The three principal organs of seed plants are roots, stems, and leaves.

Roots:

- absorb water and dissolved nutrients.
- anchor plants in the ground.
- protect the plant from harmful soil bacteria and fungi.

Stems provide:

- a support system for the plant body.
- a transport system that carries nutrients.
- a defense system that protects the plant against predators and disease.

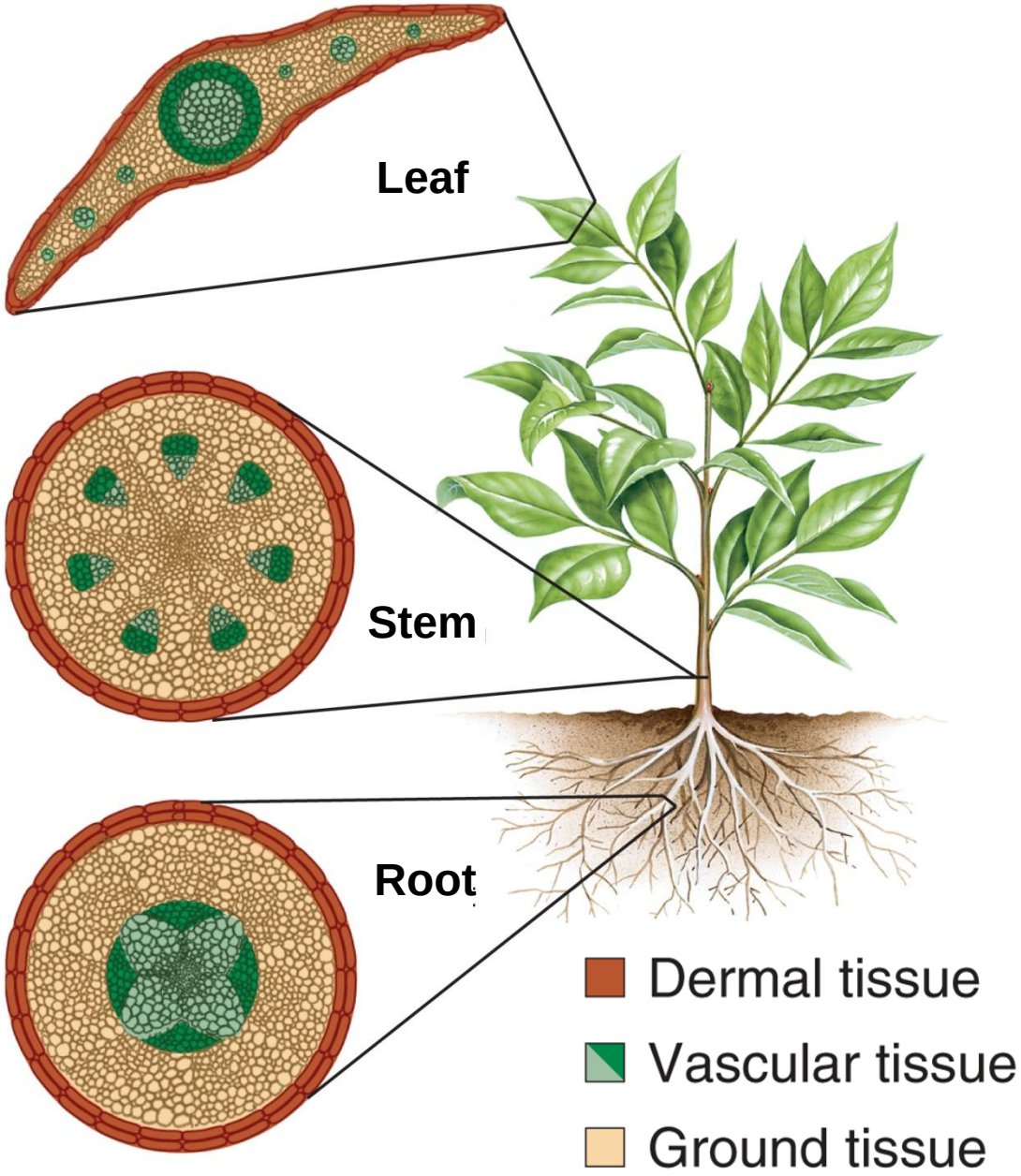
Leaves:

- are a plant's main photosynthetic systems.
- increase the amount of sunlight plants absorb.

Adjustable pores conserve water and let oxygen and carbon dioxide enter and exit the leaf.

Plants consist of three main tissue systems:

- **dermal tissue**
- **vascular tissue**
- **ground tissue**

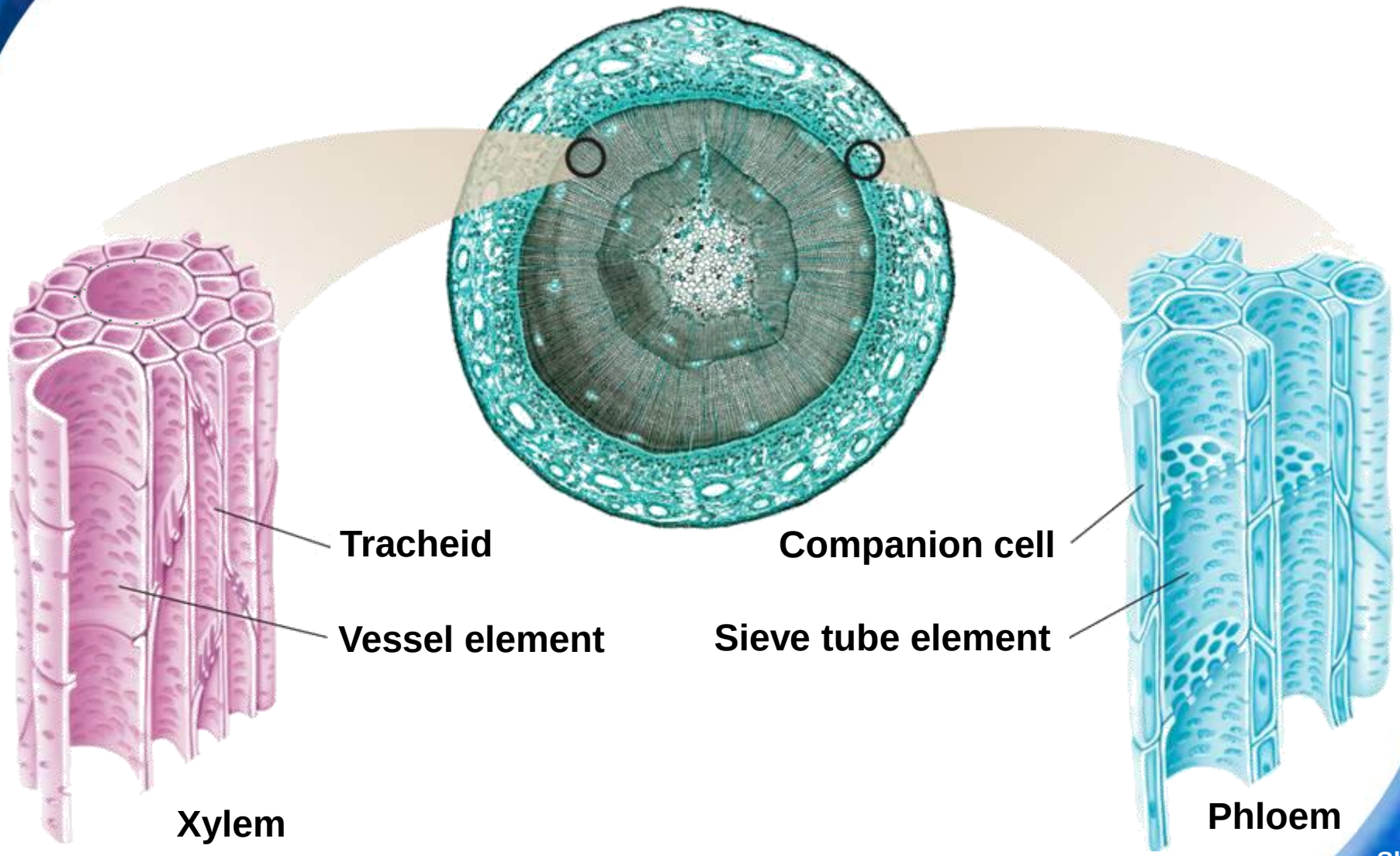


Vascular Tissue

Vascular tissue contains several types of specialized cells.

- **Xylem consists of tracheids and vessel elements.**
- **Phloem consists of sieve tube elements and companion cells.**

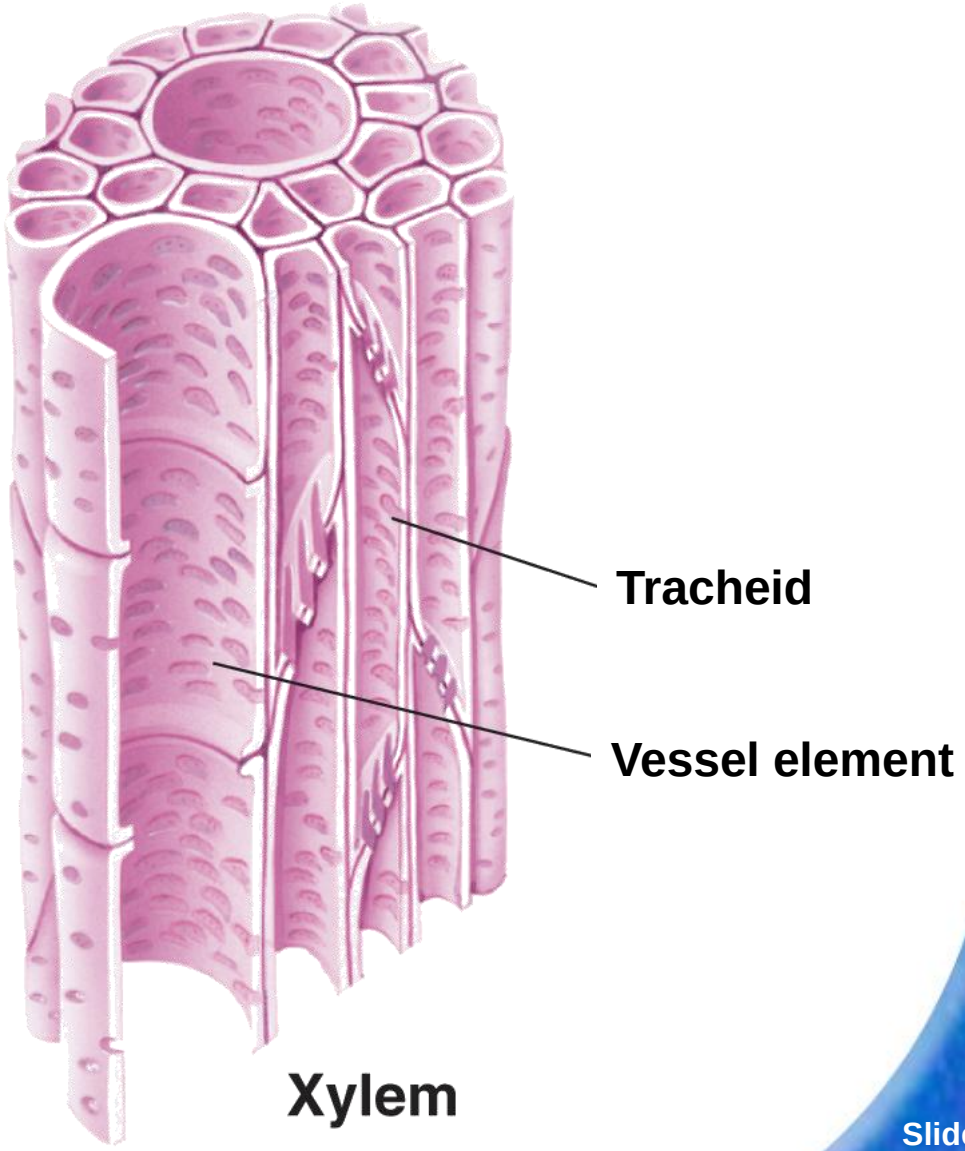
Cross Section of a Stem



Xylem

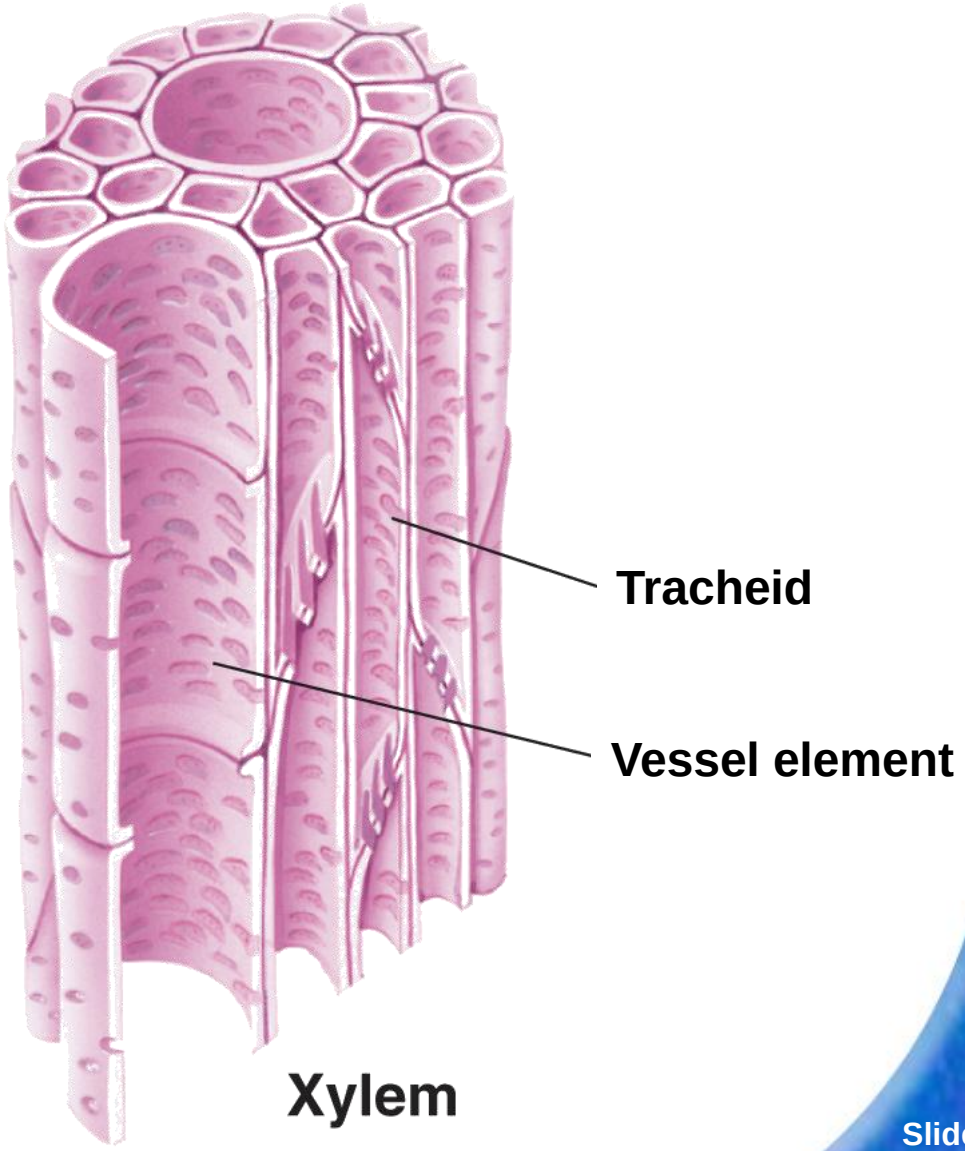
All seed plants have tracheids.

Tracheids are long, narrow cells that are impermeable to water. They are pierced by openings that connect neighboring cells to one another.



Angiosperms also have **vessel elements**.

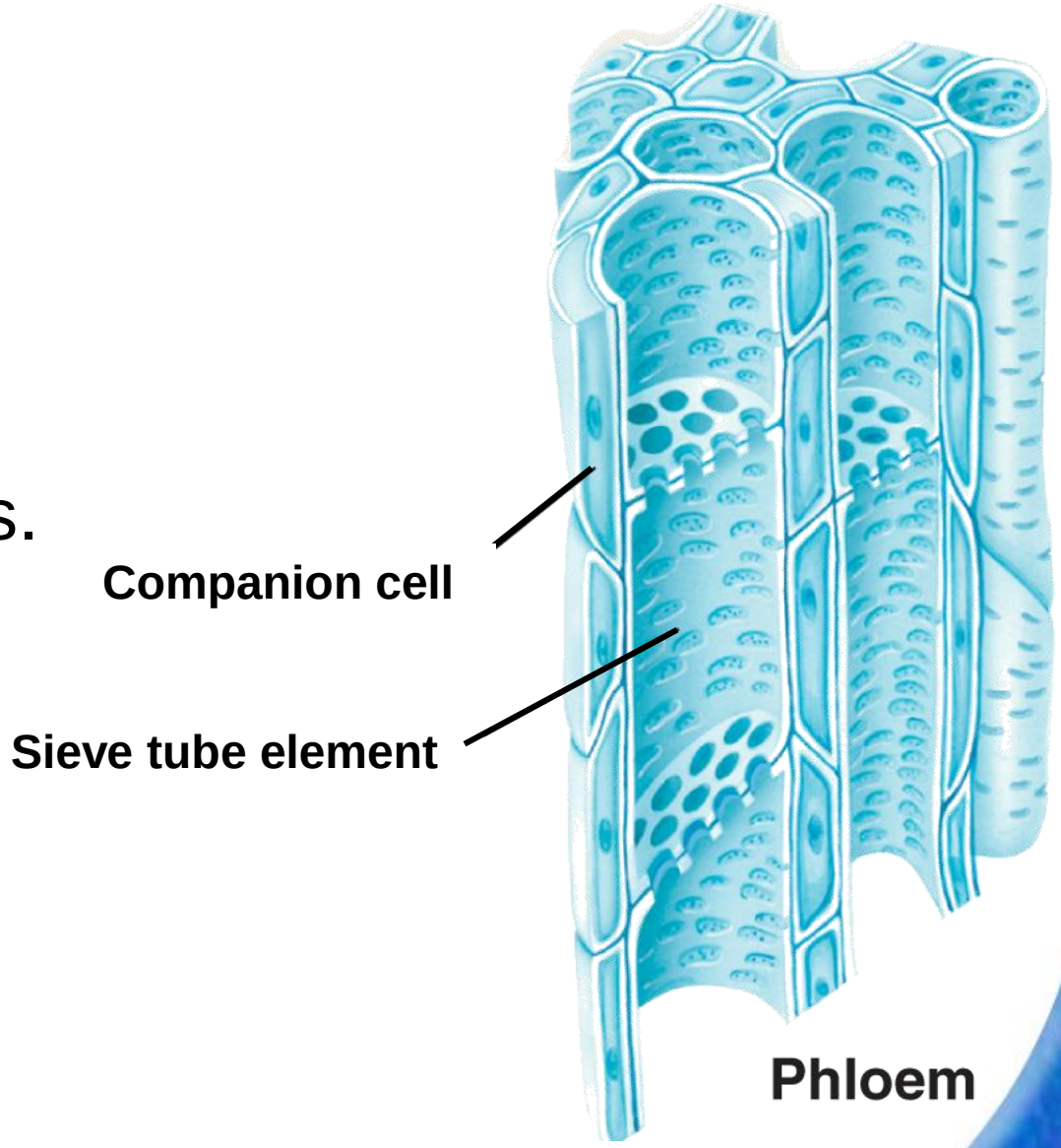
Vessel elements form a continuous tube through which water can move.



