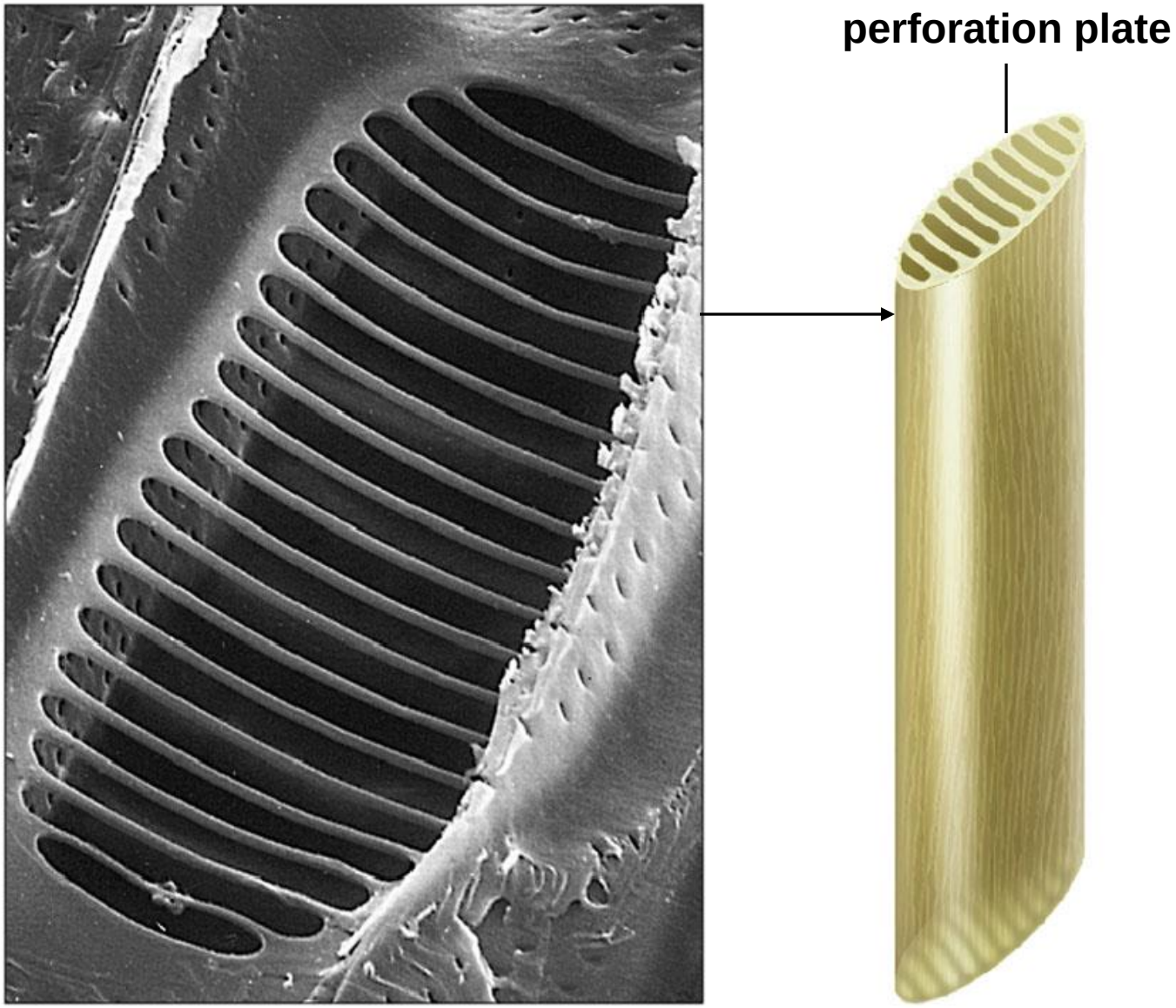
pits in tracheid

Tracheids have tapered, unperforated end walls. Pits in adjoining tracheid walls match up.

Fig. 30-7a, p.516



Three adjoining members of a vessel. Thick, finely perforated walls of these dead cells connect as long vessels, another type of water-conducting tube in xylem.



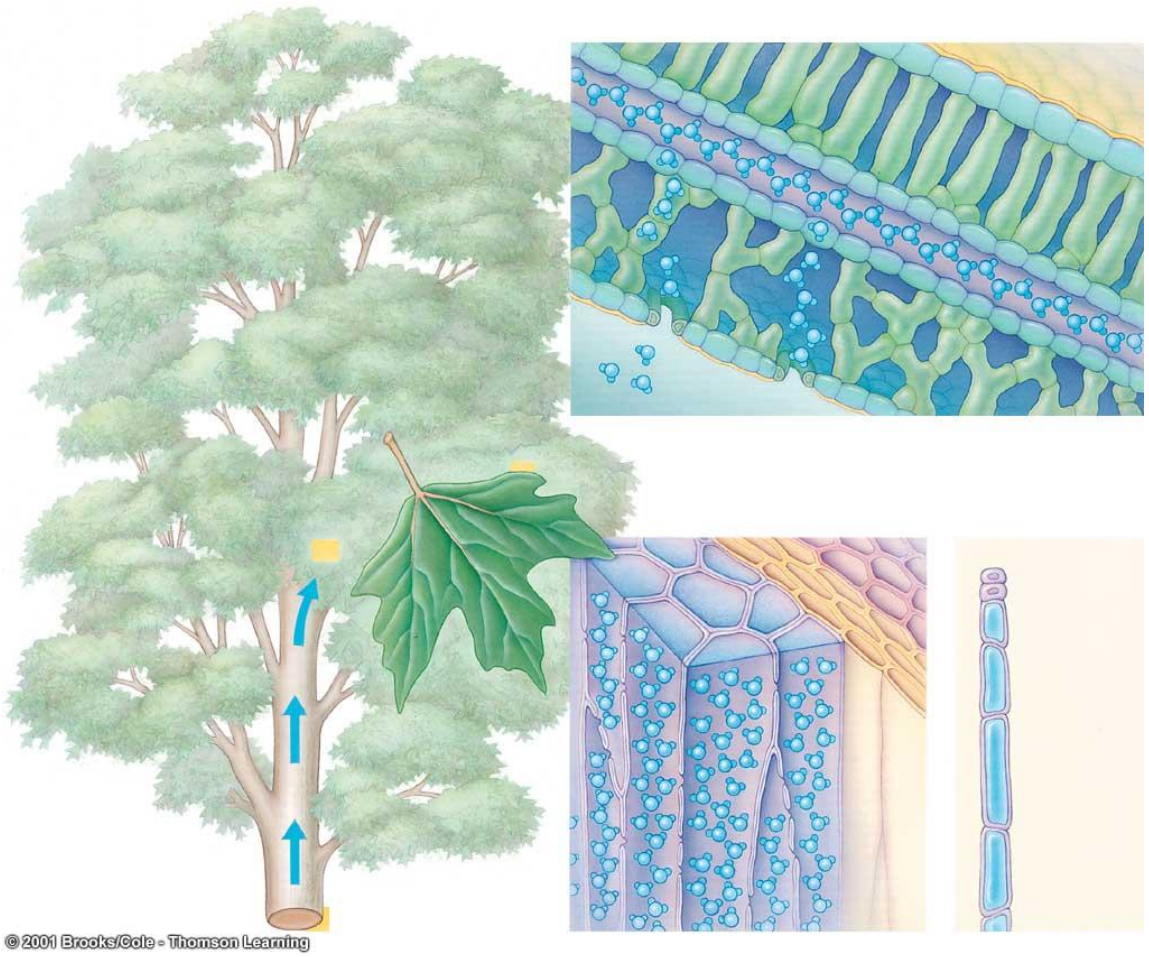
Perforation plate at the end wall of one type of vessel member. Perforated ends allow water to flow unimpeded.