Phloem

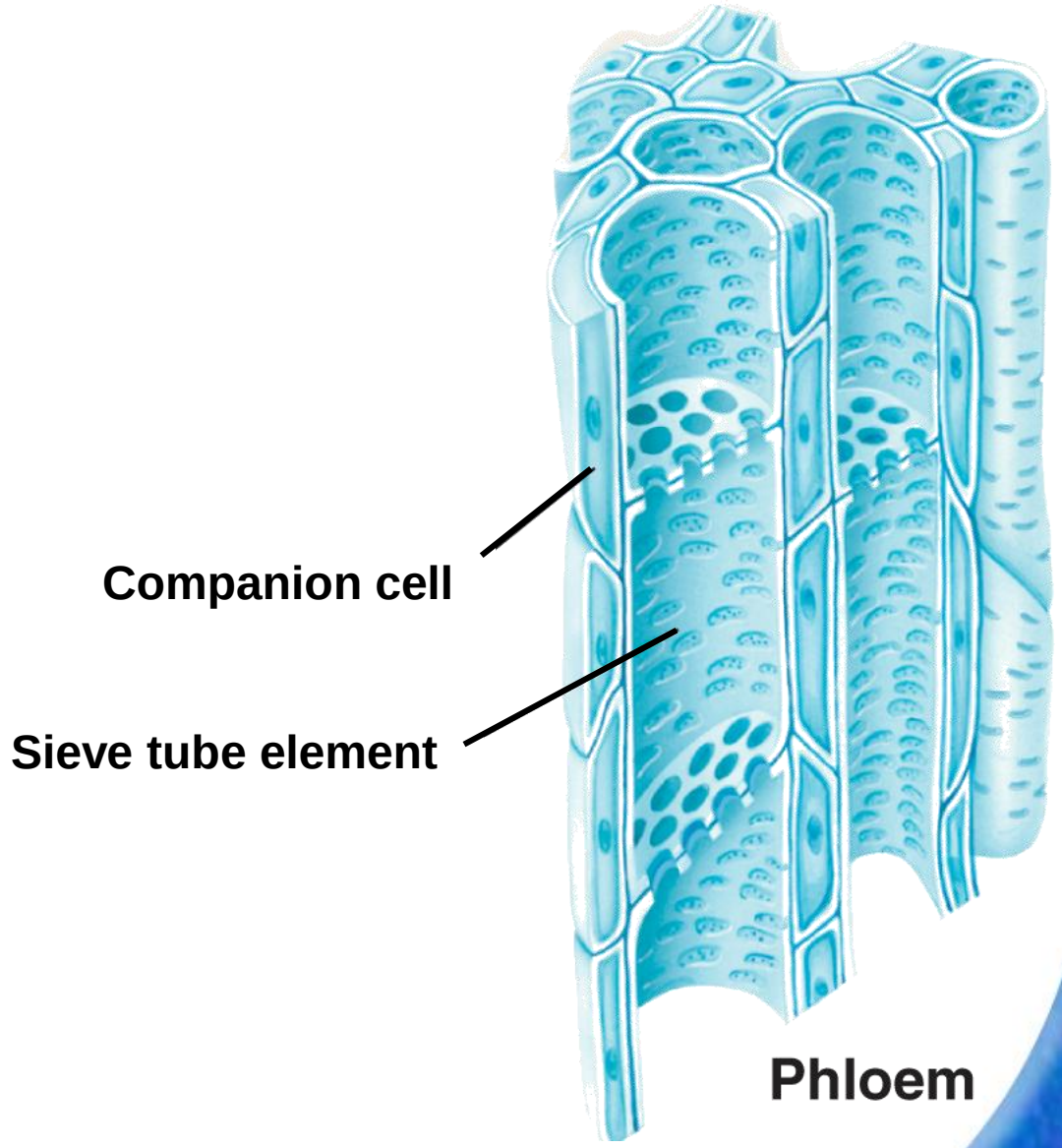
Phloem contains sieve tube elements and companion cells.

Sieve tube elements are phloem cells joined end-to-end to form sieve tubes.



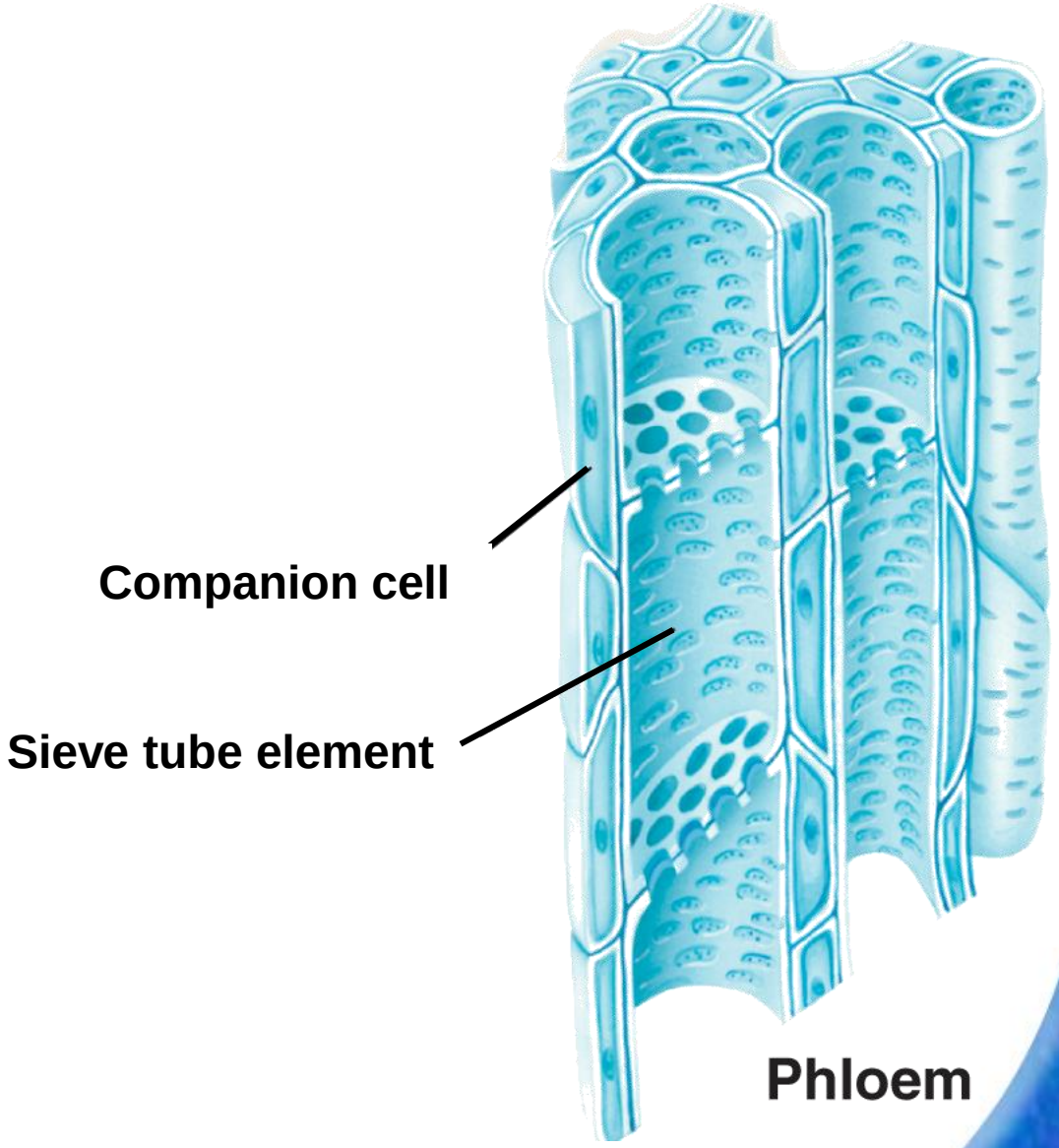
The end walls of sieve tube elements have many small holes.

Sugars and other foods can move through these holes from one adjacent cell to another.



Companion cells are phloem cells that surround sieve tube elements.

Companion cells support the phloem cells and aid in the movement of substances in and out of the phloem.



Ground Tissue

Cells that lie between dermal and vascular tissues make up the ground tissues.

The three kinds of ground tissue are:

- parenchyma
- collenchyma
- sclerenchyma

Parenchyma cells have thin walls and large central vacuoles surrounded by a thin layer of cytoplasm.

Collenchyma cells have strong, flexible cell walls that help support larger plants.

Sclerenchyma cells have extremely thick, rigid cell walls that make ground tissue tough and strong.

Meristematic tissue is the only plant tissue that produces new cells by mitosis.

23–5 Section QUIZ

Continue to:

Section QUIZ

- or -

Click to Launch:

23–1 Section QUIZ

1 The principle organs of seed plants are

a. reproductive organs and photosynthetic organs.

b. stems, leaves, and flowers.

c. roots, vessels, and cones.

A d. leaves, stems, and roots.

2 Phloem cells that surround sieve tube elements are called

a. epidermal cells.

b. cuticle cells.

A c. companion cells.

d. vessel elements.

23–1 Section QUIZ

3 Which type of ground tissue has thin cell walls and large central vacuoles?

A a. parenchyma

b. collenchyma

c. sclerenchyma

d. tracheids

4 Cells that can differentiate into many plant tissues are found in

a. the vascular cylinder.

b. dermal tissue.

A c. meristematic tissue.

d. ground tissue.

5 When cells in the apical meristem first develop, they are

a. highly specialized and divide often.

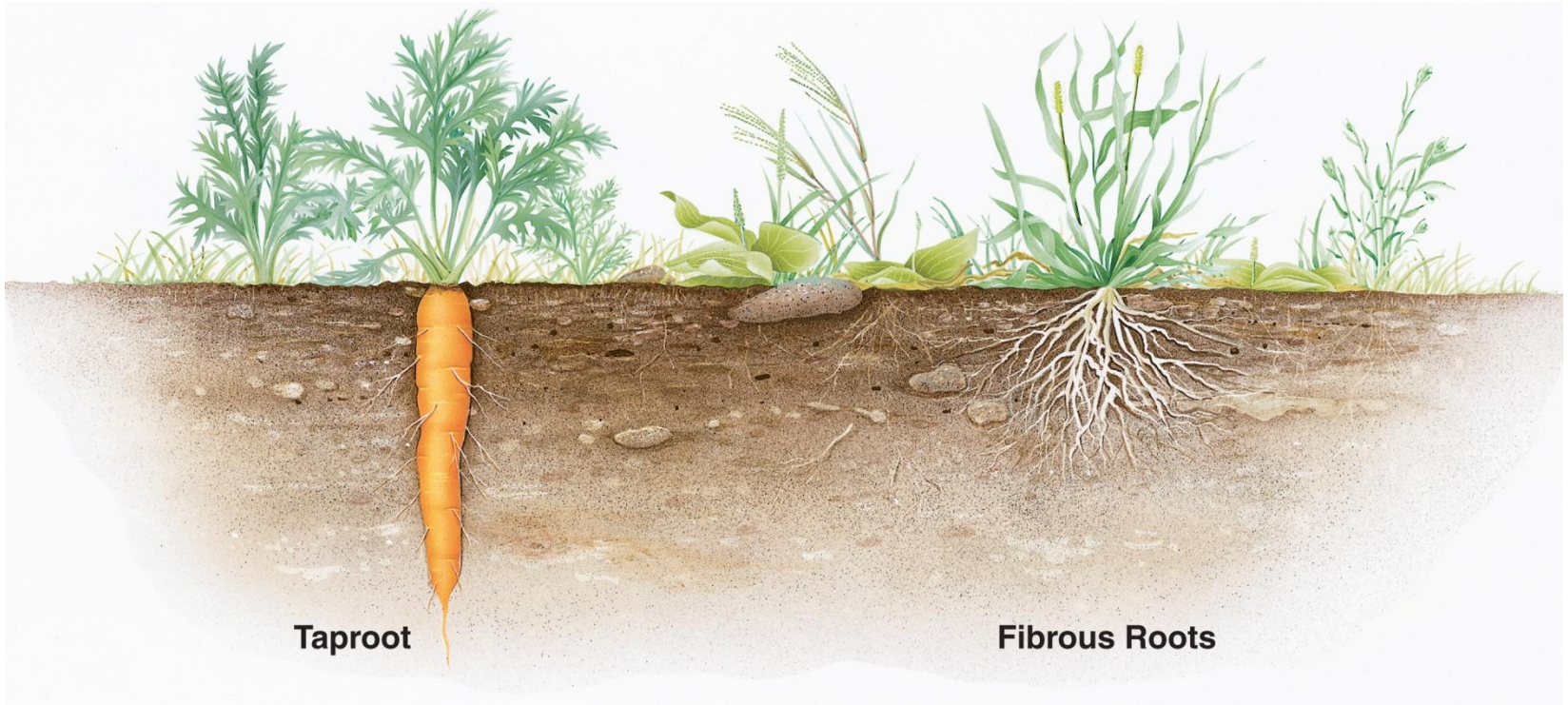
b. unspecialized and divide rarely.

c. highly specialized and divide rarely.

A d. unspecialized and divide often.

END OF SECTION

23–2 Roots

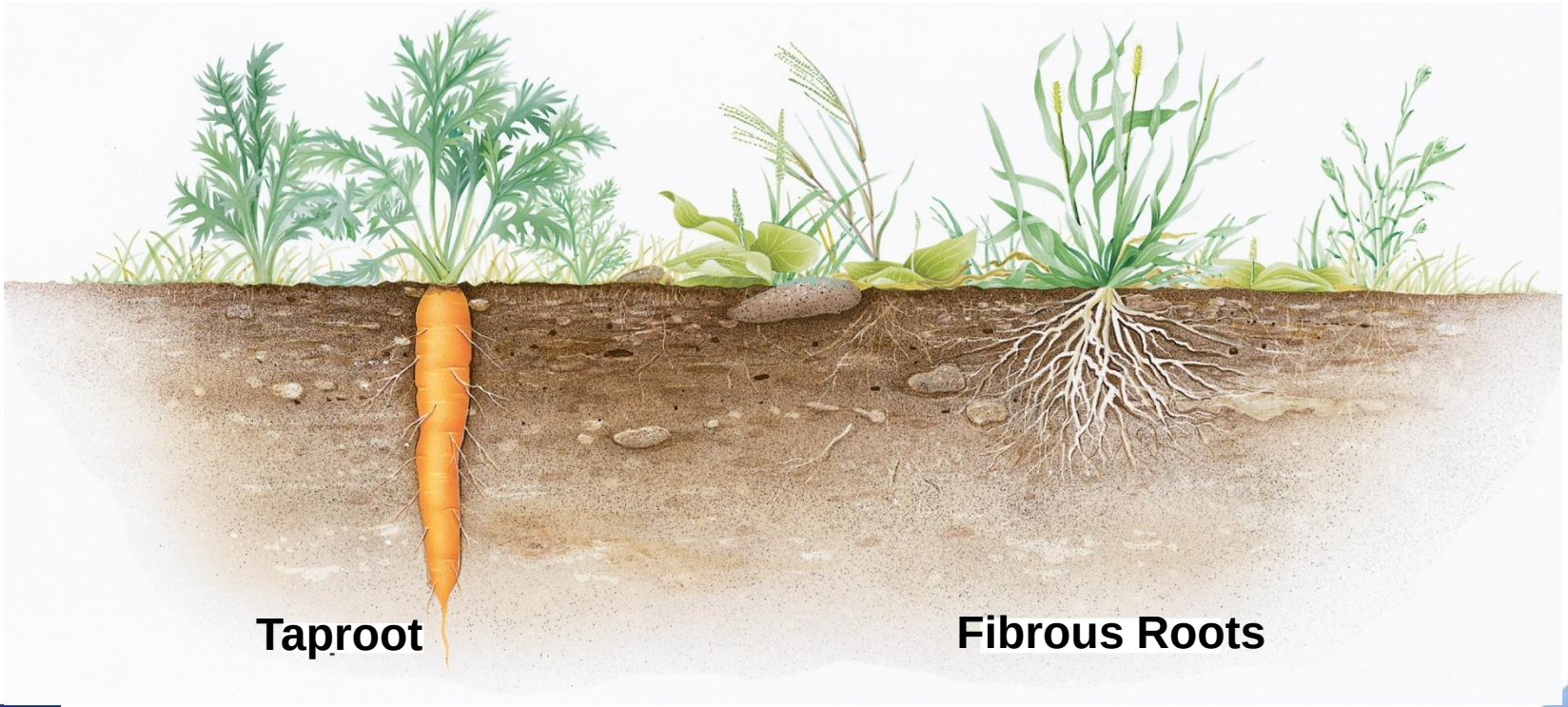


The two main types of roots are:

- **taproots, which are found mainly in dicots, and**
- **fibrous roots, which are found mainly in monocots.**

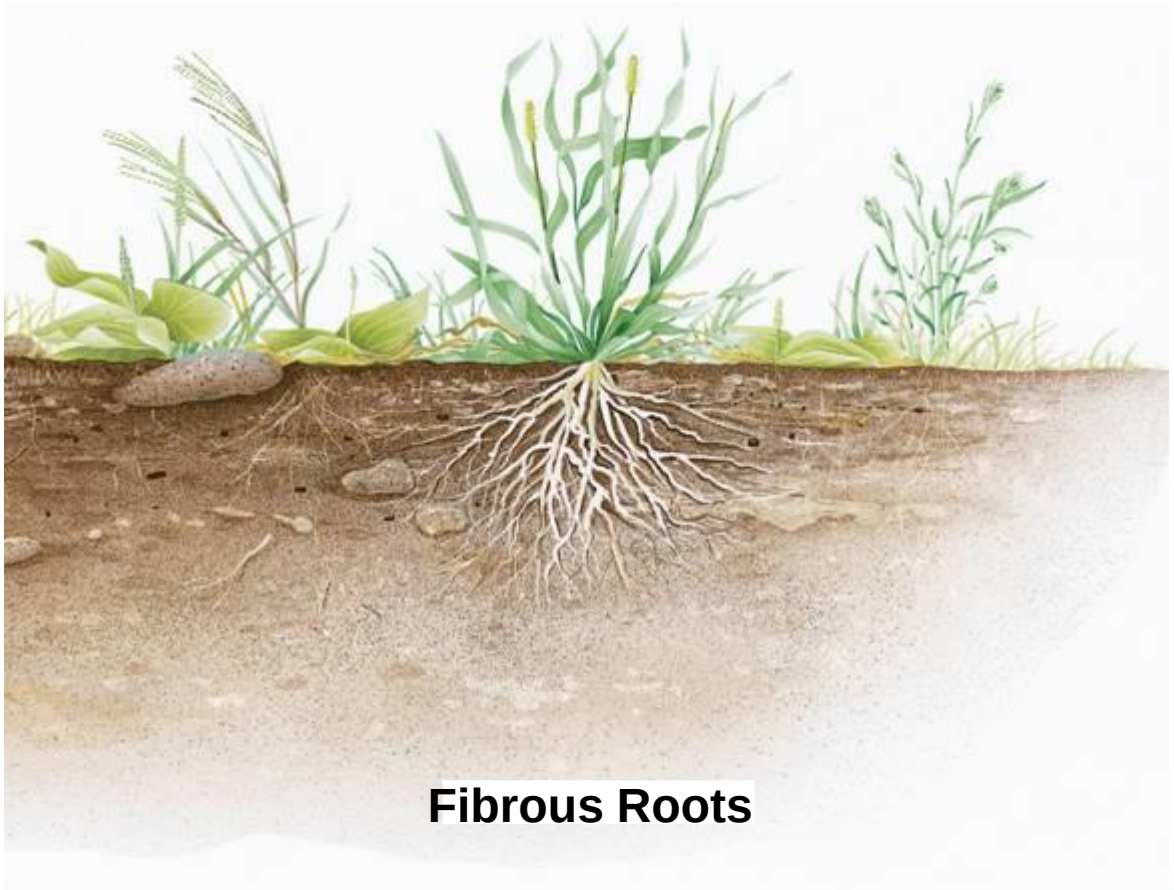
In some plants, the primary root grows long and thick. This primary root is called a **taproot**.

A carrot is an example of a taproot.



Fibrous roots branch to such an extent that no single root grows larger than the rest.

Fibrous roots are found in grasses.