Fig. 30-7c, p.516

Cohesion-Tension Theory of Water Transport

- Transpiration creates negative tensions in xylem
- Tensions extend downward from leaves to roots
- Hydrogen-bonded water molecules are pulled upward through xylem as continuous columns

Transpiration Drives Water Transport



Water evaporates from leaves through stomata

This creates a tension in water column in xylem

Figure 30.8.a,b

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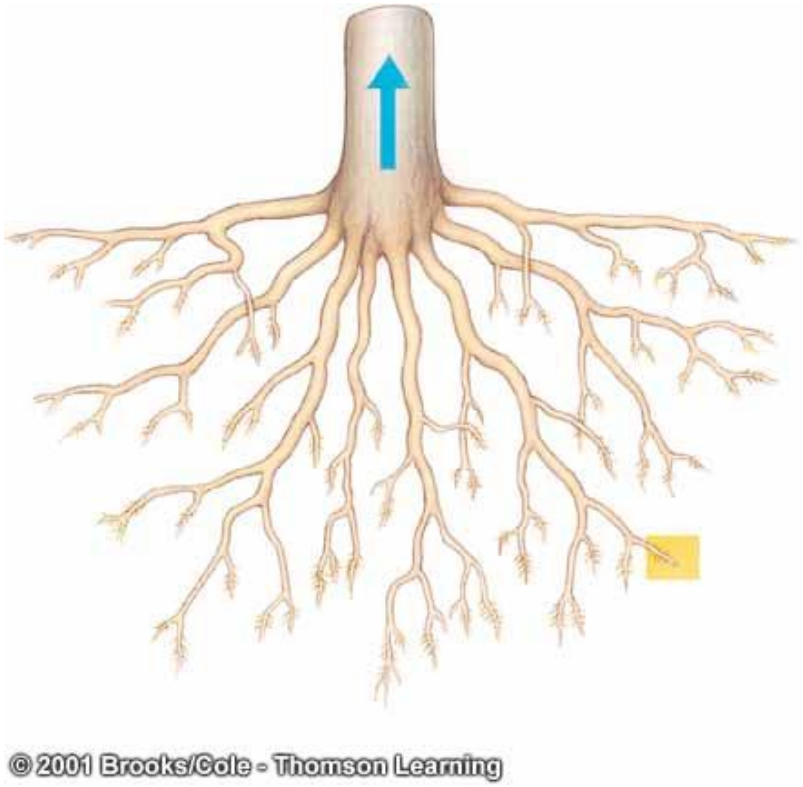
Replacement Water is Drawn in through Roots



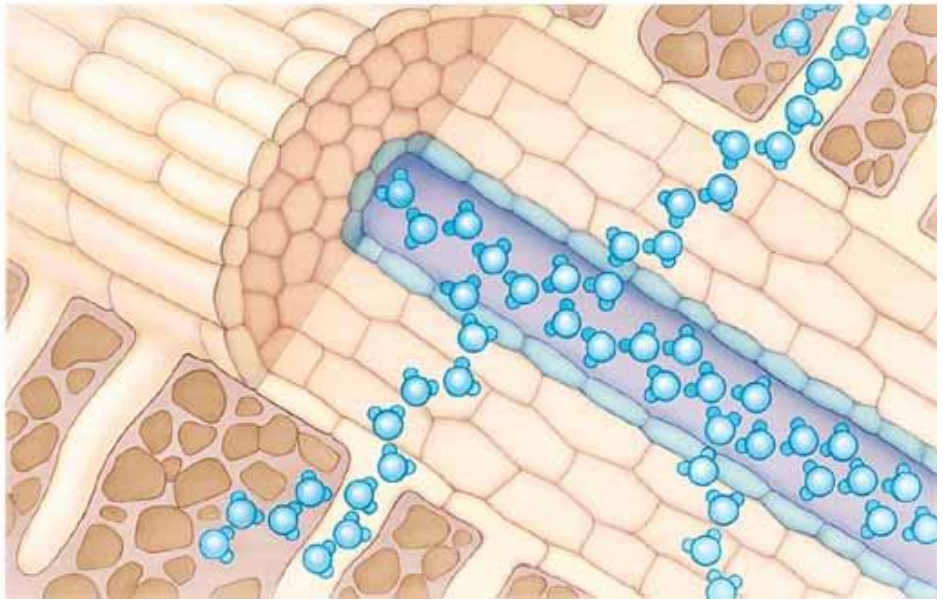


Figure 30.8.c

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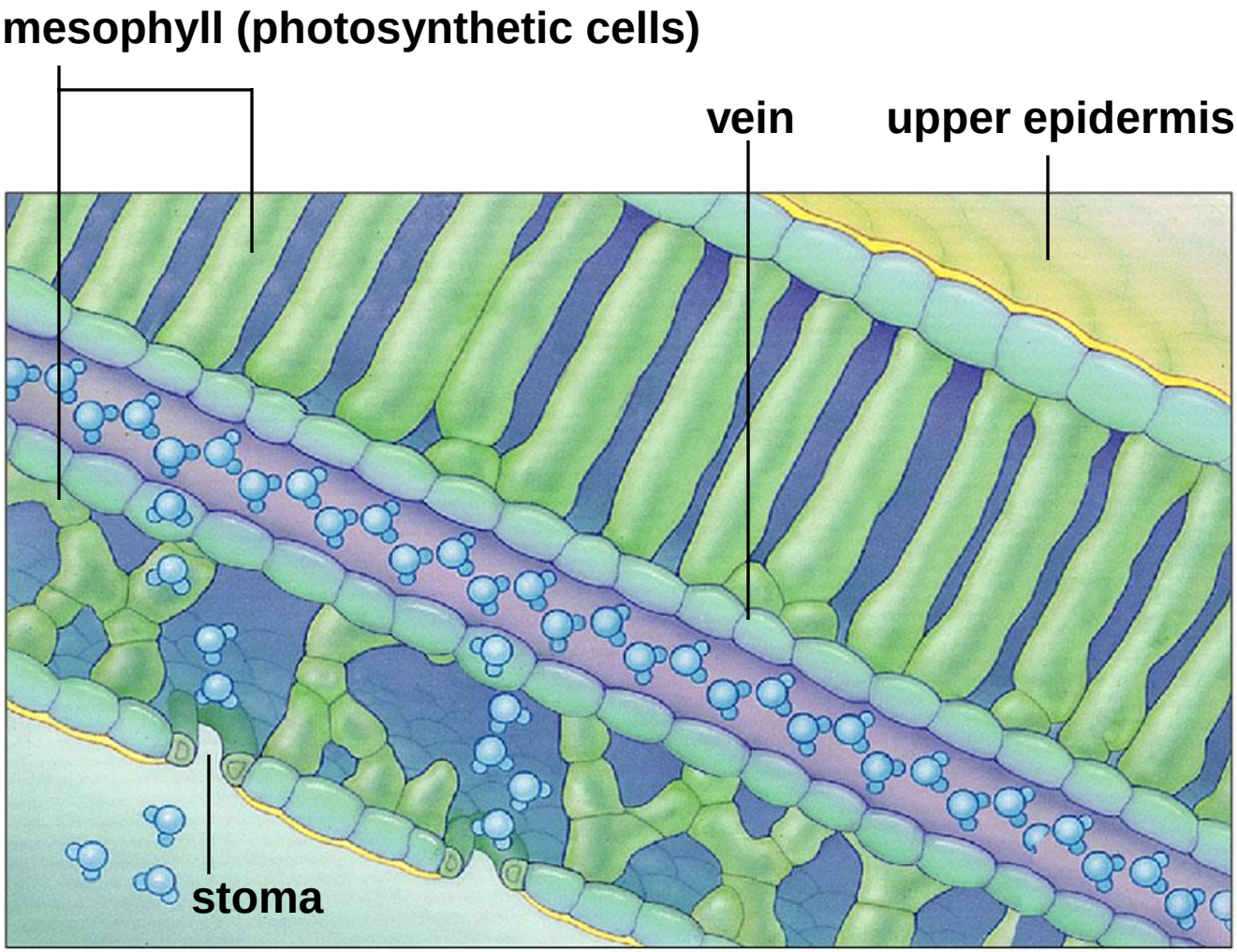
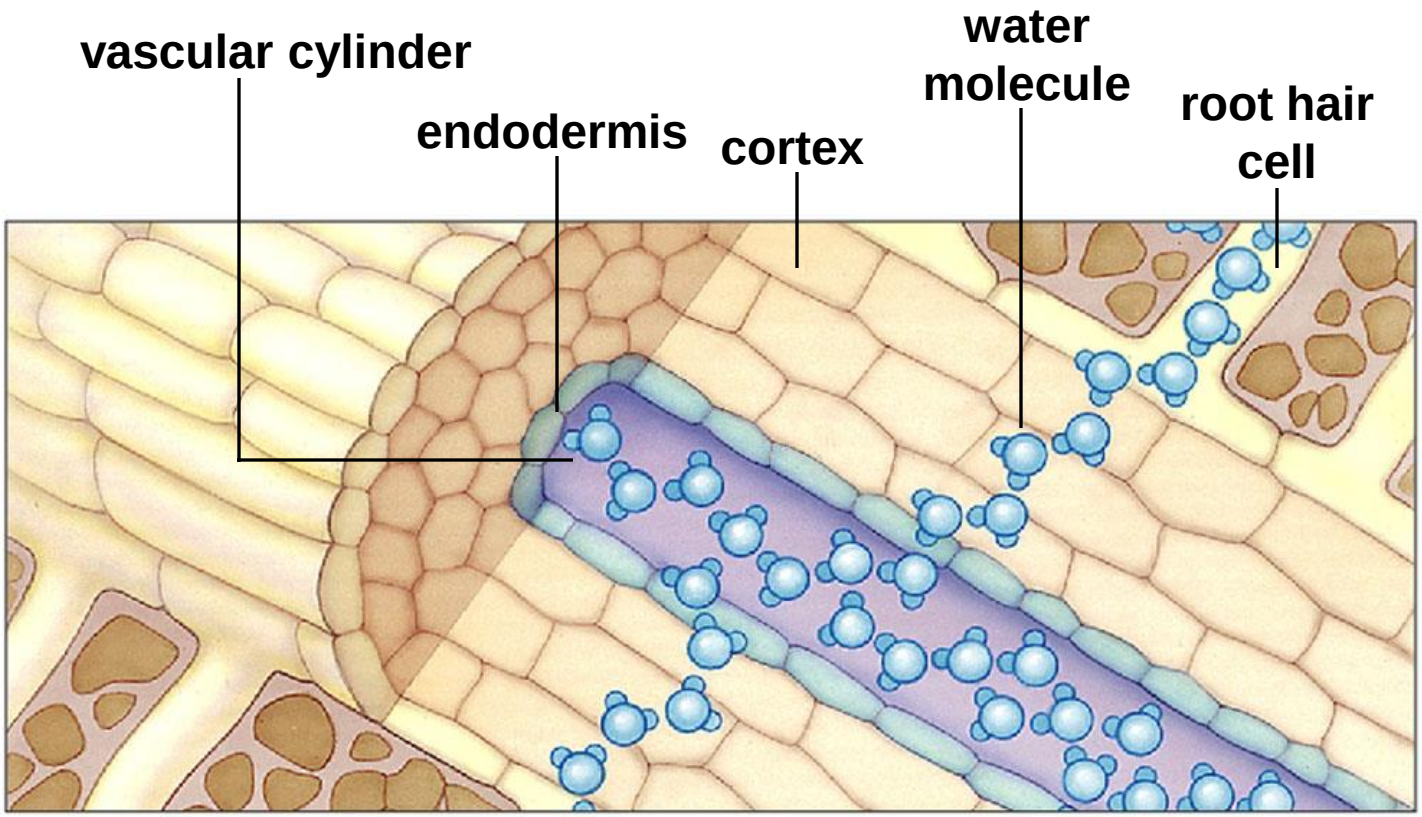
Fig. 30-8a1, p.517



The driving force of evaporation in air

Transpiration is the evaporation of water molecules from aboveground plant parts, especially at stomata. The process puts the water in xylem in a state of tension that extends from roots to leaves.



Ongoing water uptake at roots

For as long as water molecules continue to escape by transpiration, that tension will drive the uptake of replacements from soil water.