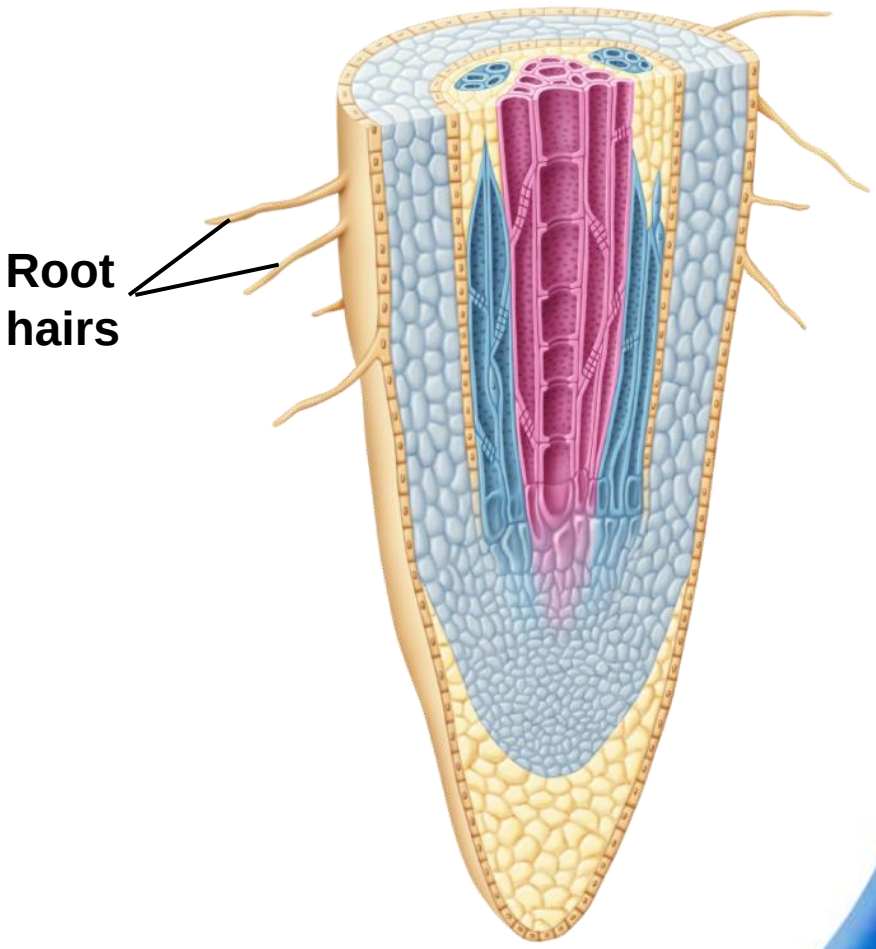


Fibrous Roots

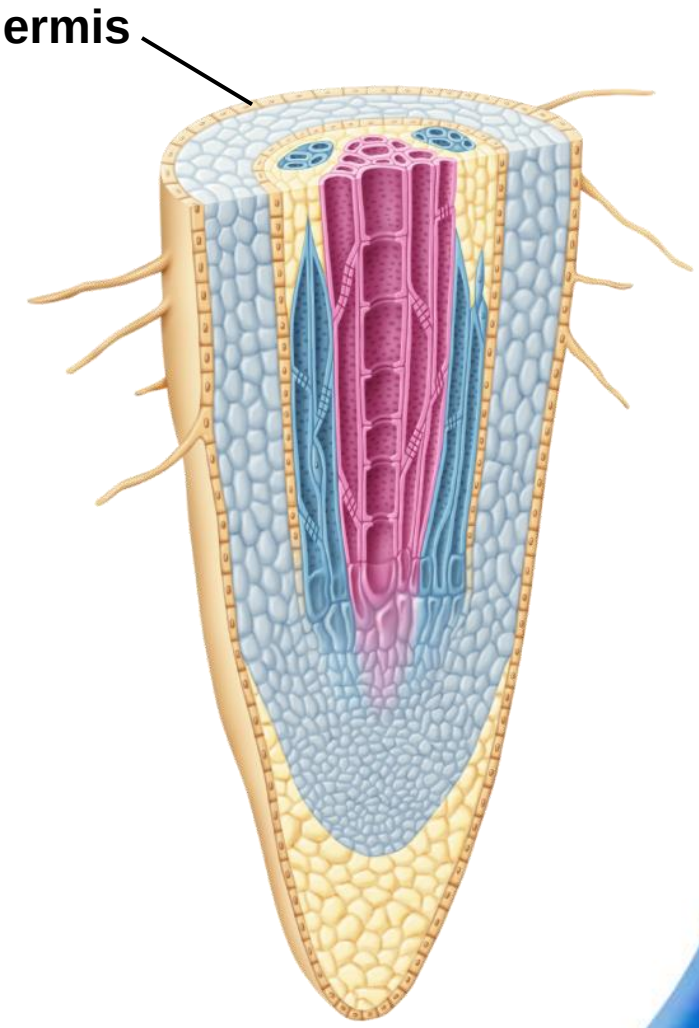
A mature root has an outside layer, the epidermis, and a central cylinder of vascular tissue. Between these two tissues lies a large area of ground tissue.

The root system plays a key role in water and mineral transport.

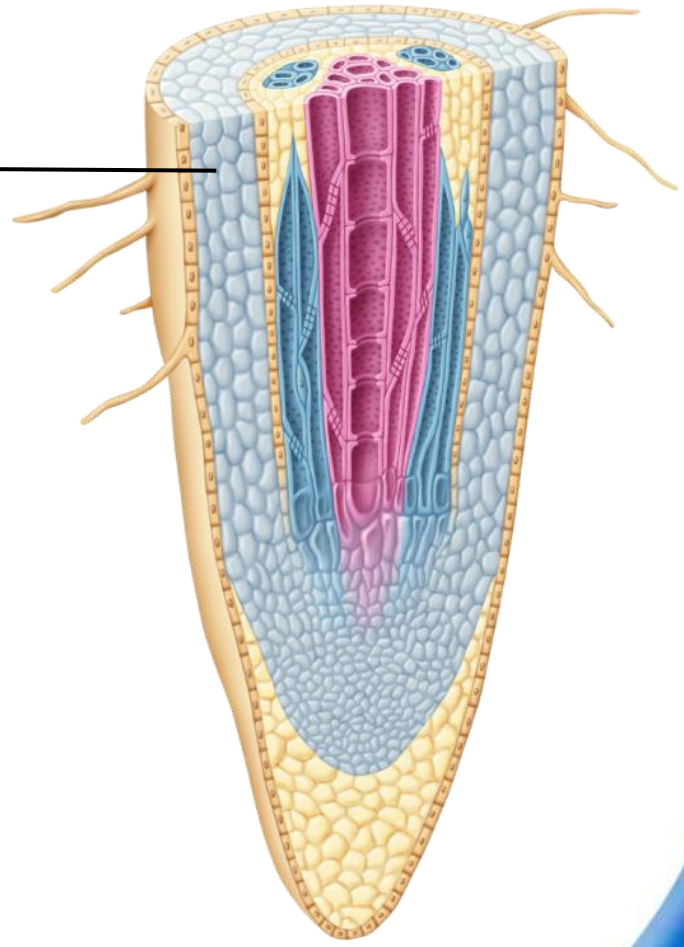
The root's surface is covered with cellular projections called **root hairs**. Root hairs provide a large surface area through which water can enter the plant.



The epidermis protects the root and absorbs water.

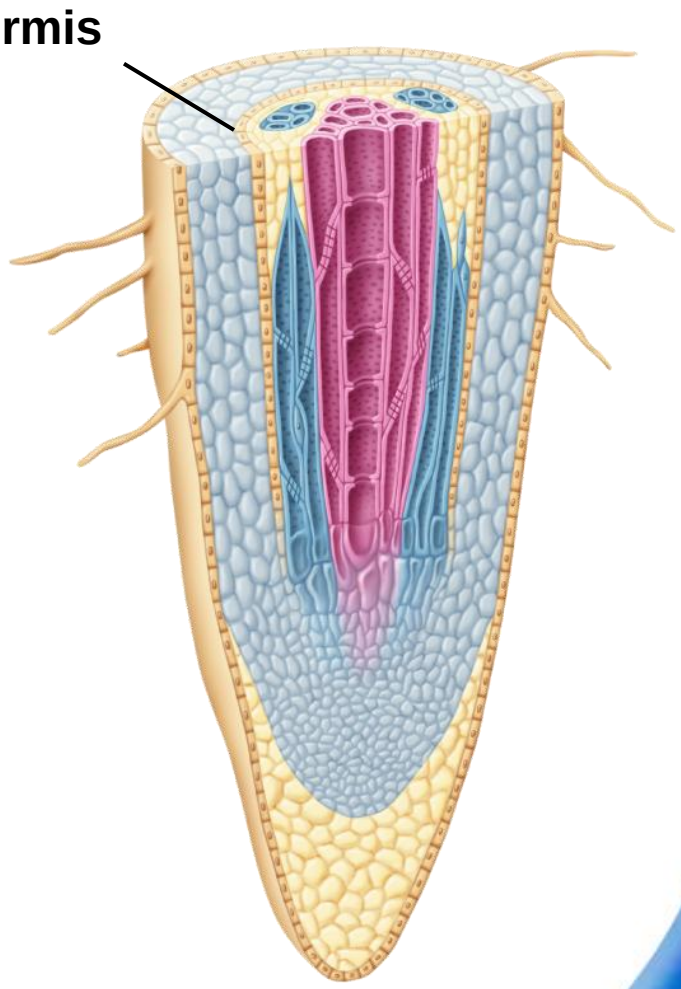


Inside the epidermis is a layer of ground tissue called the **cortex**.

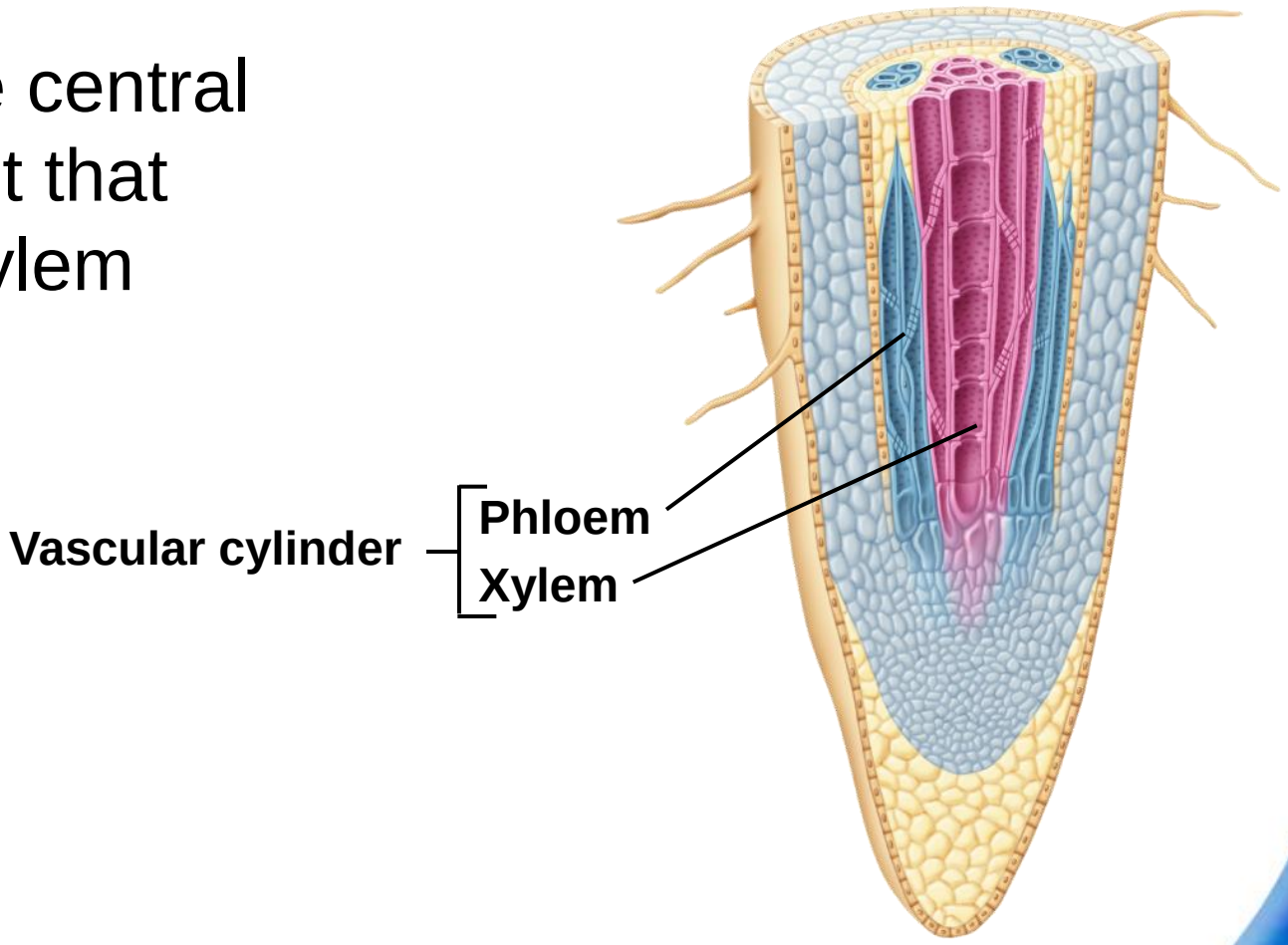


The cortex extends to another layer of cells, the **endodermis**.

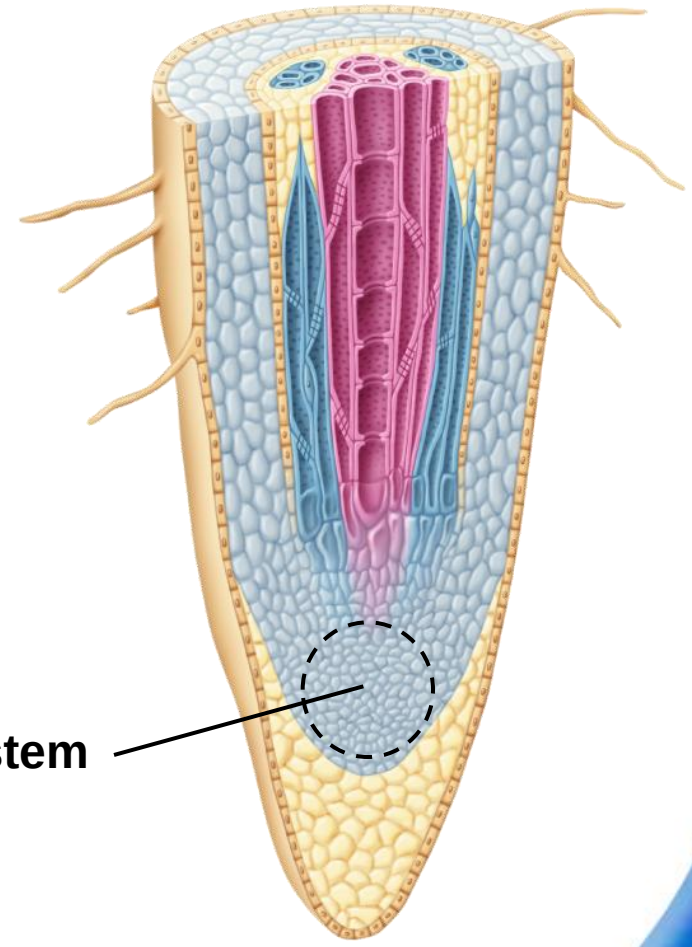
The endodermis completely encloses the vascular cylinder.



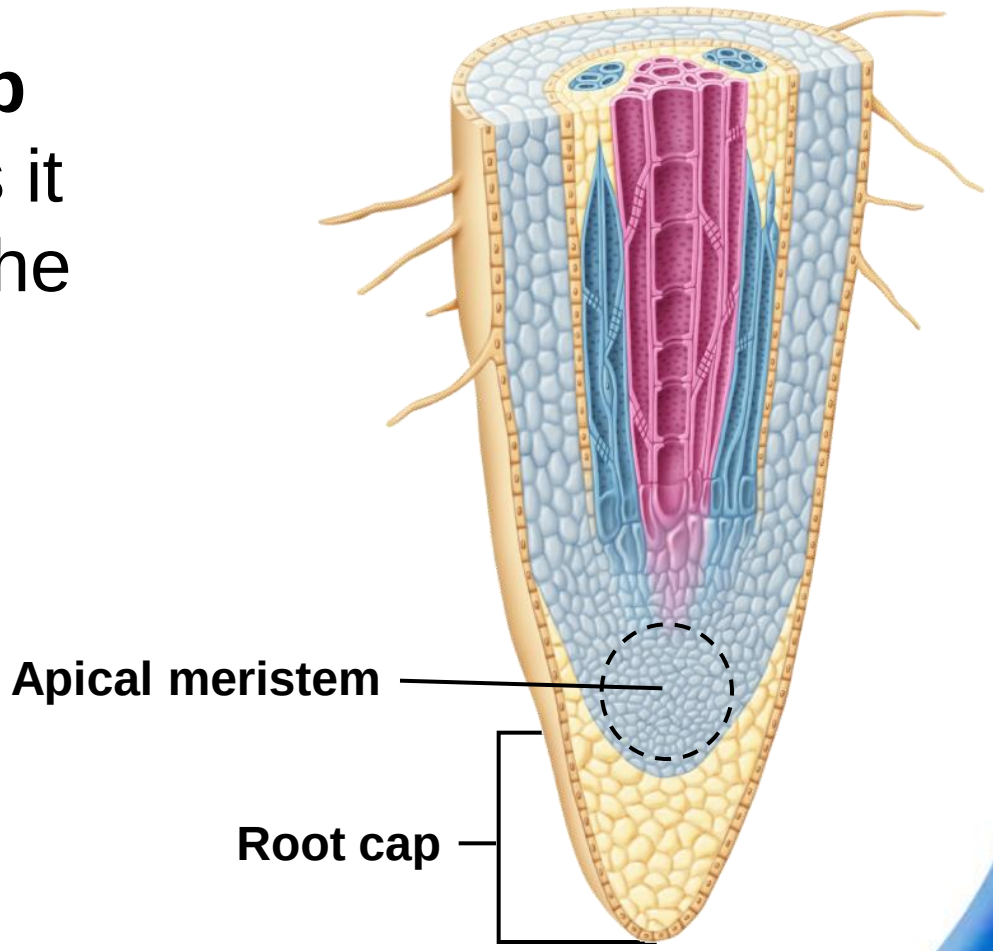
The **vascular cylinder** is the central region of a root that includes the xylem and phloem.



Roots grow in length as their apical meristem produces new cells near the root tip.



These new cells are covered by the **root cap** that protects the root as it forces its way through the soil.



Roots anchor a plant in the ground and absorb water and dissolved nutrients from the soil.

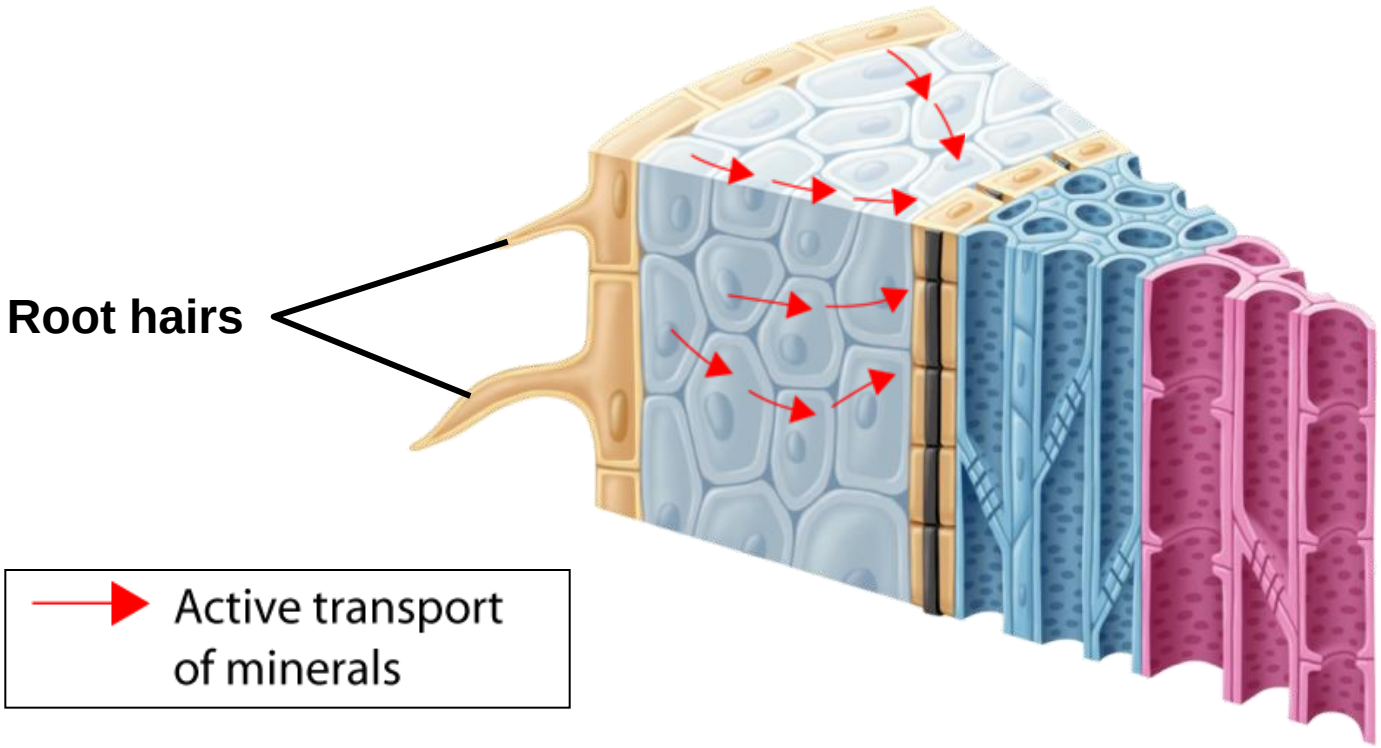
The most important nutrients plants need include:

- nitrogen
- phosphorus
- potassium
- magnesium
- calcium

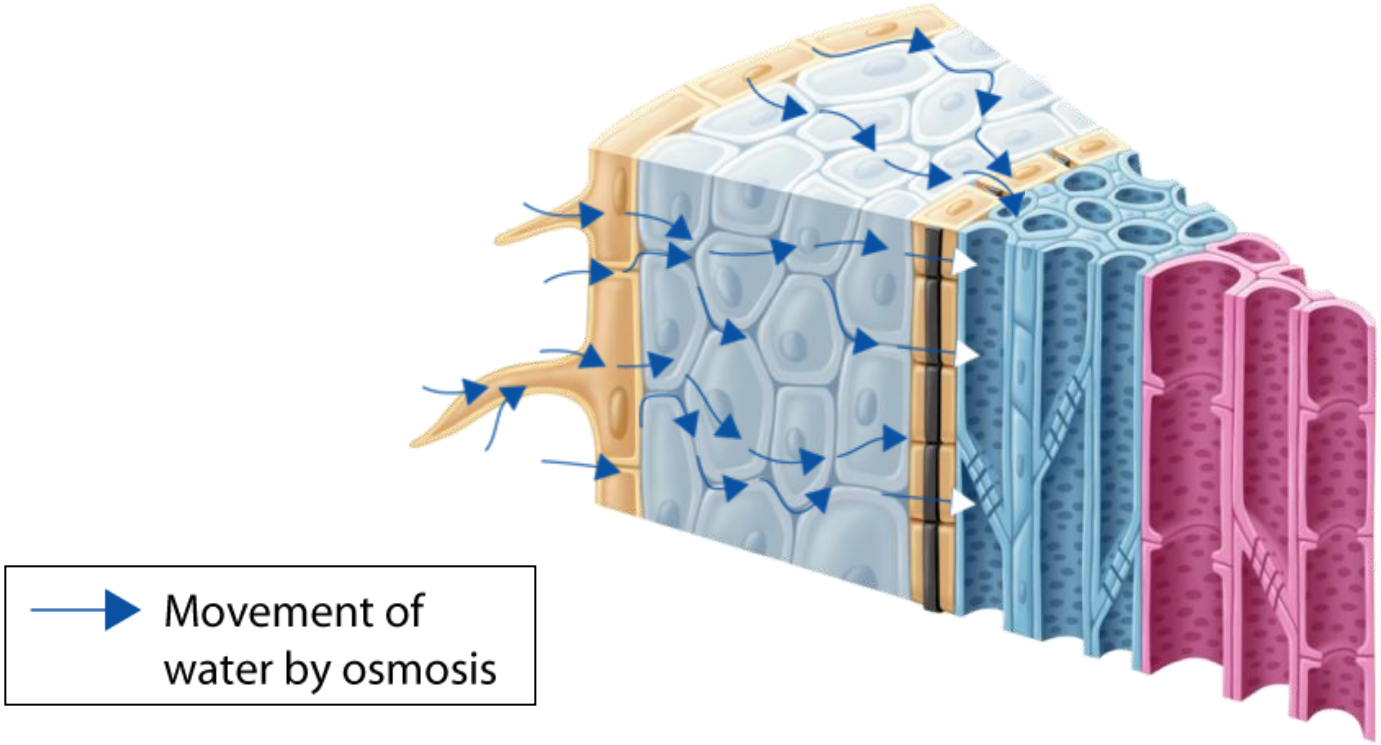
Active Transport of Minerals

The cell membranes of root hairs and other cells in the root epidermis contain active transport proteins.

Transport proteins use ATP to pump mineral ions from the soil into the plant.



The high concentration of mineral ions in the plant cells causes water molecules to move into the plant by osmosis.

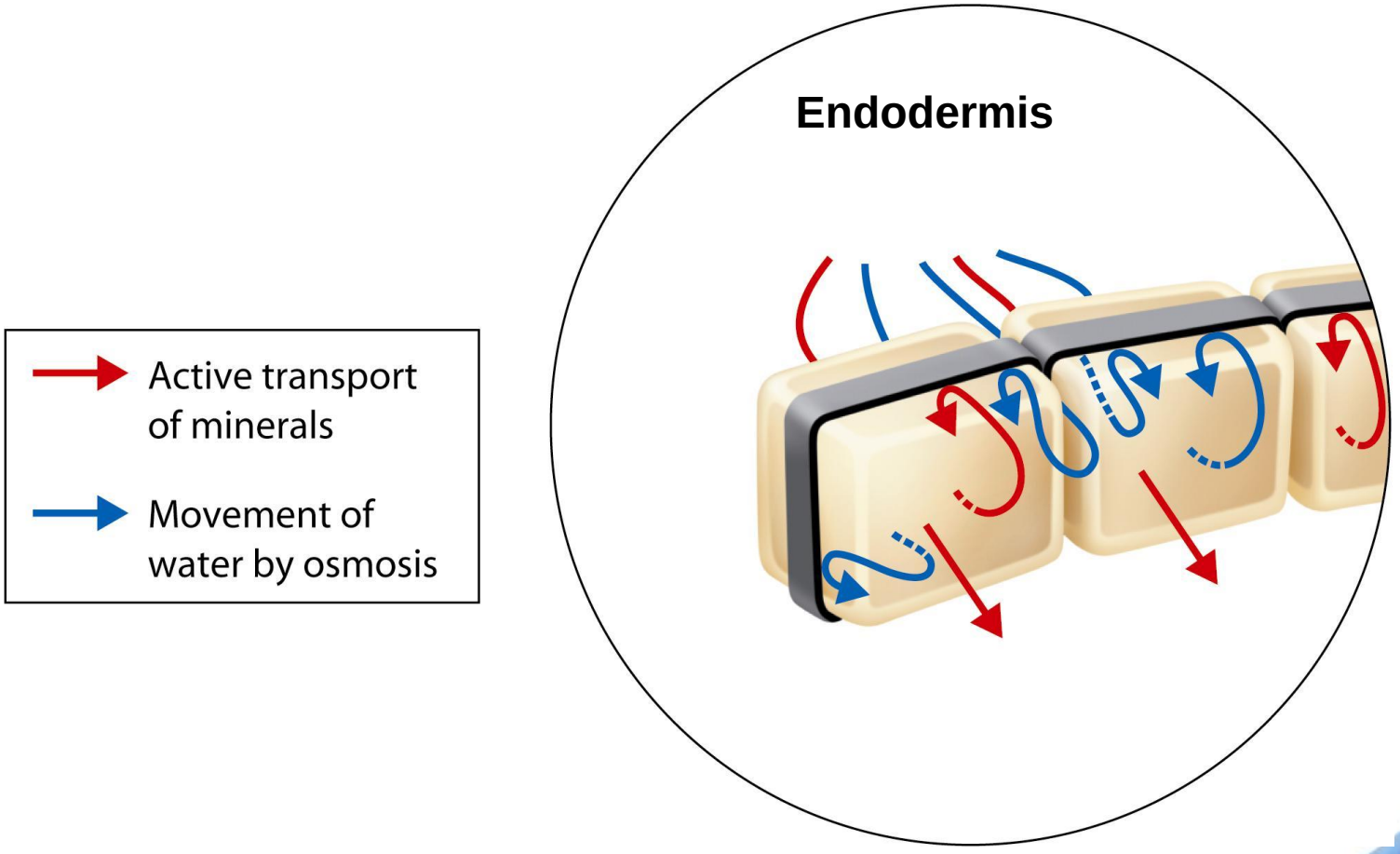


Movement Into the Vascular Cylinder

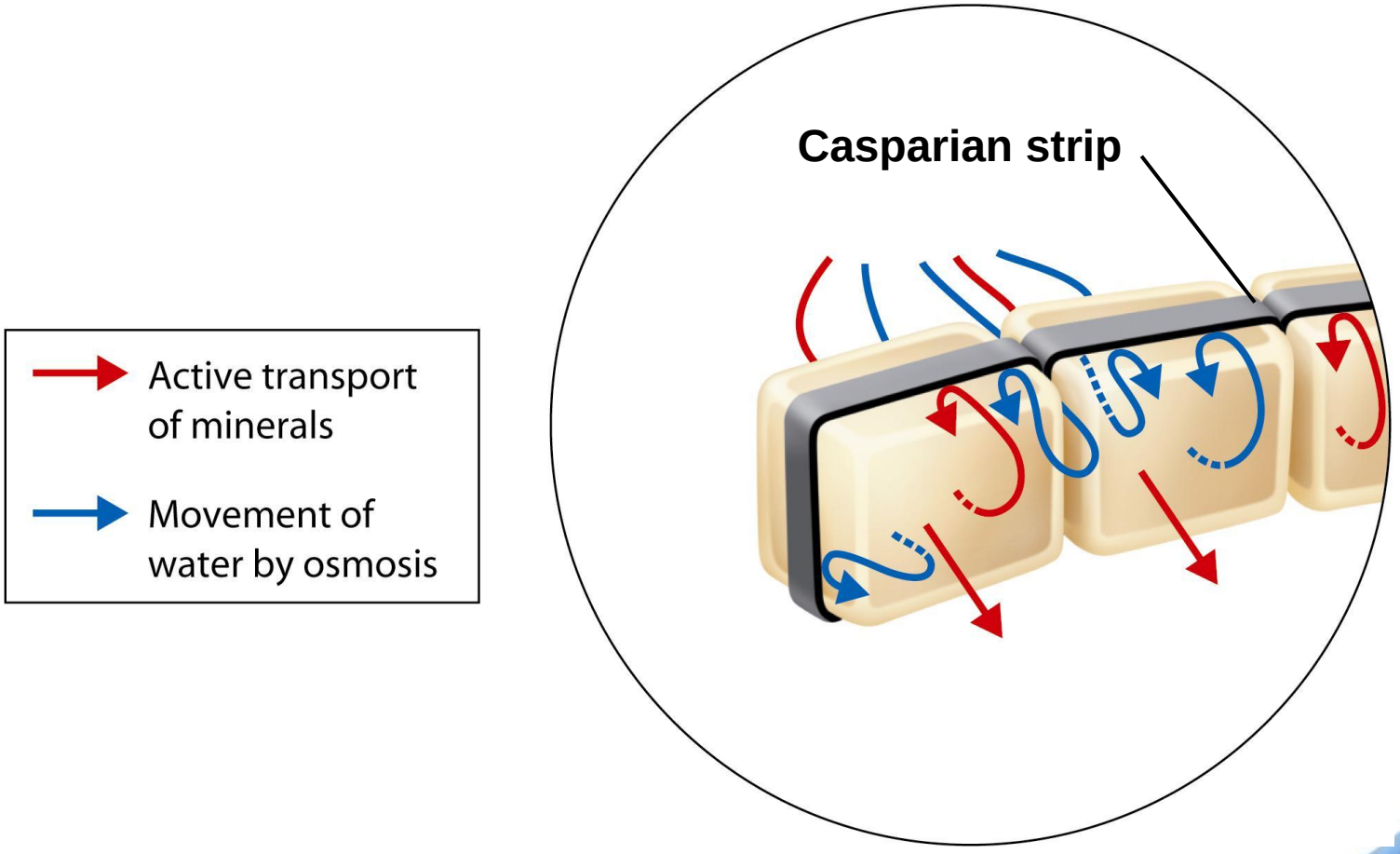
Osmosis and active transport move water and minerals from the root epidermis into the cortex.

The water and dissolved minerals pass the inner boundary of the cortex and enter the endodermis.

The endodermis is composed of many individual cells.



Each cell is surrounded on four sides by a waterproof strip called a **Casparian strip**.



The Casparian strip prevents the backflow of water out of the vascular cylinder into the root cortex.

Root Pressure

As minerals are pumped into the vascular cylinder, more and more water follows by osmosis, producing a strong pressure.

This root pressure forces water through the vascular cylinder and into the xylem.

23–5 Section QUIZ

Continue to:

Section QUIZ

- or -

Click to Launch:

23–2 Section QUIZ

1 Taproots are more common than fibrous roots in

a. monocots.

A b. dicots.

c. neither monocots or dicots.

d. both dicots and monocots.

2 The cells in a root that divide are found in the

A a. apical meristem.

b. epidermis.

c. endodermis.

d. vascular cylinder.

3 The tough layer of cells that covers the root tip is called the

a. vascular cylinder.

A b. root cap.

c. ground tissue.

d. apical meristem.

4 Xylem and phloem are found in the

a. epidermis.

b. endodermis.

c. apical meristem.

A d. vascular cylinder.

5 Roots absorb minerals from the surrounding soil by

a. diffusion.

A b. active transport.

c. passive transport.

d. root pressure.

END OF SECTION

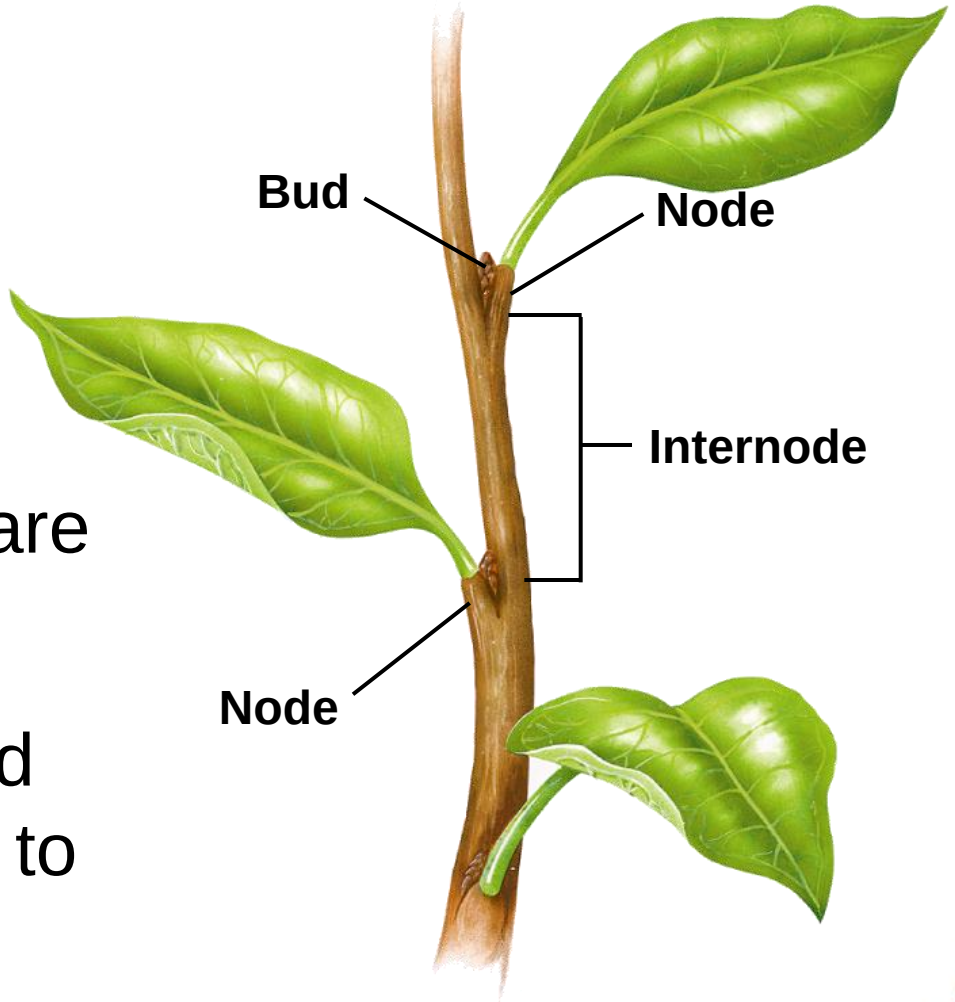
Stems have three important functions:

- they produce leaves, branches and flowers
- they hold leaves up to the sunlight
- they transport substances between roots and leaves

Leaves attach to the stem at structures called **nodes**.

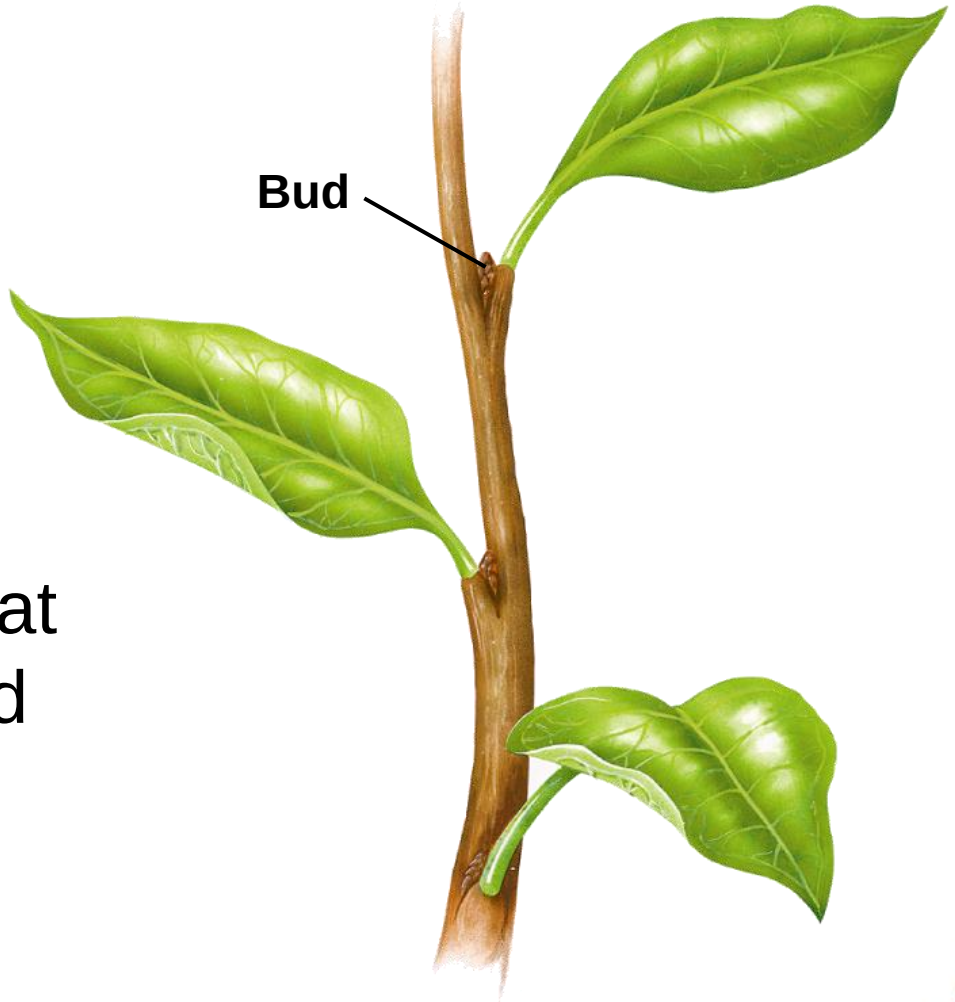
The regions of stem between the nodes are **internodes**.

Small buds are found where leaves attach to nodes.



Buds contain undeveloped tissue that can produce new stems and leaves.

In larger plants, stems develop woody tissue that helps support leaves and flowers.



In monocots, vascular bundles are scattered throughout the stem. In dicots and most gymnosperms, vascular bundles are arranged in a ringlike pattern.

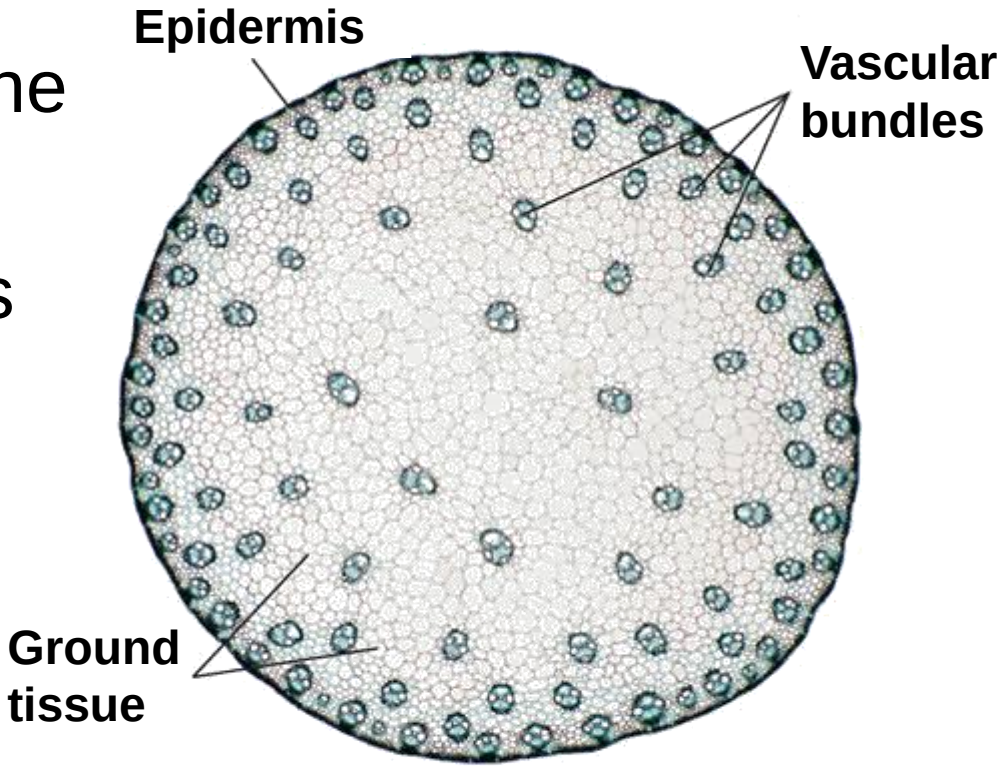
Monocot Stems

Monocot stems have a distinct epidermis, which encloses **vascular bundles**.