Fig. 30-8c, p.517

Osmosis and Wilting

- Water responds to solute concentrations; moves osmotically into plant cells
- When water loss is balanced by osmotically induced movement inward, plant is erect
- If water concentration of soil drops, inward movement stops, plant wilts

The Role of Hydrogen Bonds

- Hydrogen bonds attract the hydrogen of one water molecule to the -OH group of another
- Hydrogen bonds make water cohesive; water molecules stick together inside the narrow xylem walls as the molecules are pulled upward

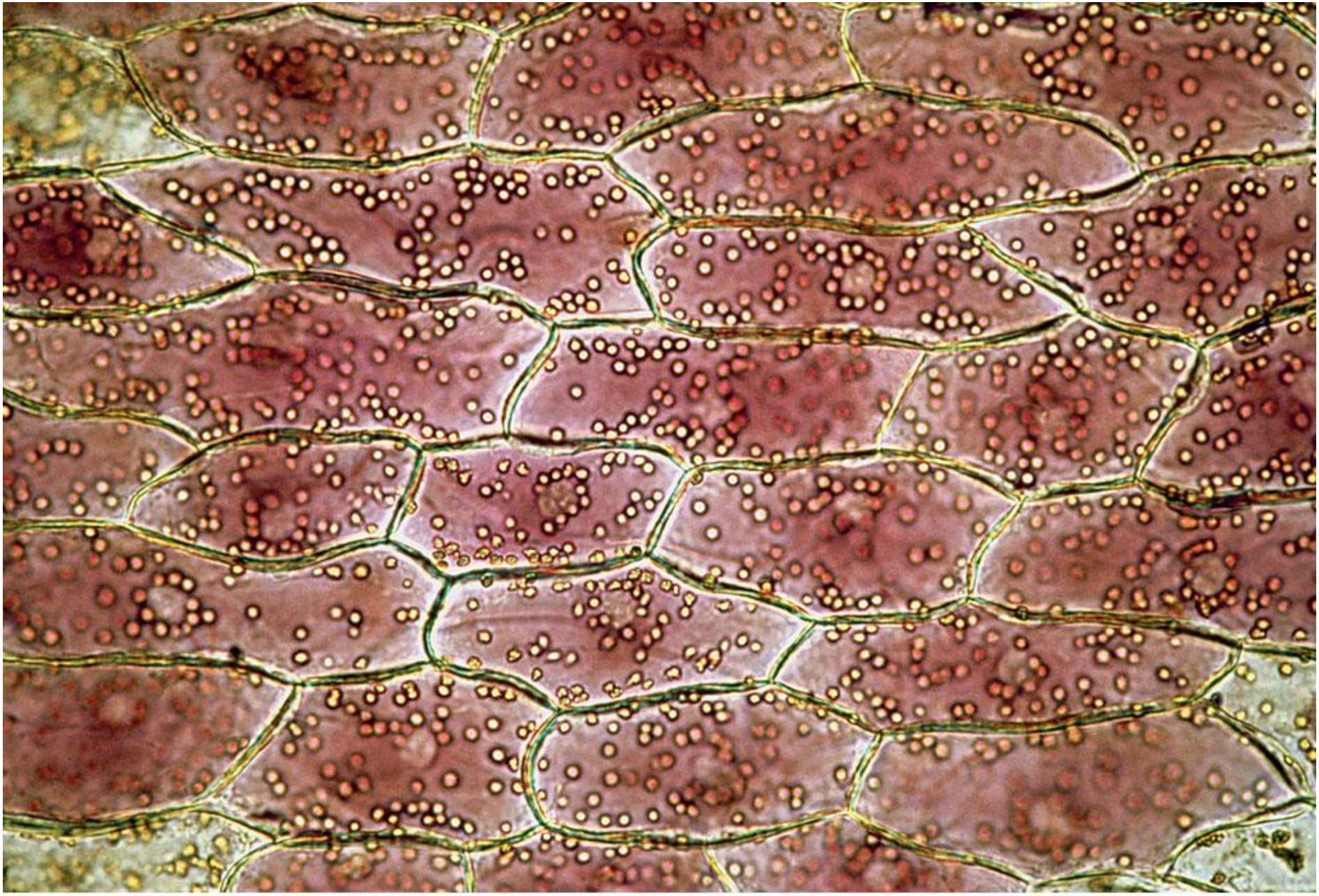


Fig. 30-9a, p.518

Cuticle

- Translucent coating secreted by epidermal cells
- Consists of waxes in cutin
- Allows light to pass though but restricts water loss