Each vascular bundle contains xylem and phloem tissue.

Vascular bundles are scattered throughout the ground tissue.

Ground tissue consists mainly of parenchyma cells.

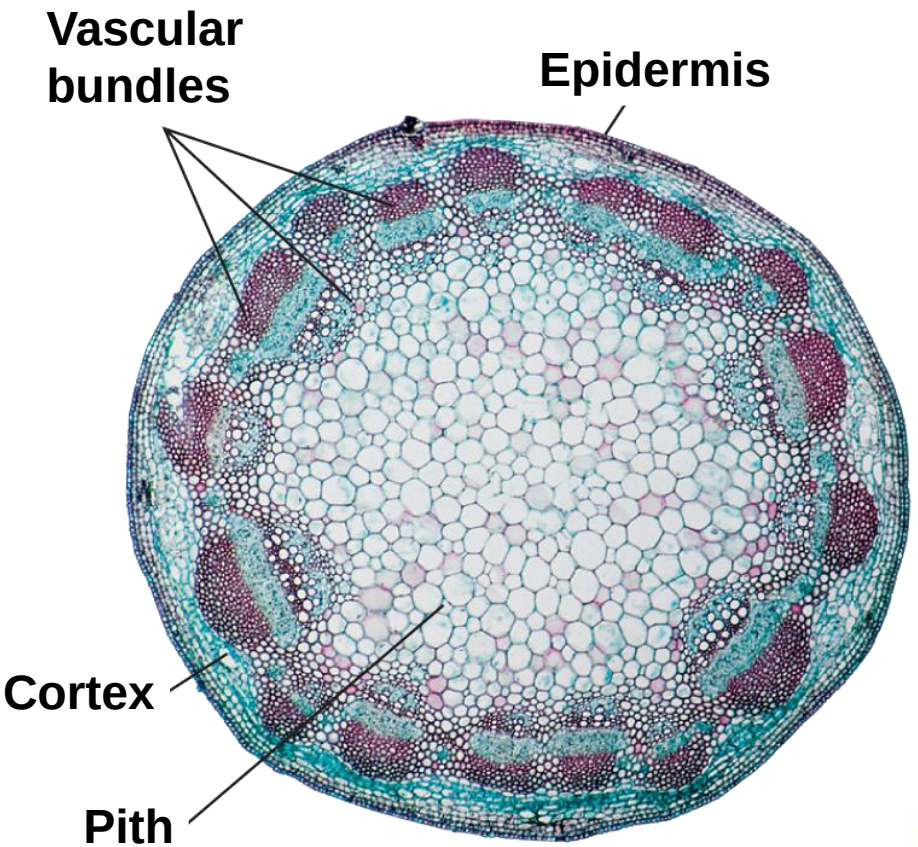


Monocot

Dicot Stems

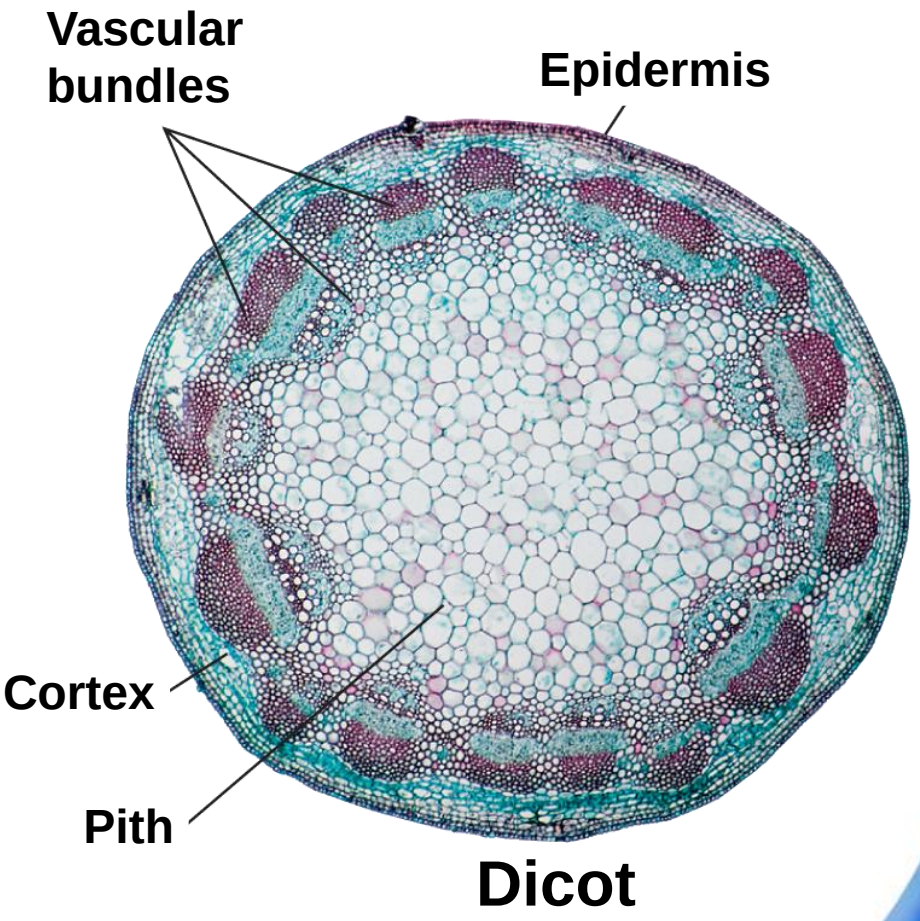
Dicot stems have vascular bundles arranged in a ringlike pattern.

The parenchyma cells inside the vascular tissue are known as **pith**.



Dicot

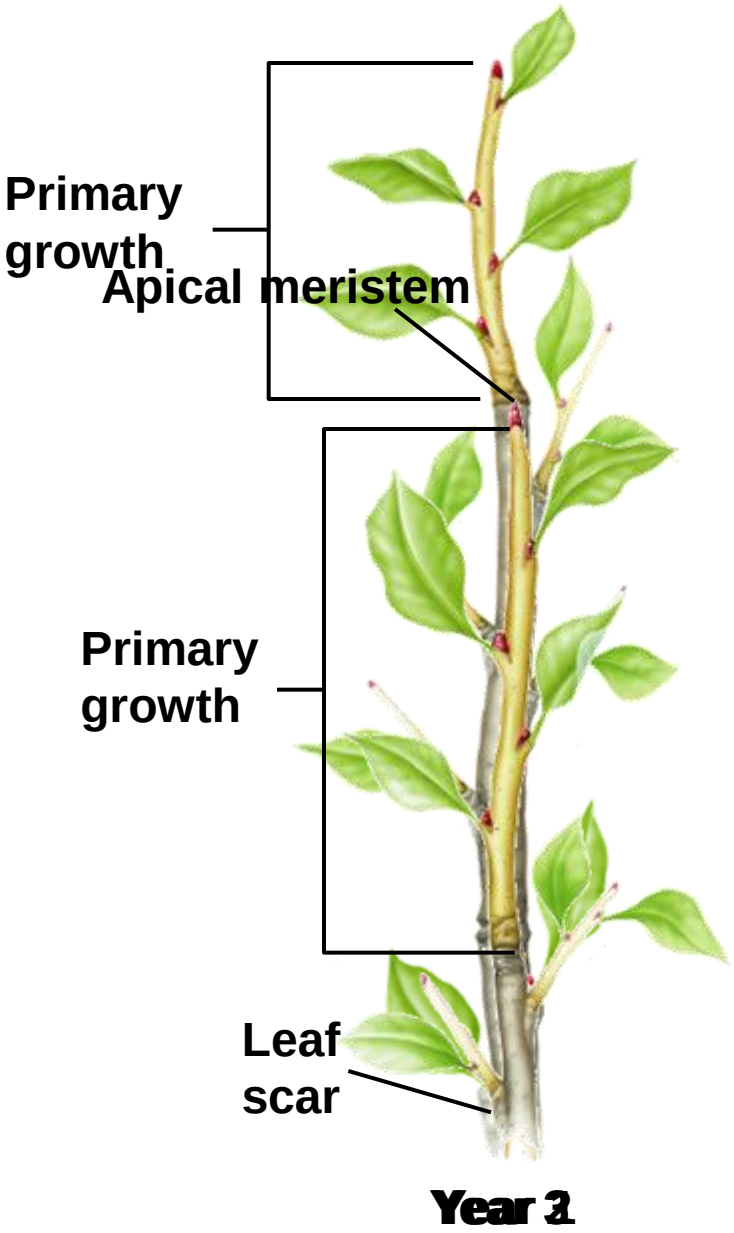
The parenchyma cells outside of the vascular tissue form the cortex of the stem.



Primary Growth of Stems

All seed plants undergo **primary growth**, which is an increase in length.

For the entire life of the plant, new cells are produced at the tips of roots and shoots.



Primary growth of stems is produced by cell divisions in the apical meristem. It takes place in all seed plants.

Secondary Growth of Stems

The method of growth in which stems increase in width is called **secondary growth**.

In conifers and dicots, secondary growth takes place in the vascular cambium and cork cambium.

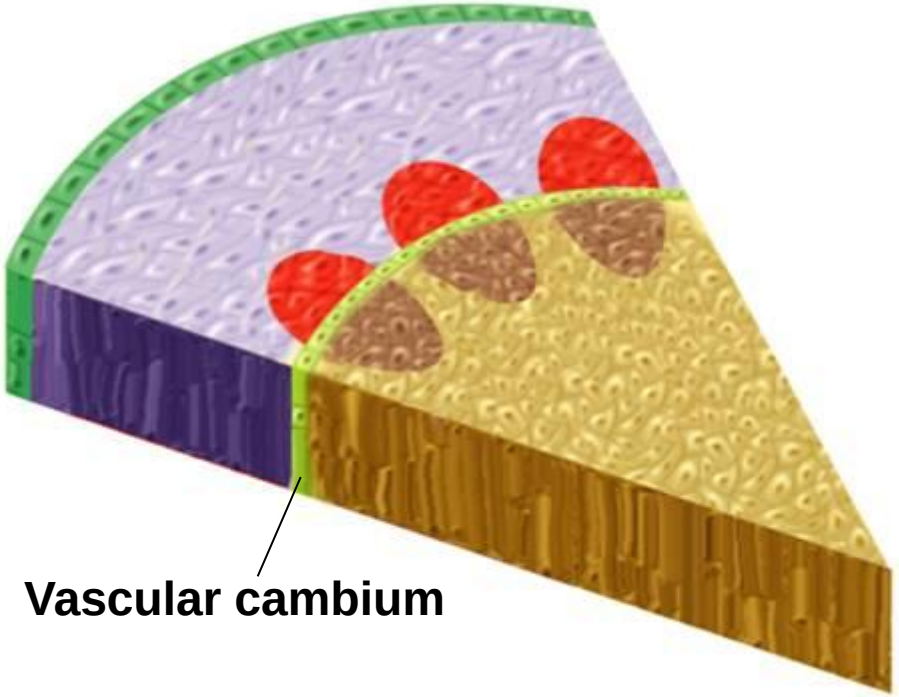
Vascular cambium produces vascular tissues and increases the thickness of stems over time.

Cork cambium produces the outer covering of stems.

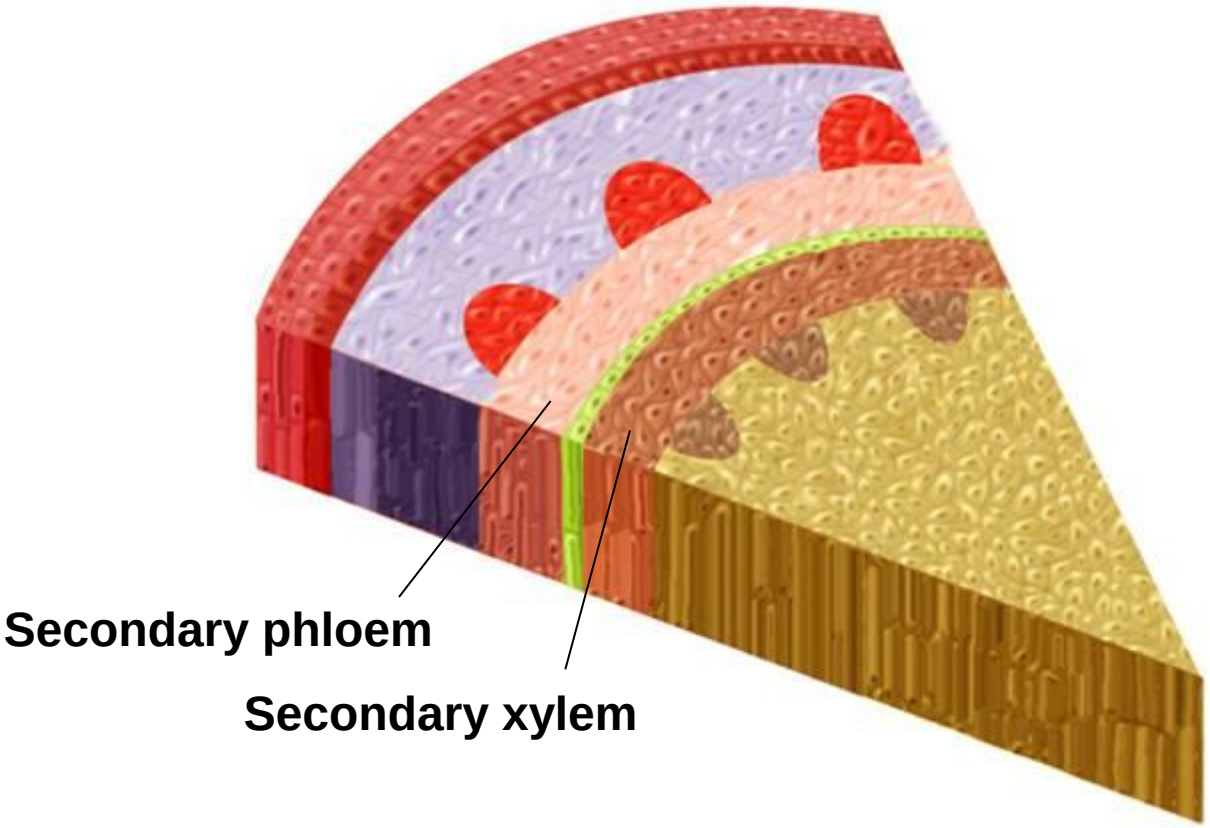
The addition of new tissue in these cambium layers increases the thickness of the stem.

Formation of the Vascular Cambium

Once secondary growth begins, the vascular cambium appears as a thin layer between the xylem and phloem of each vascular bundle.

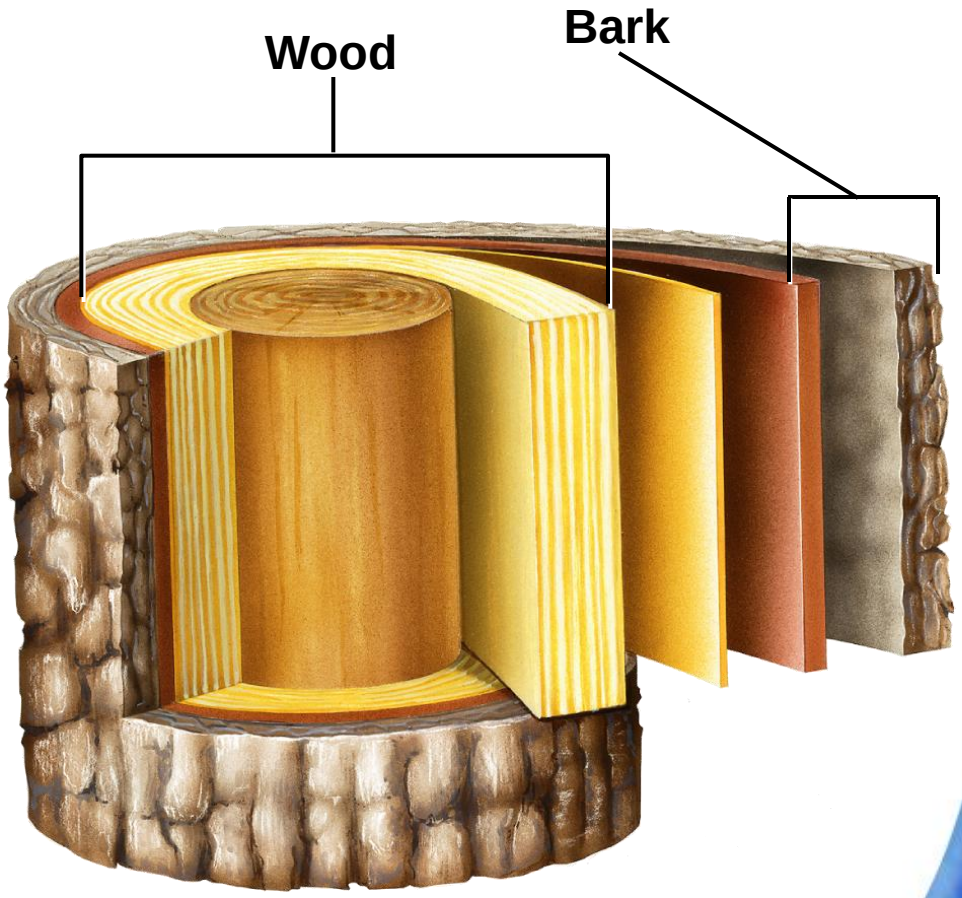


The vascular cambium divides to produce xylem cells toward the center of the stem and phloem cells toward the outside.



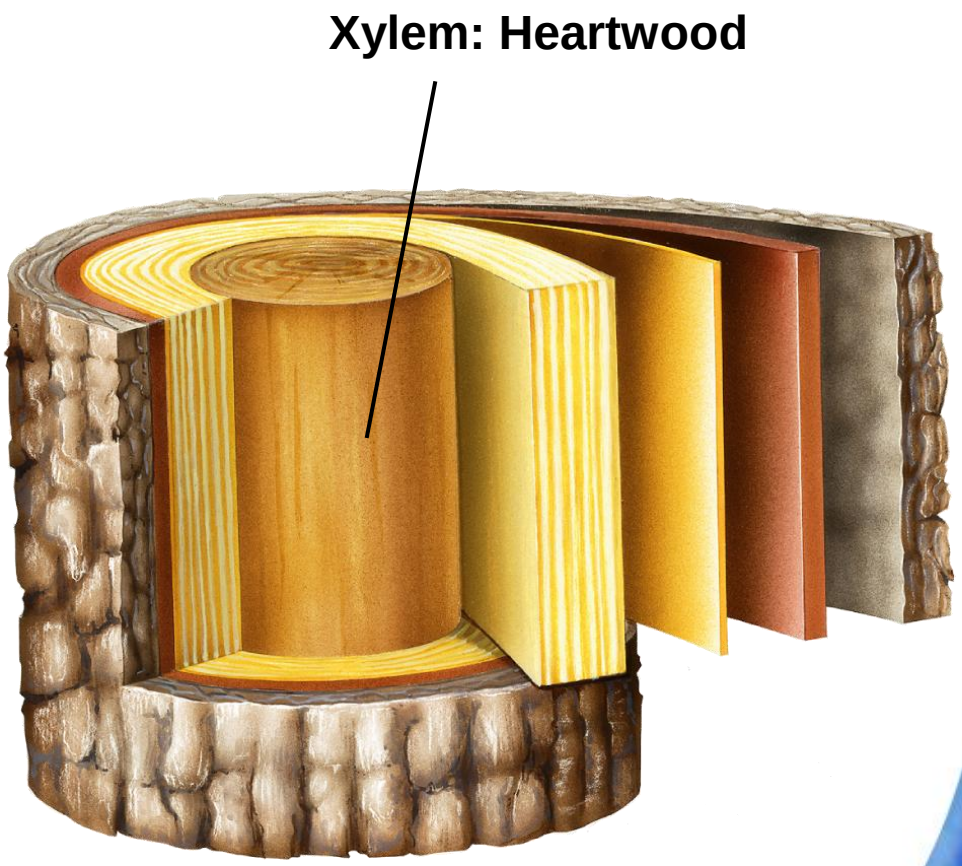
Formation of Wood

Wood is actually layers of xylem. These cells build up year after year.



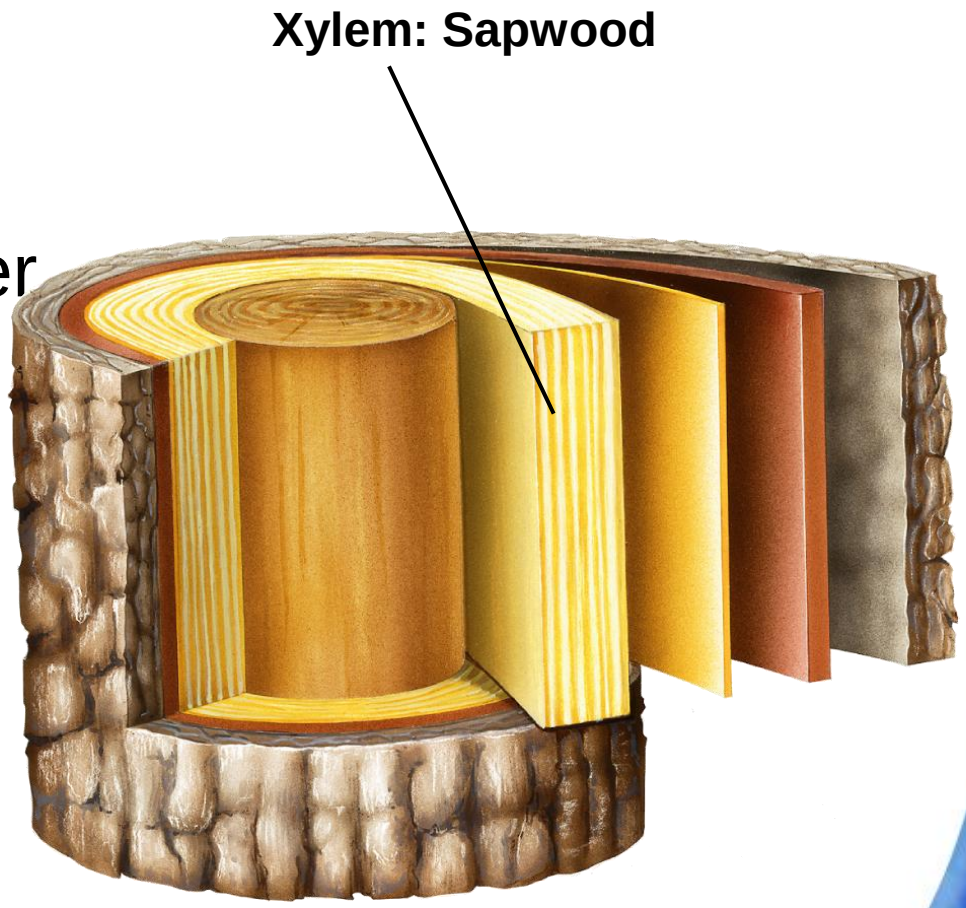
As woody stems grow thicker, older xylem cells near the center of the stem no longer conduct water.

This is called **heartwood**. Heartwood supports the tree.



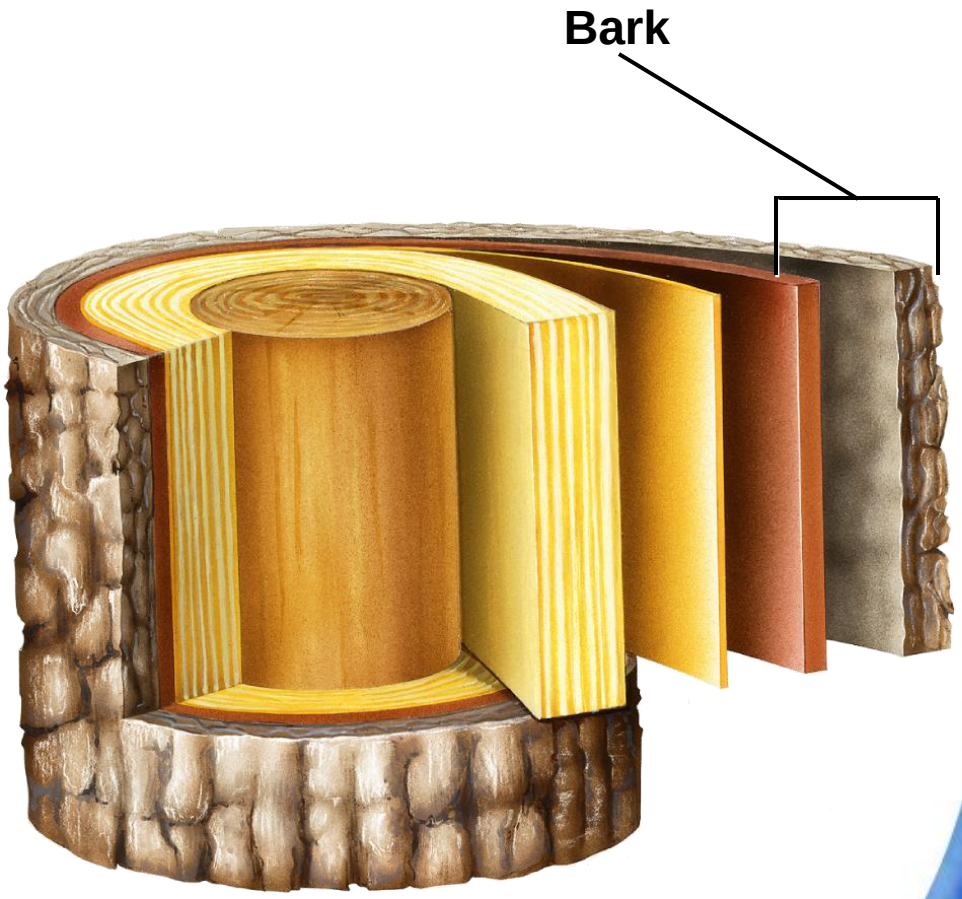
Heartwood is surrounded by **sapwood.**

Sapwood is active in water and mineral transport.

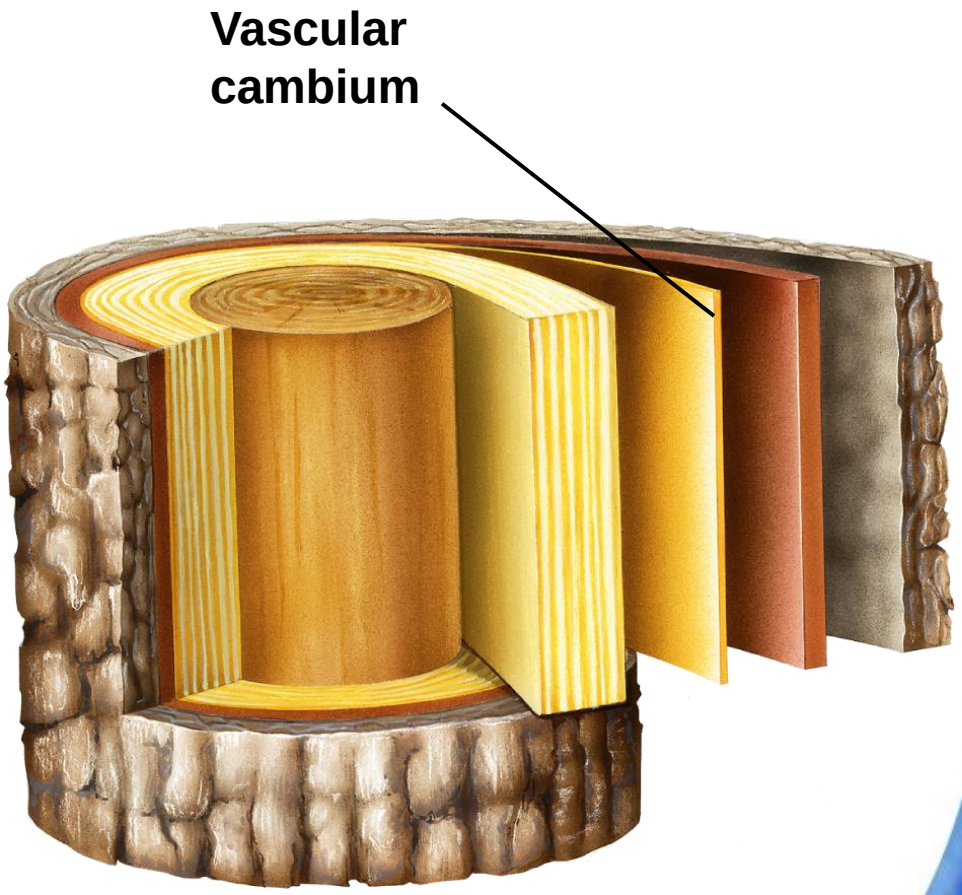


Formation of Bark

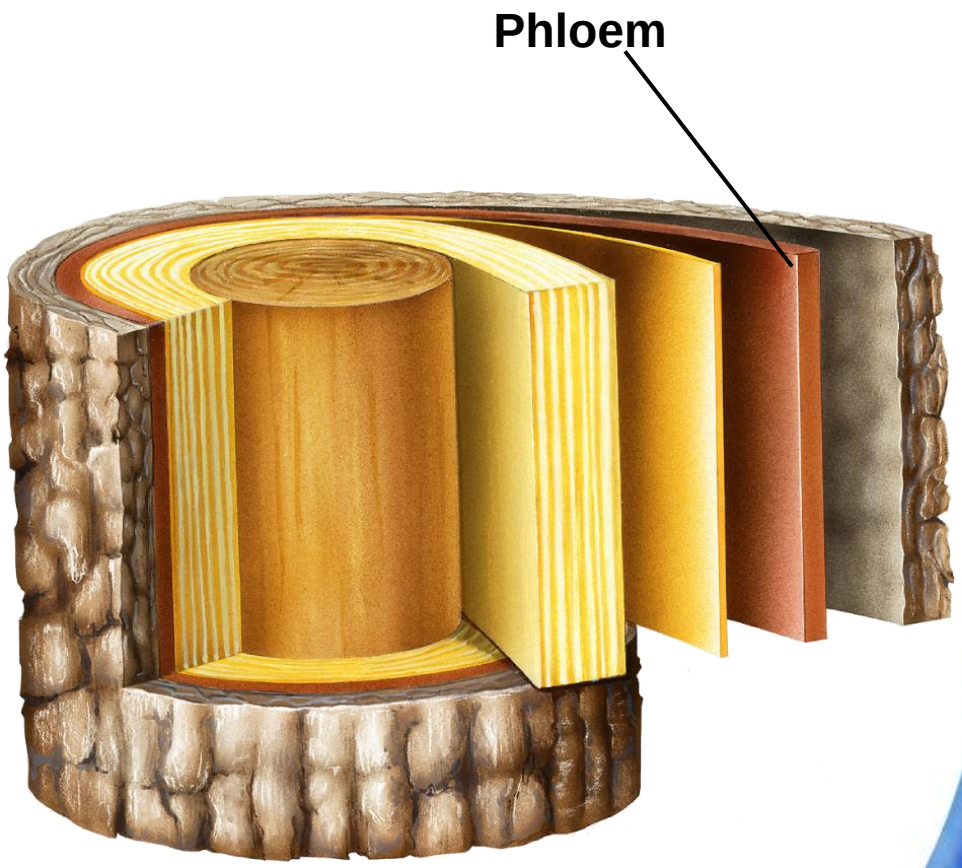
On most trees, **bark** includes all of the tissues outside the vascular cambium — phloem, the cork cambium and cork.



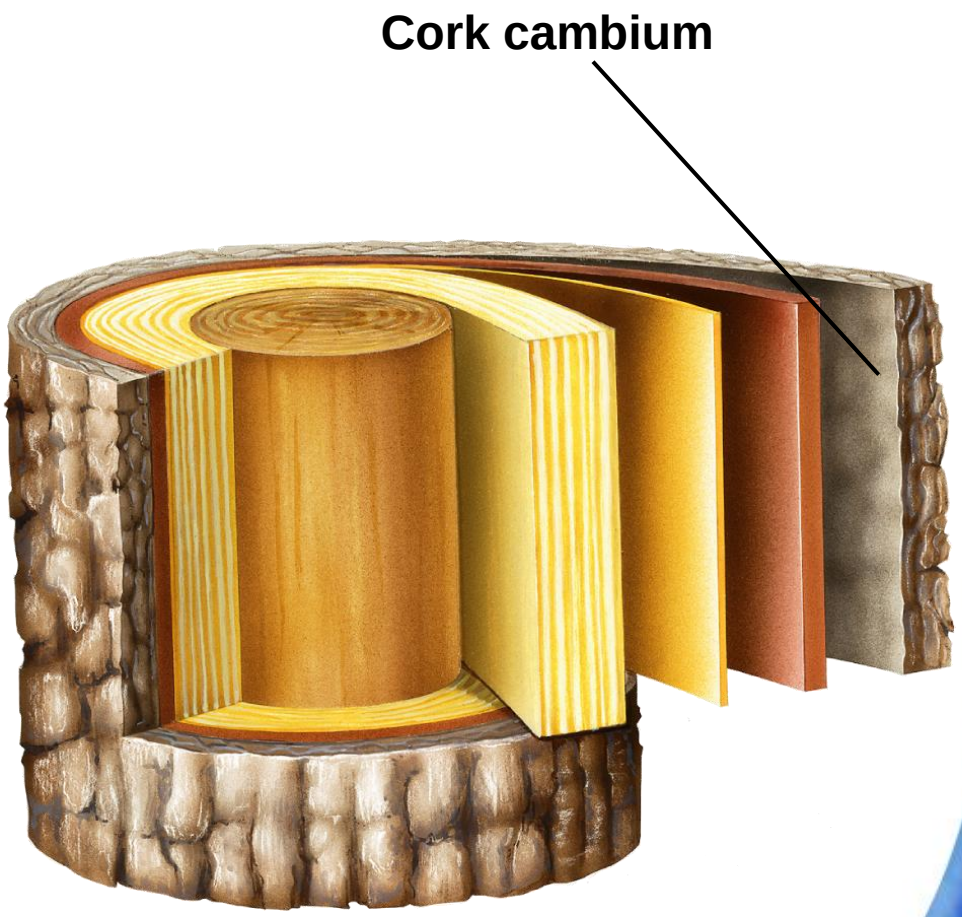
The vascular cambium produces new xylem and phloem, which increase the width of the stem.



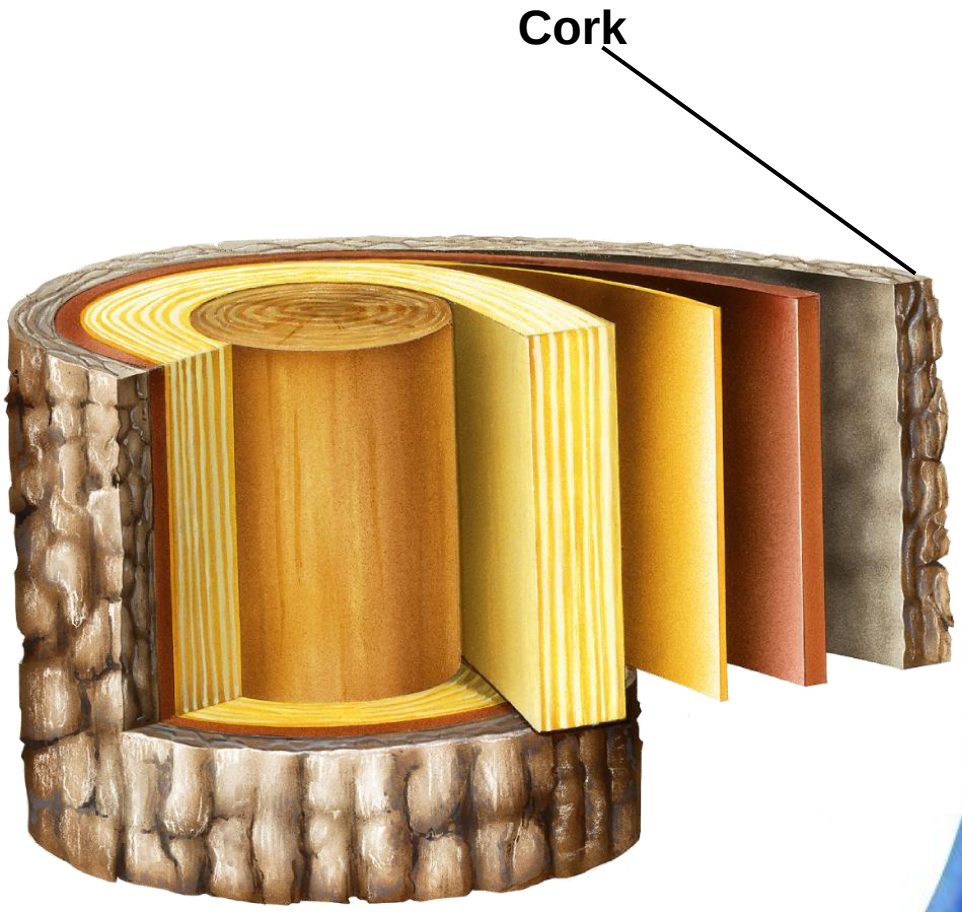
The phloem transports sugars produced by photosynthesis.



The cork cambium produces a protective layer of cork.



The cork contains old, nonfunctioning phloem that protects the tree.



23–5 Section QUIZ

Continue to:

Section QUIZ

- or -

Click to Launch:

23–3 Section QUIZ

1 Structures on a stem that can produce new stems and leaves are called

a. nodes.

b. internodes.

A c. buds.

d. branches.

2 The vascular bundles in a monocot stem

a. form a cylinder, or ring.

A b. are scattered throughout the stem.

c. form concentric rings.

d. separate into xylem bundles and phloem bundles.

3 The outermost layer of a tree that contains old, nonfunctioning phloem is

a. bark.

A b. cork.

c. pith.

d. apical meristem.

4 Xylem and phloem are contained in

a. the epidermis.

A b. vascular bundles.

c. the pith.

d. cork cambium.

23–3 Section QUIZ

5 In stems, secondary growth results in

a. growth at the tips of roots.

b. growth at the tips of shoots.