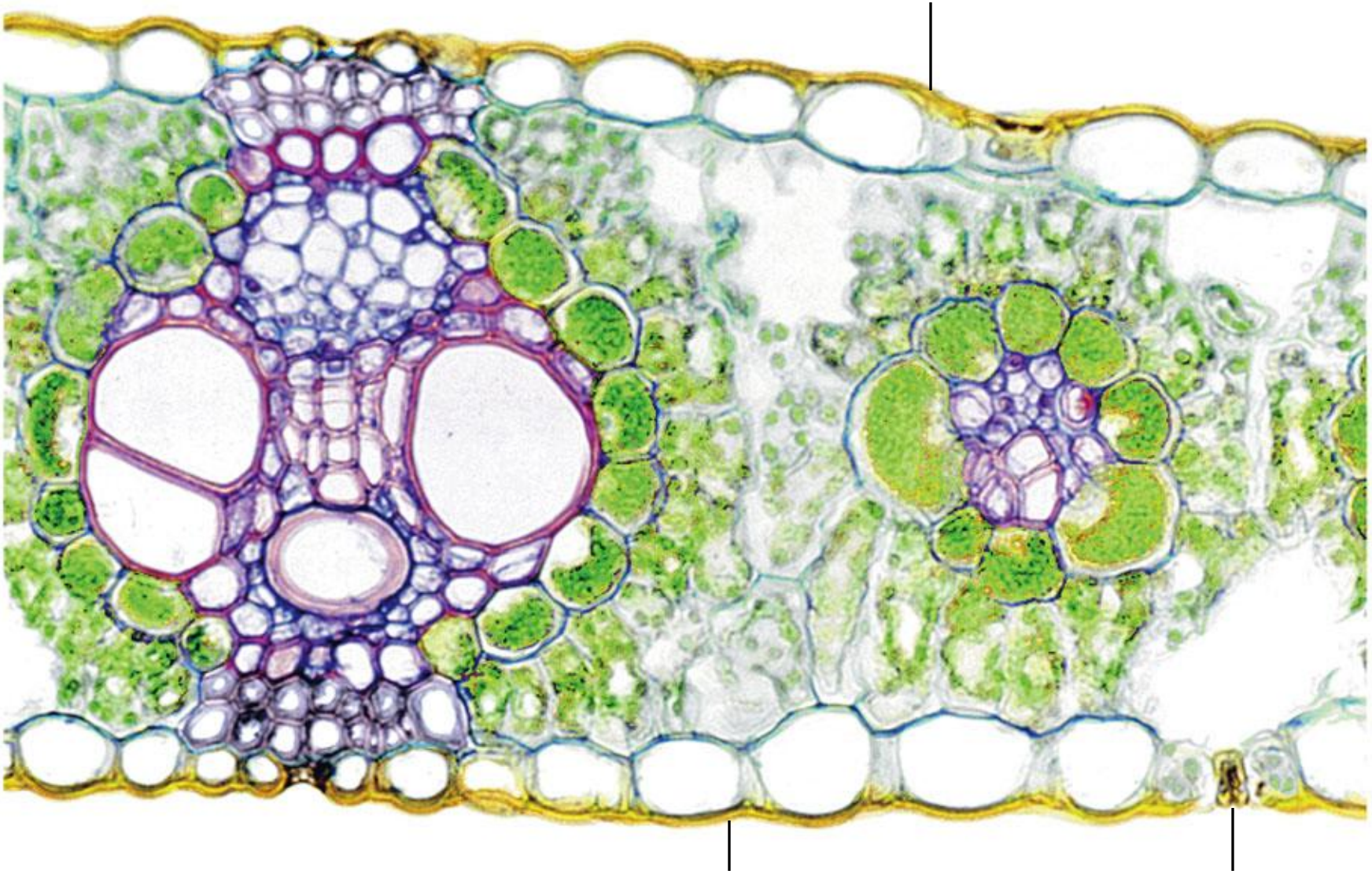


Fig. 30-10, p.518

Stomata

- **Openings across the cuticle and epidermis; allow gases in and out**
- **Guard cells on either side of a stoma**
- Turgor pressure in guard cells affects opening and closing of stomata

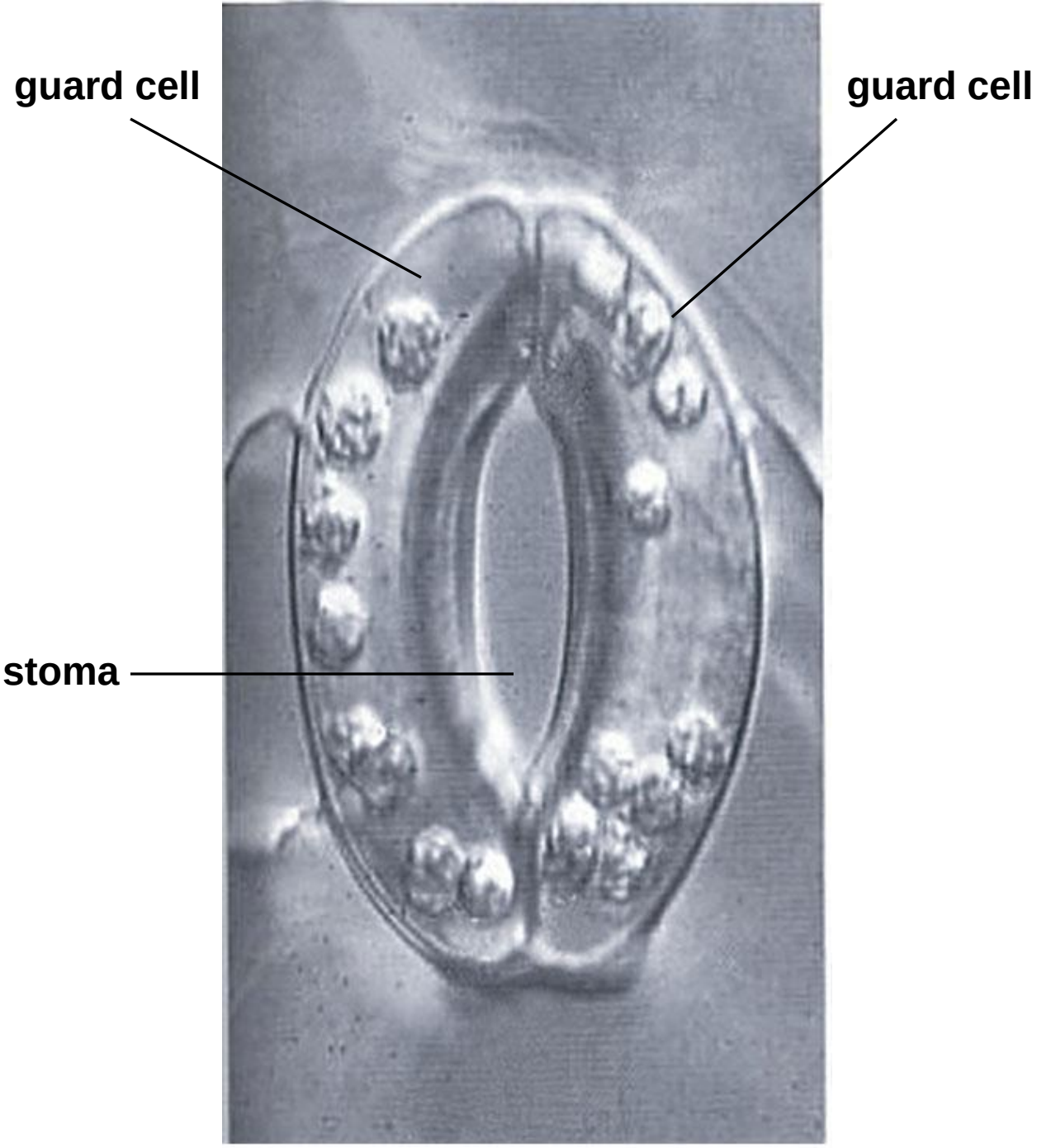
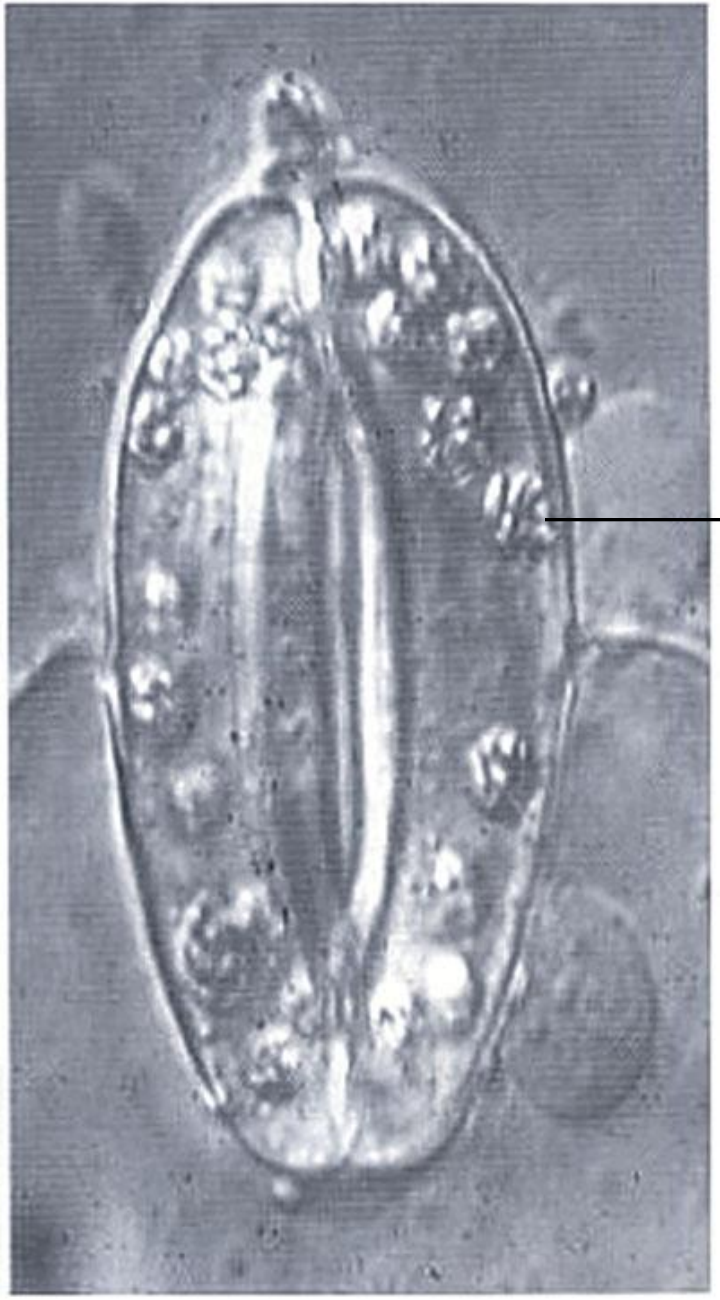


Fig. 30-11a, p.519



chloroplast (guard cells are the only epidermal cells that have these organelles)

20 µm

Fig. 30-11b, p.519

Control of Stomata

- **Close in response to water loss**
- ABA binds to receptors on guard cell membranes
- **Calcium ions flow into cells**
- Chloride and malate flow from cytoplasm to extracellular matrix
- **Potassium ions flow out**
- **Water moves out of guard cells**

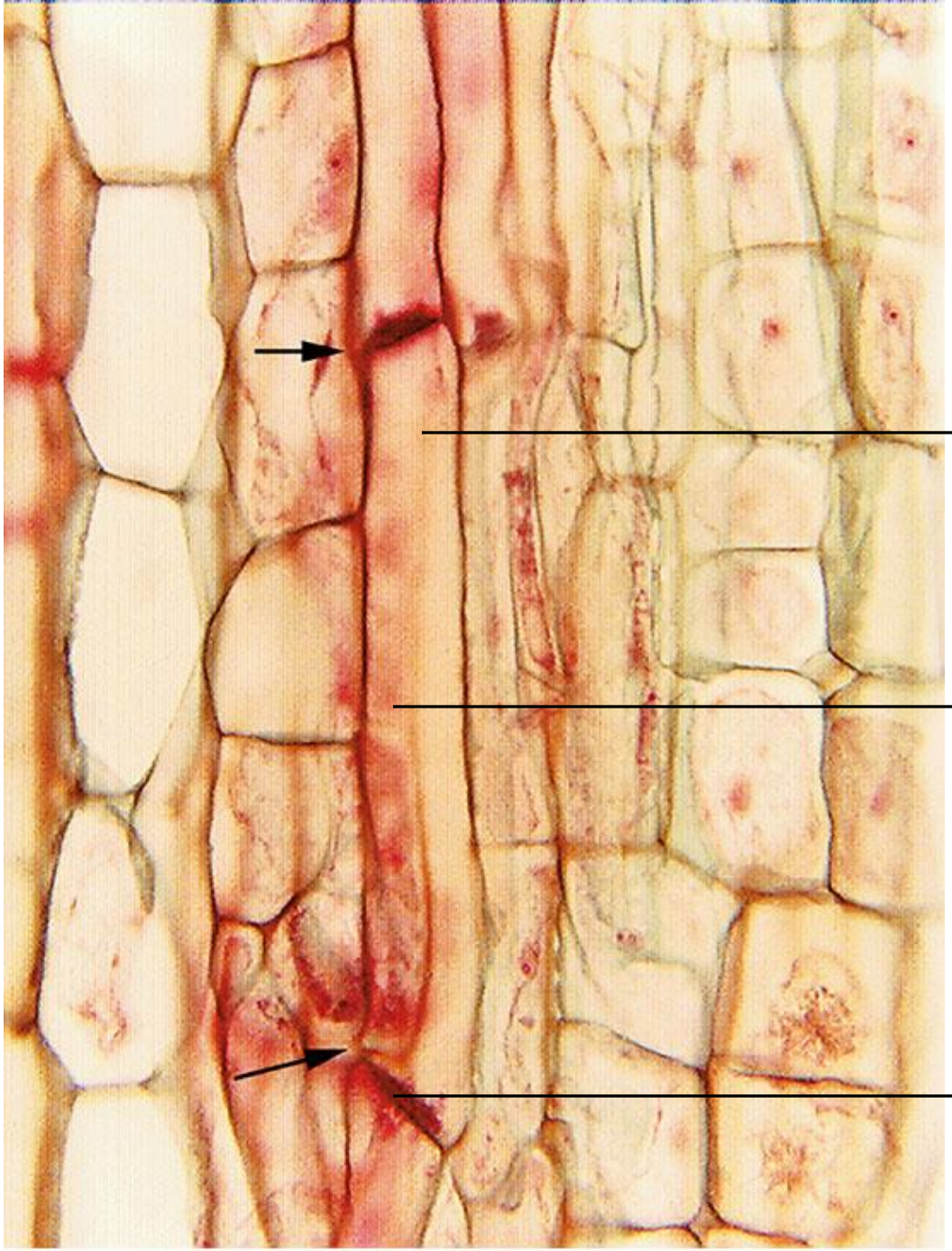
Fig. 30-13c, p.519

CAM Plants

- Most plants are C3 or C4 plants
  - Stomata open during day and photosynthesis proceeds
- CAM plants are better at water conservation
  - Stomata open at night and carbon dioxide is fixed
  - Next day, stomata remain closed while carbon dioxide is used

Phloem

- **Carry organic compounds**
- Conducting tubes are sieve tubes
  - Consist of living sieve-tube members
- Companion cells
  - Lie next to sieve tubes
  - A type of parenchyma
  - Help load organic compounds into sieve tubes



one of a series of living cells that abut, end to end,and form a sieve tube

companion cell (in the background, pressed right against the sieve tube)

perforated end plate of sieve tube cell, of the sort shown in (b)