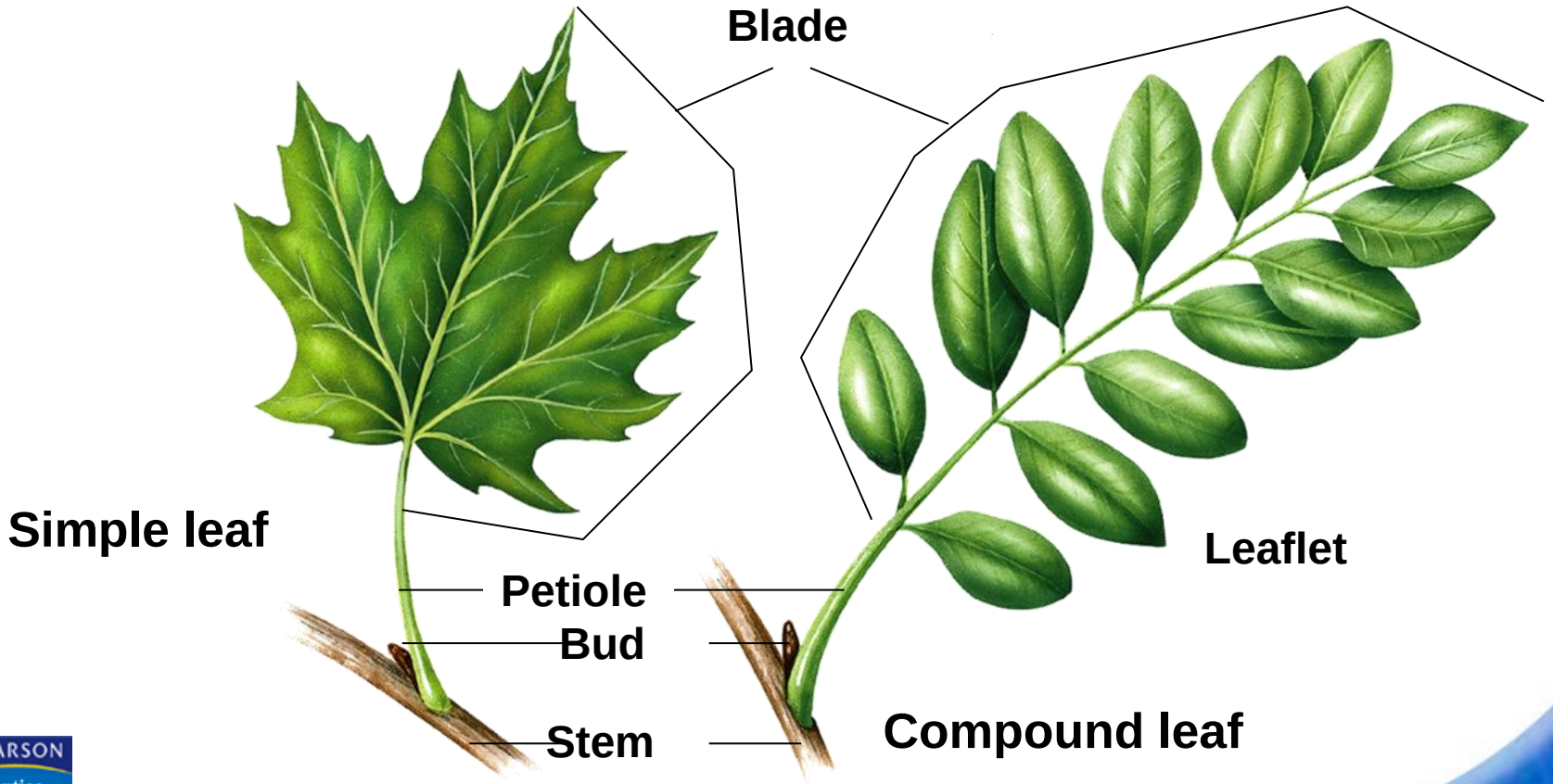
A c. an increase in the width of stems.

d. an increase in the length of stems.

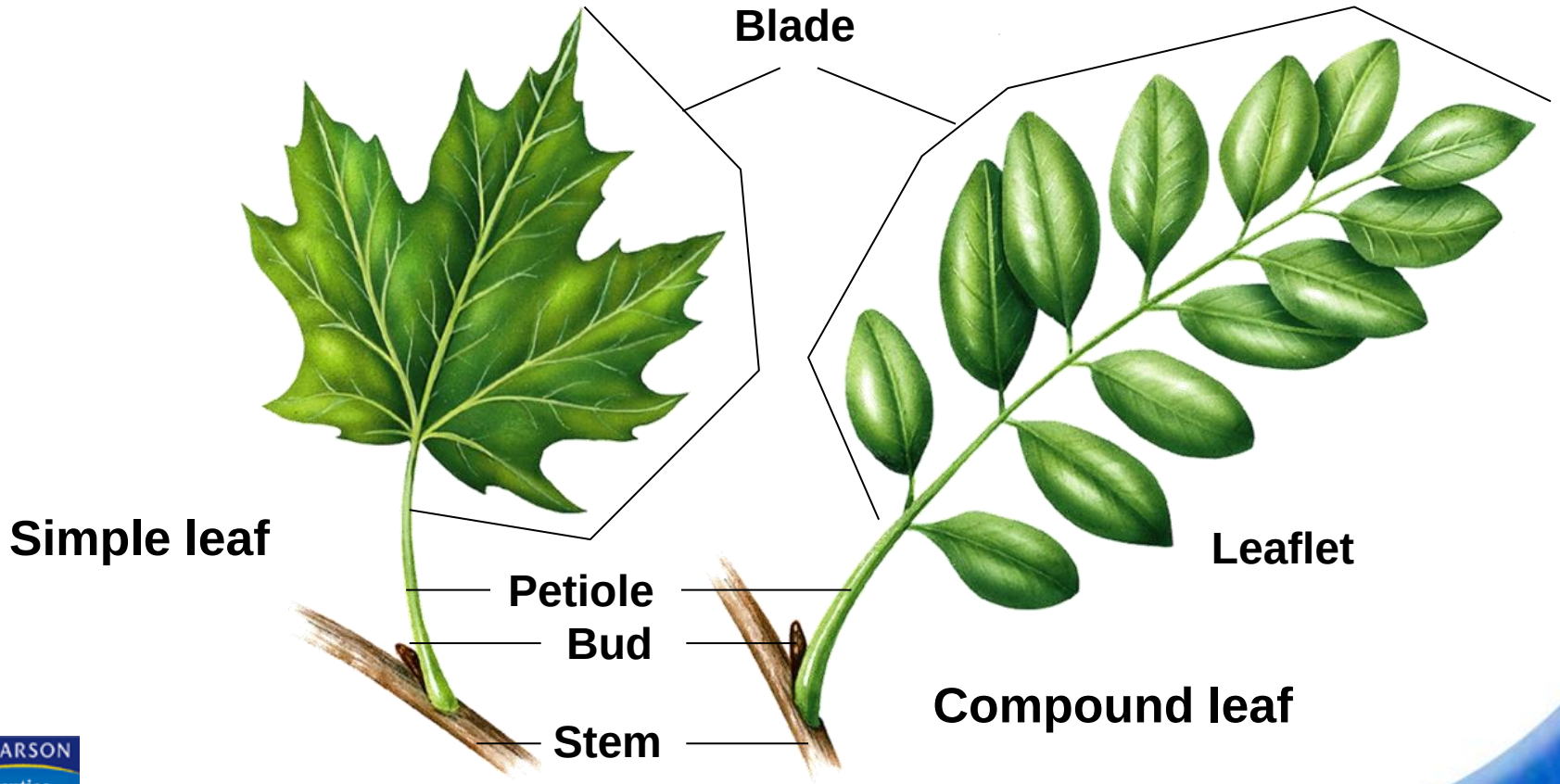
END OF SECTION

The structure of a leaf is optimized for absorbing light and carrying out photosynthesis.

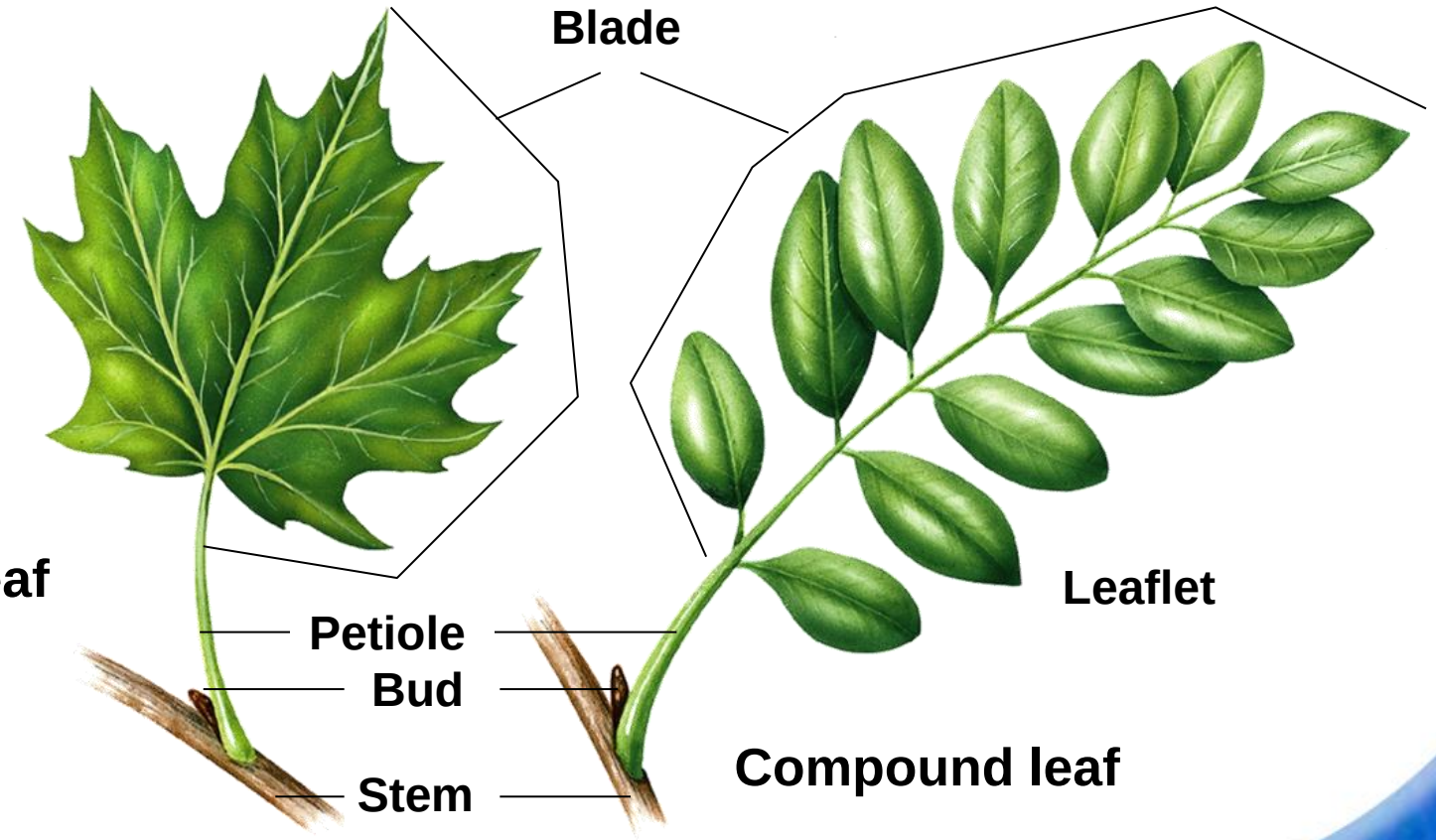
To collect sunlight, most leaves have thin, flattened sections called **blades.**



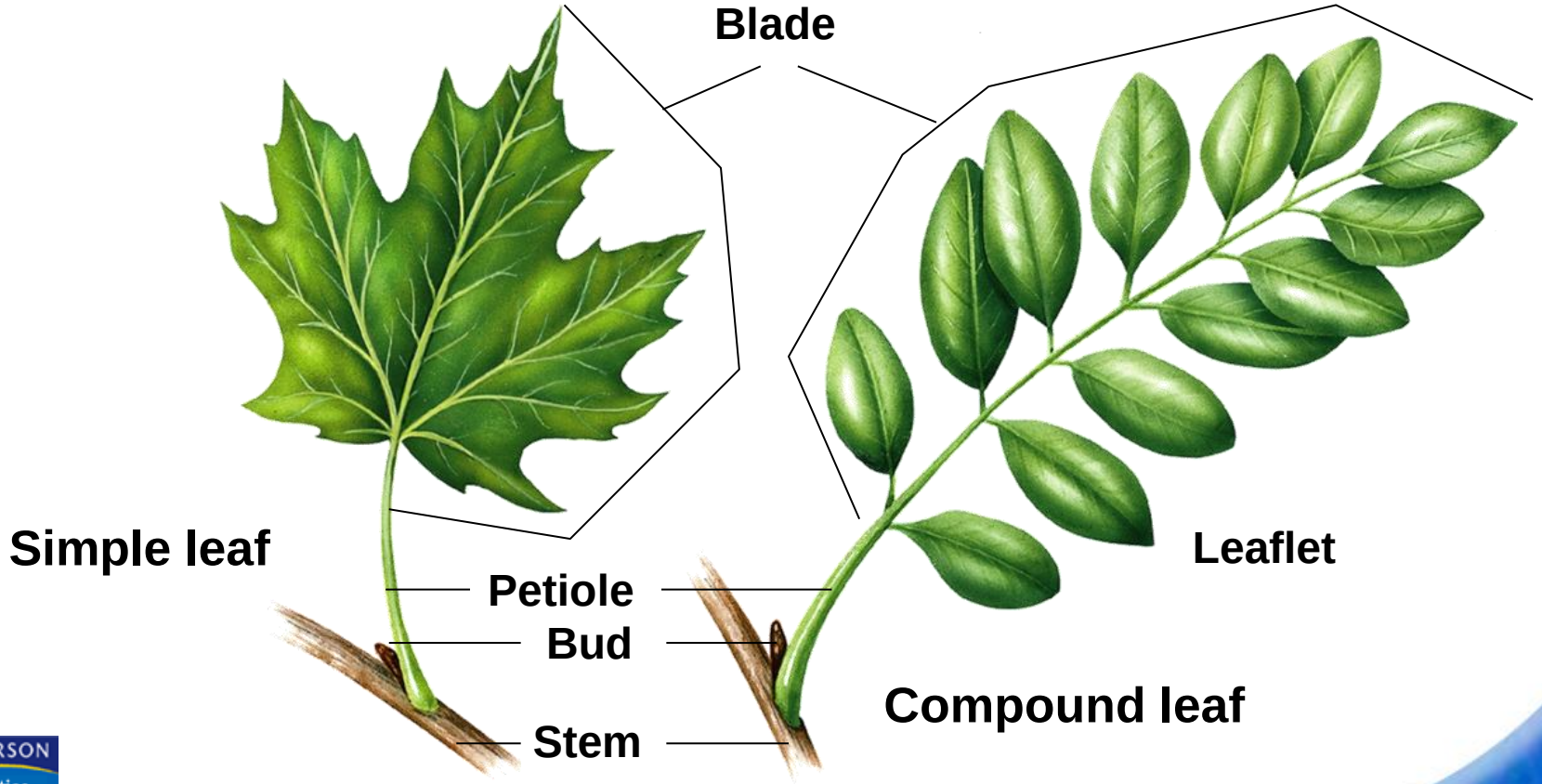
The blade is attached to the stem by a thin stalk called a **petiole**.



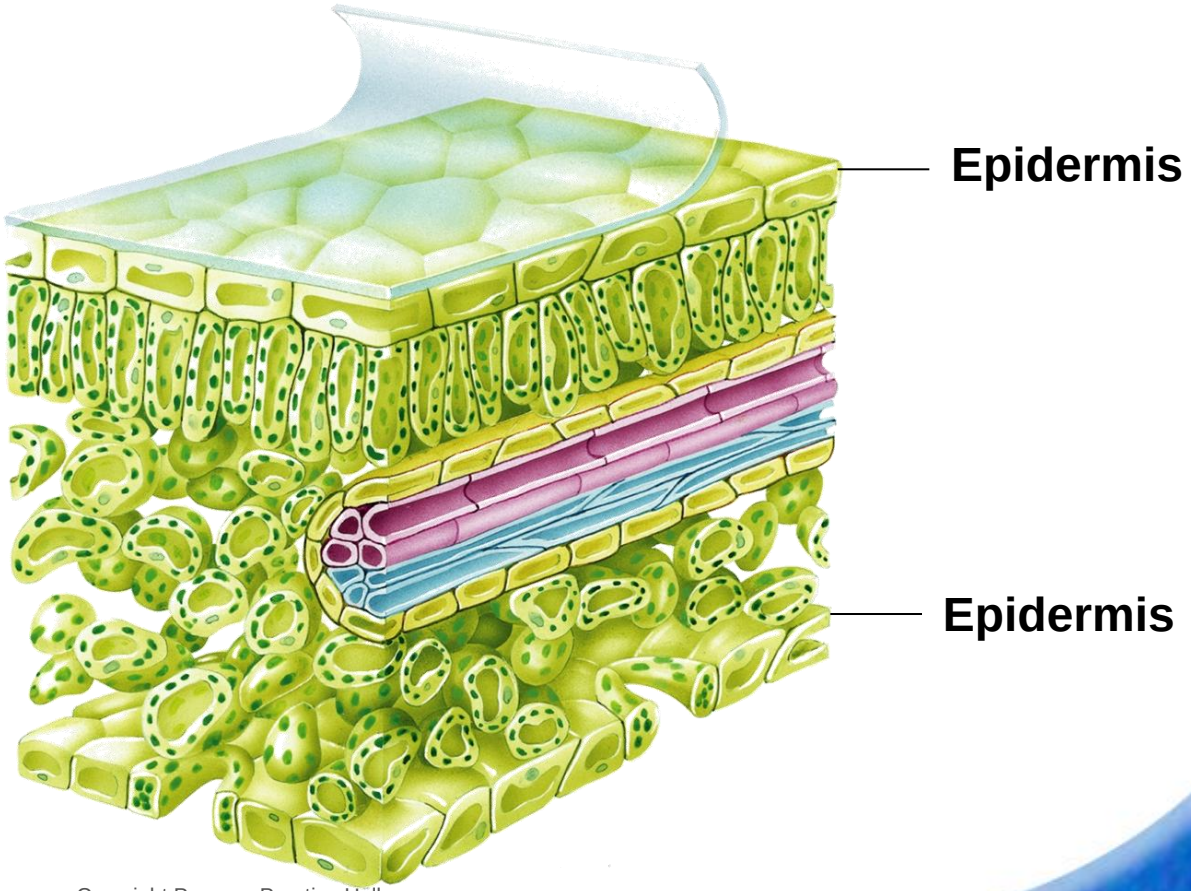
Simple leaves have only one blade and one petiole.



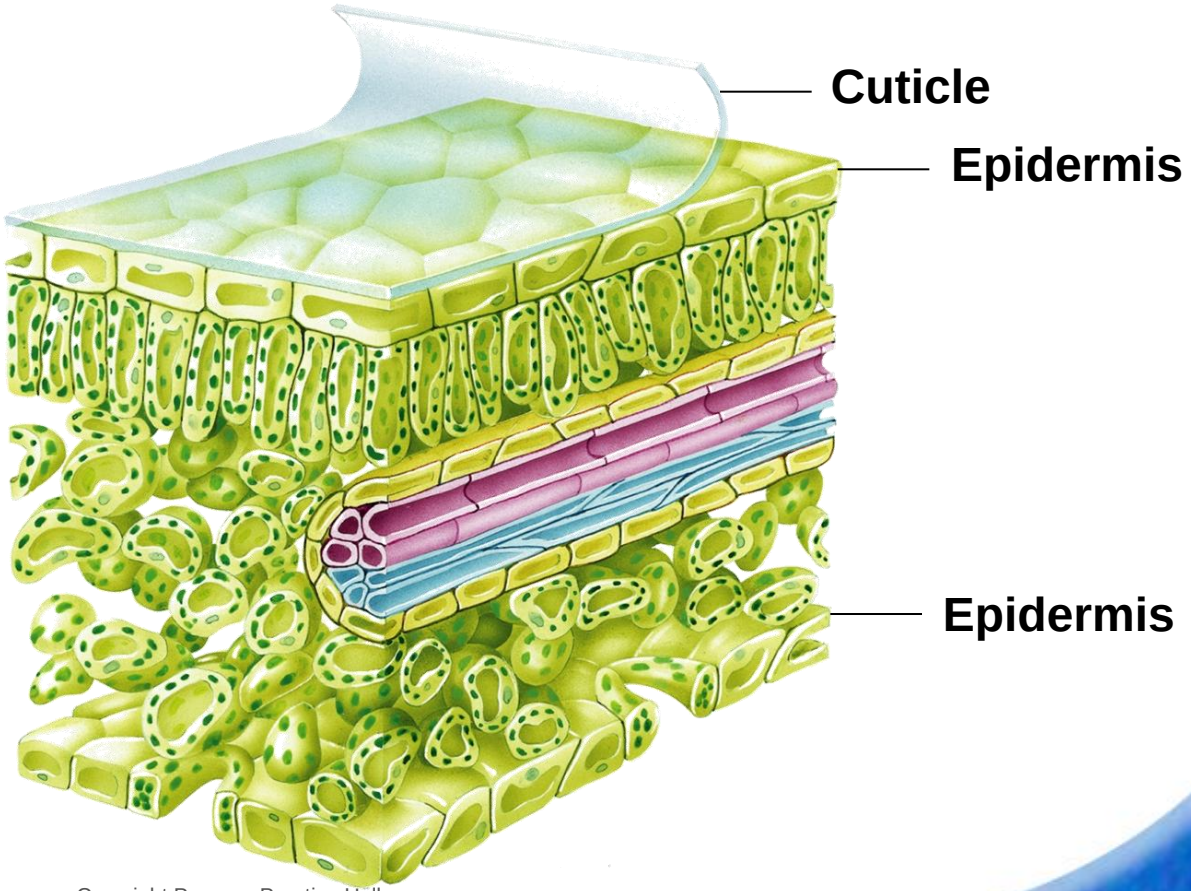
Compound leaves have several blades, or leaflets, that are joined together and to the stem by several petioles.