Fig. 30-14a, p.520

Transportable Organic Compounds

- Carbohydrates are stored as starches
- Starches, proteins, and fats are too large or insoluble for transport
- Cells break them down to smaller molecules for transport
  - Sucrose is main carbohydrate transported

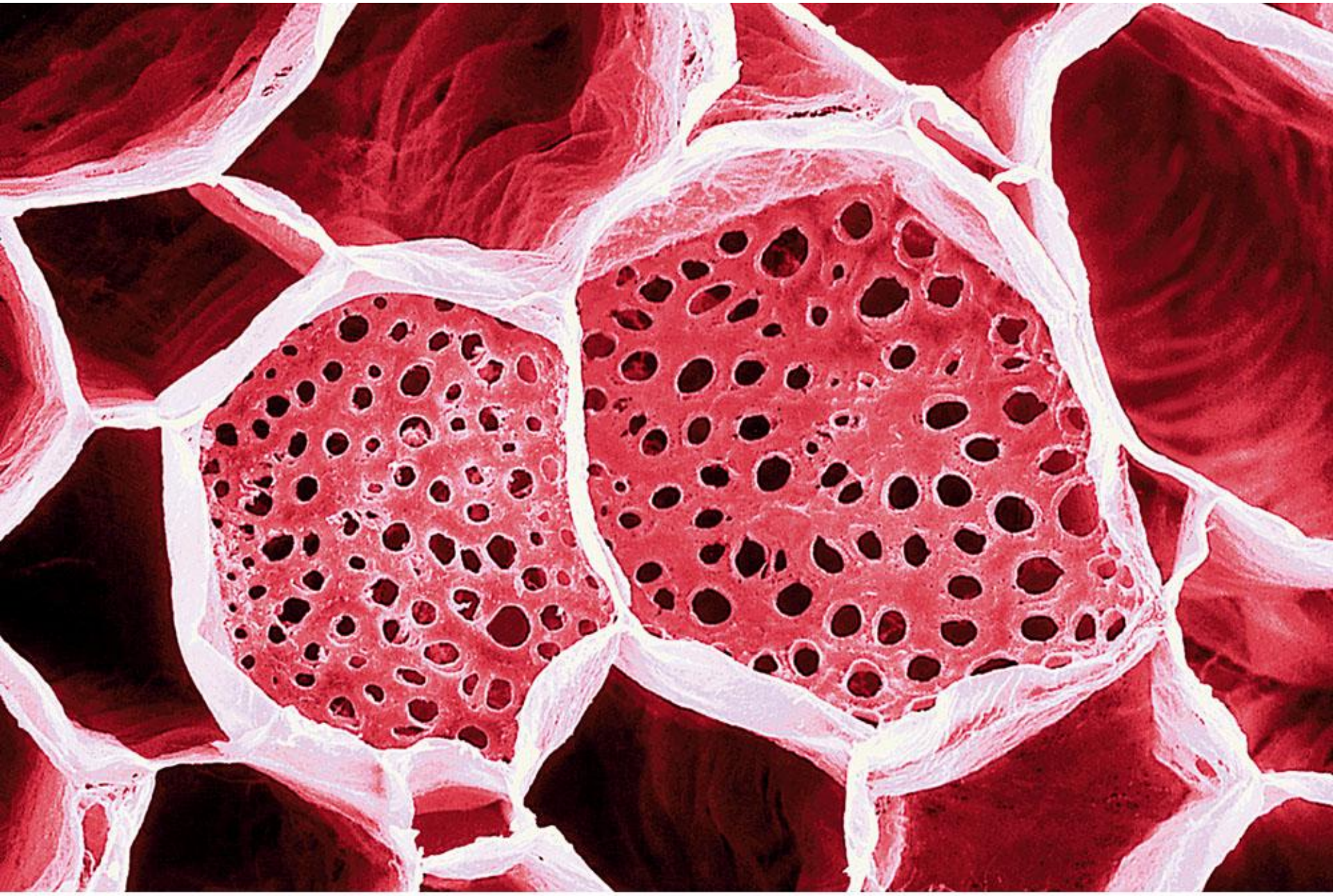
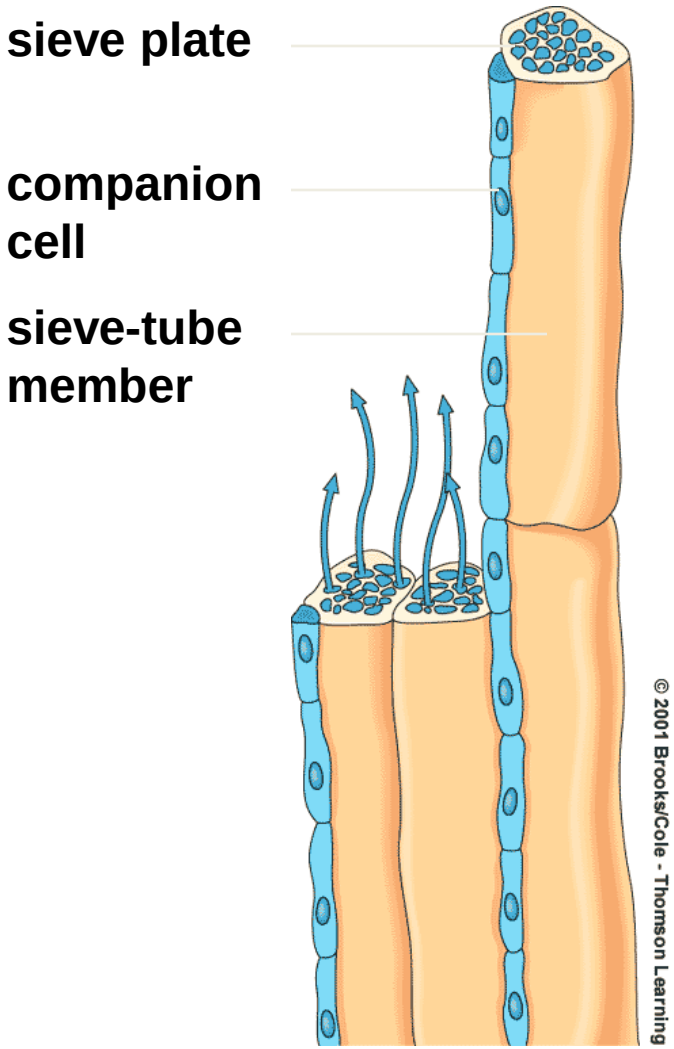


Fig. 30-14b, p.520

Transport through Phloem

- Driven by pressure gradients
- Companion cells supply energy to start process



Loading at Source

- Small soluble organic compounds loaded into phloem

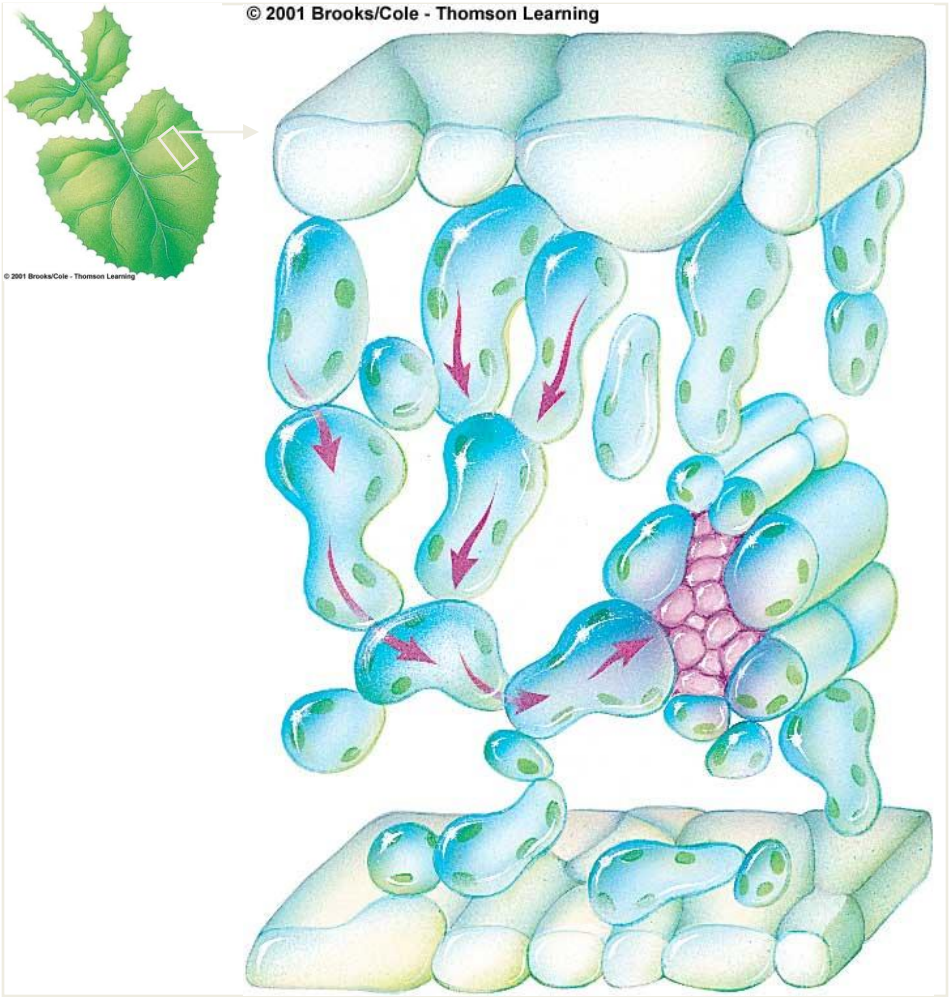


Figure 30.16

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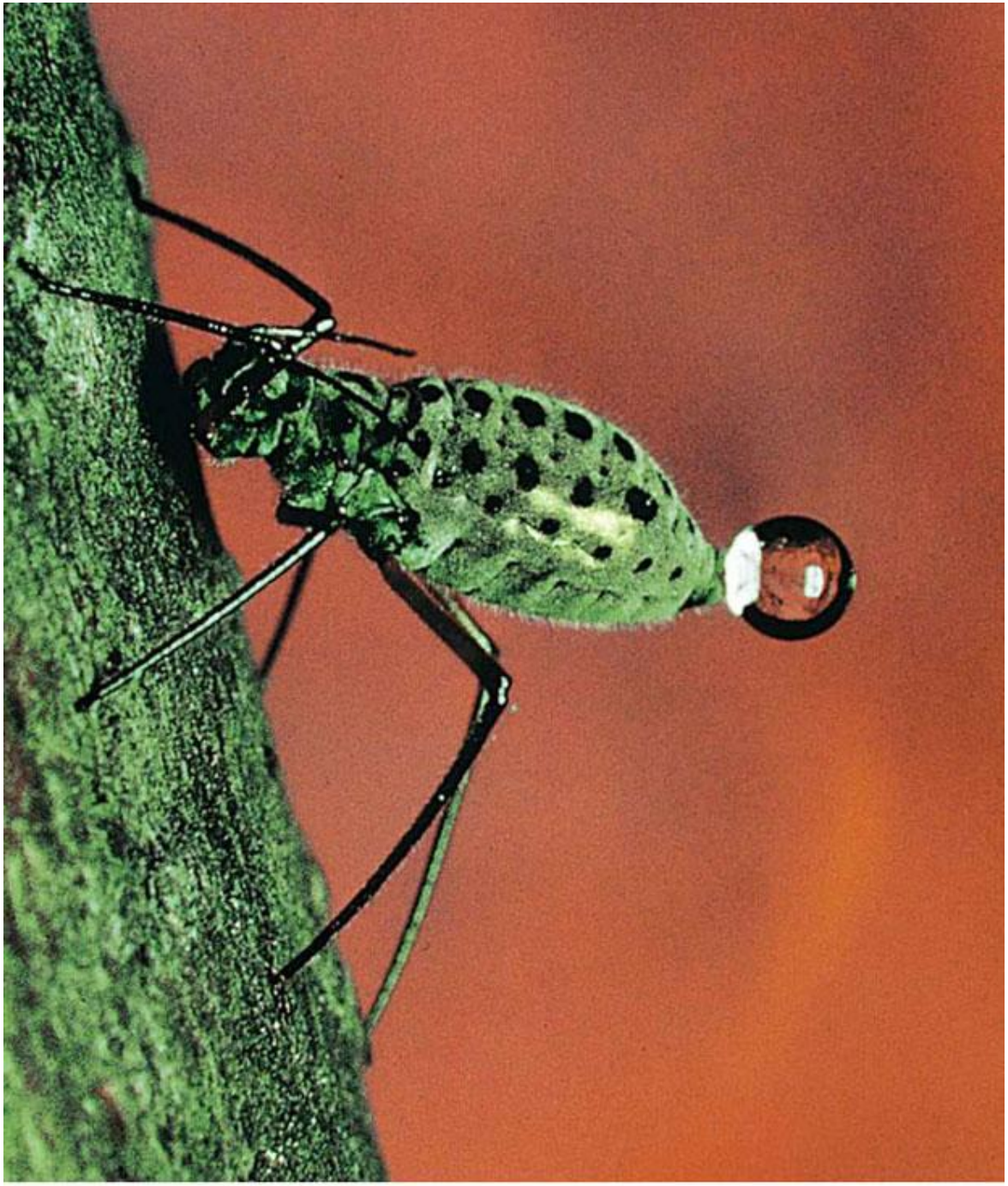

Fig. 30-15, p.520