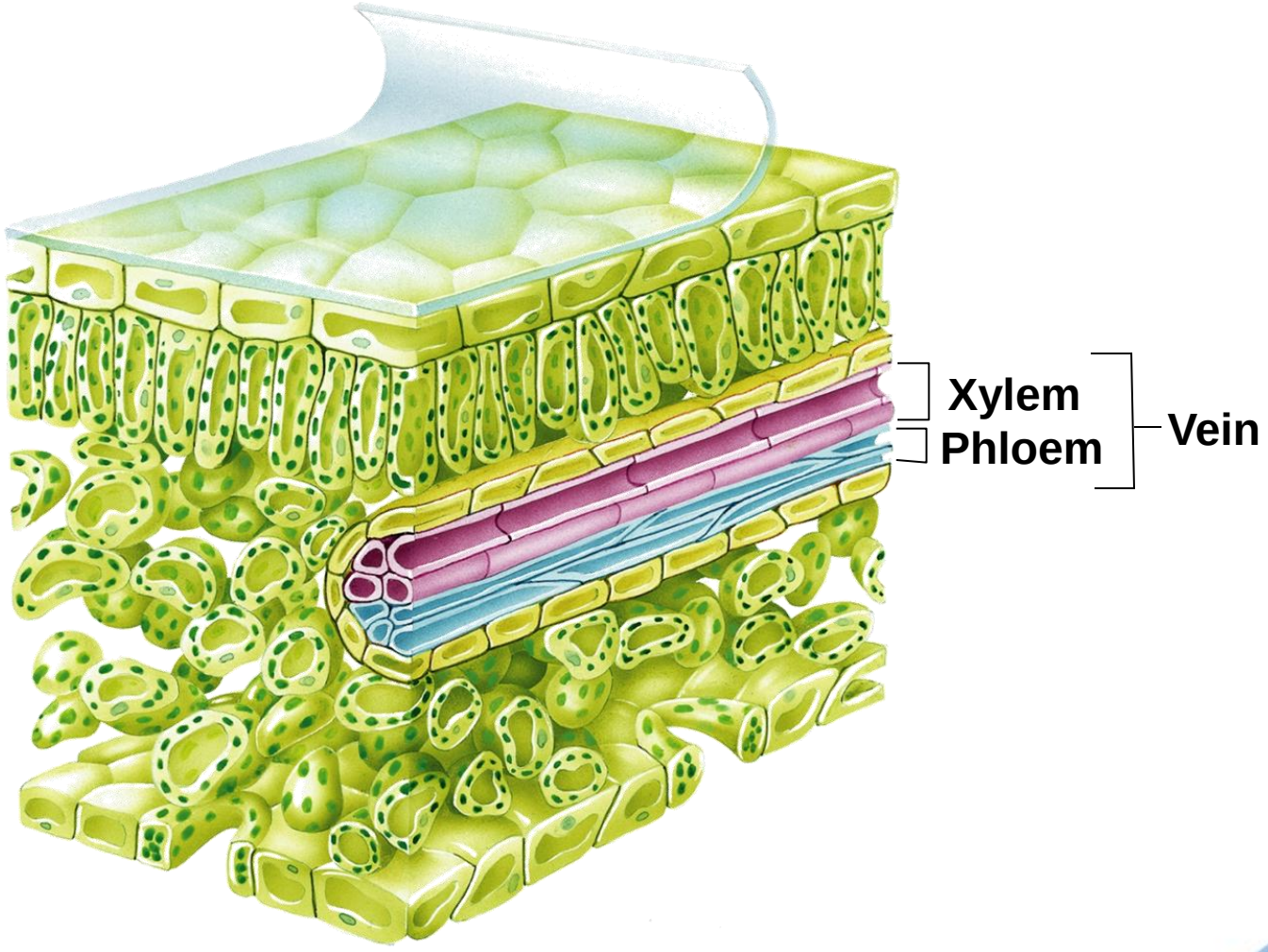
Leaves are covered on the top and bottom by epidermis.



The epidermis of many leaves is covered by the cuticle.

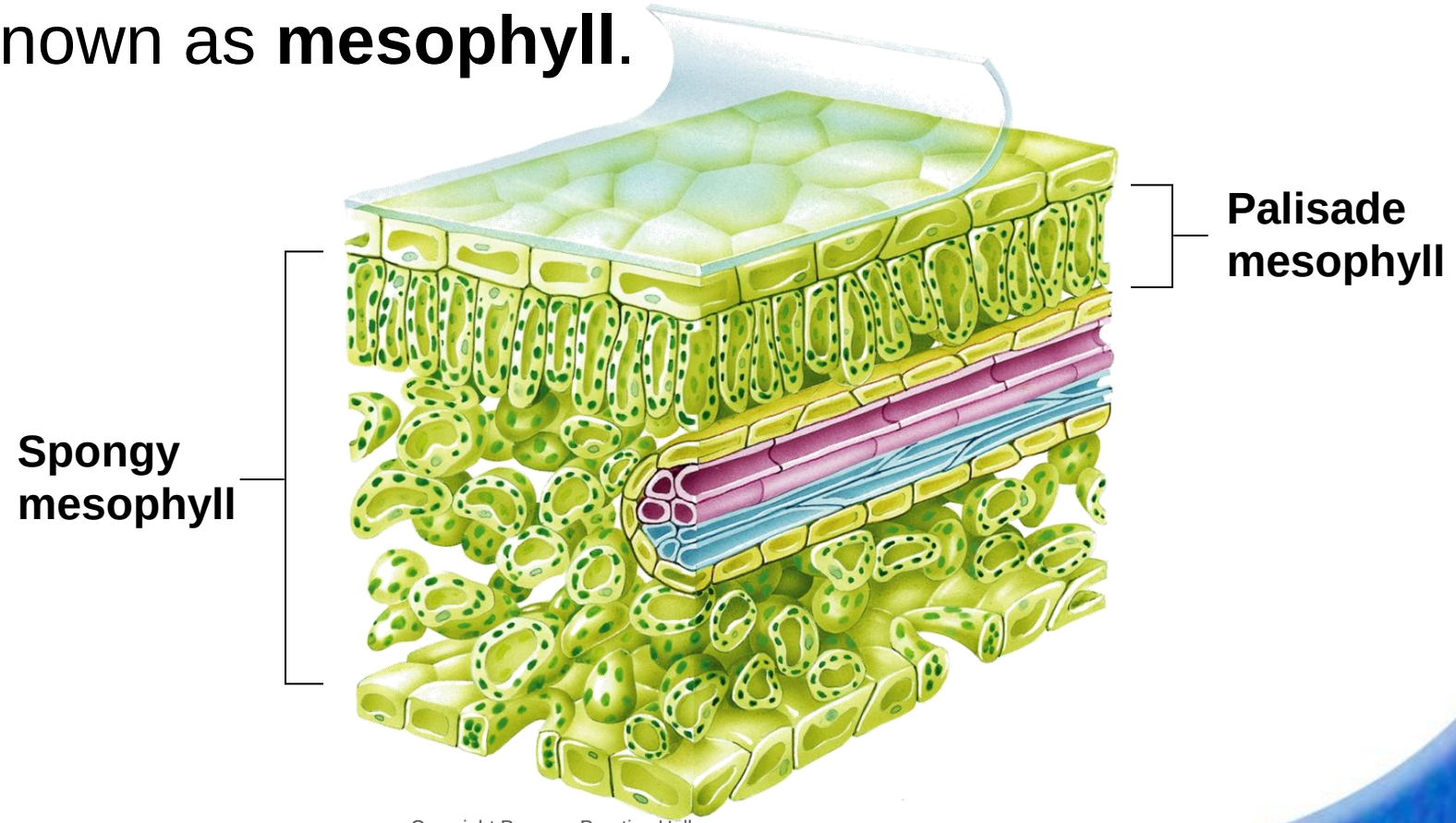


All these tissues form the veins of a leaf.

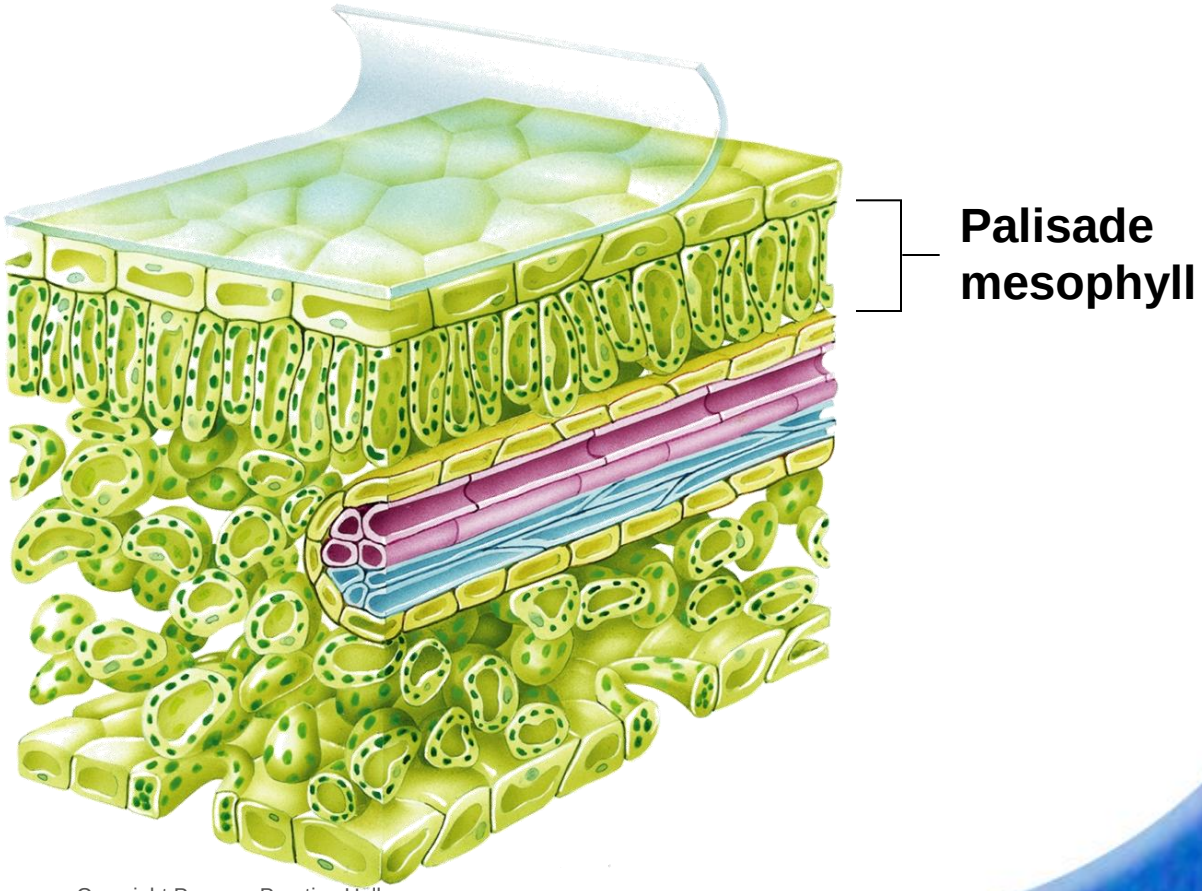


Leaf Functions

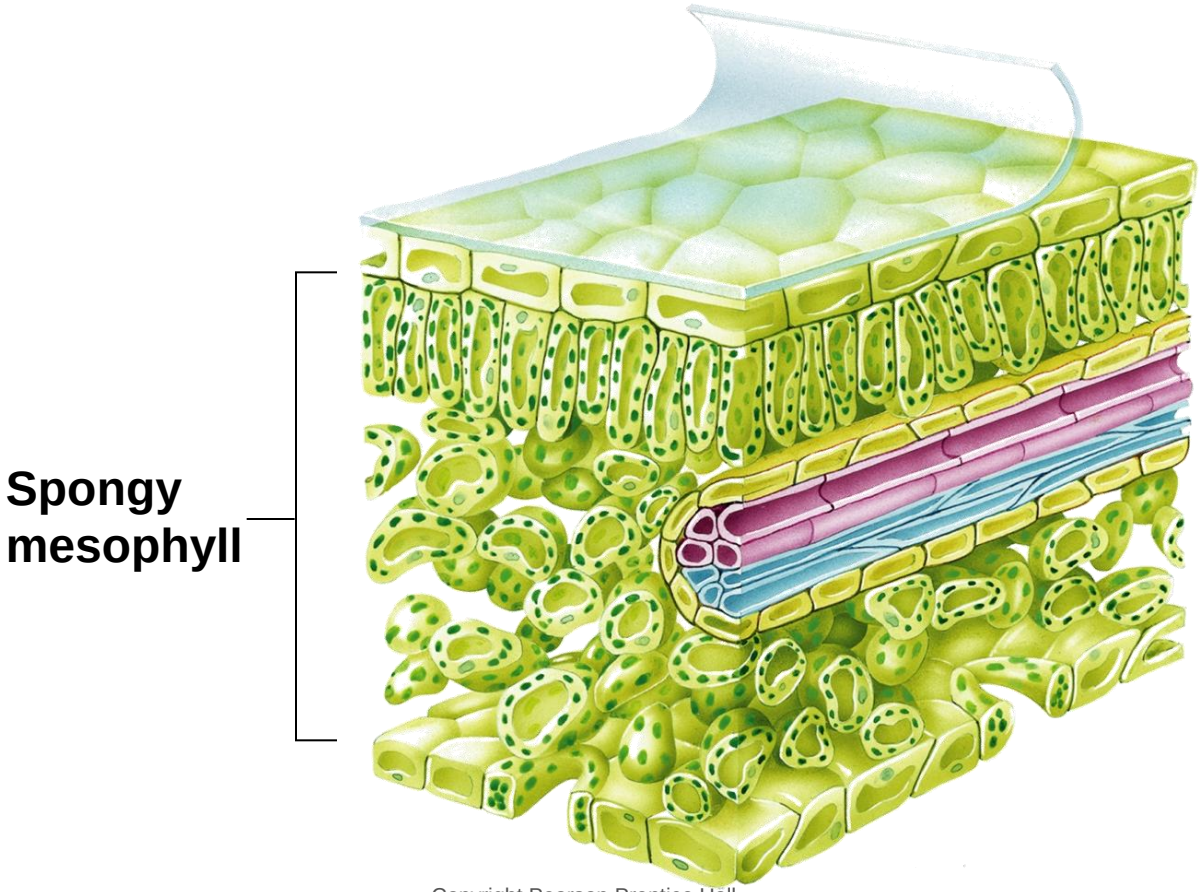
Most leaves consist of a specialized ground tissue known as **mesophyll**.



The layer of mesophyll cells found directly under the epidermis is called the **palisade mesophyll**. These closely-packed cells absorb light that enters the leaf.

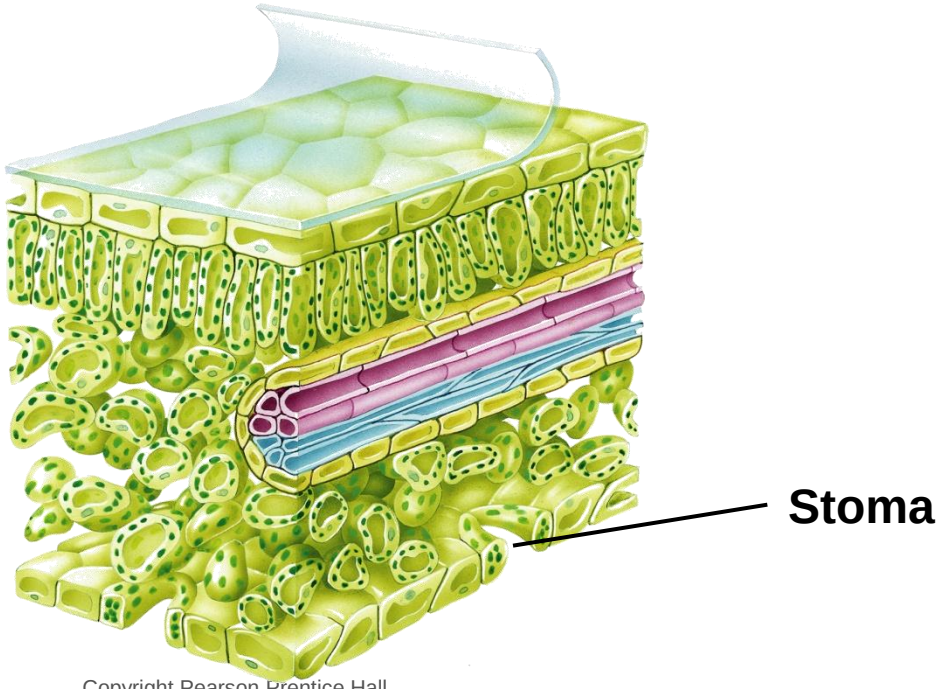


Beneath the palisade mesophyll is the **spongy mesophyll**, a loose tissue with many air spaces between its cells.



The air spaces connect with the exterior through stomata.

Stomata are porelike openings in the underside of the leaf that allow carbon dioxide and oxygen to diffuse into and out of the leaf.



Transpiration

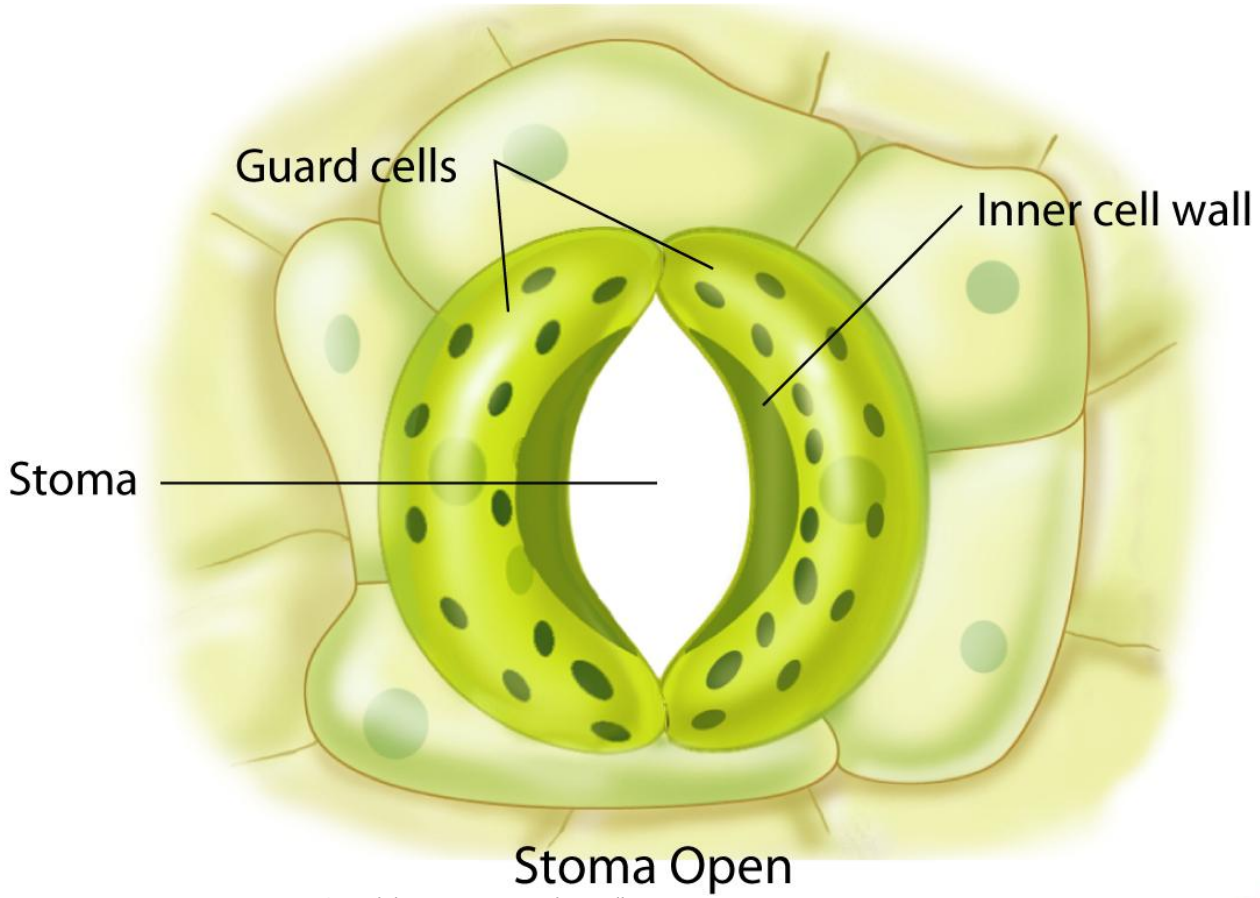
The surfaces of spongy mesophyll cells are kept moist so gases can enter and leave the cells easily.

Water evaporates from these surfaces and is lost to the atmosphere.

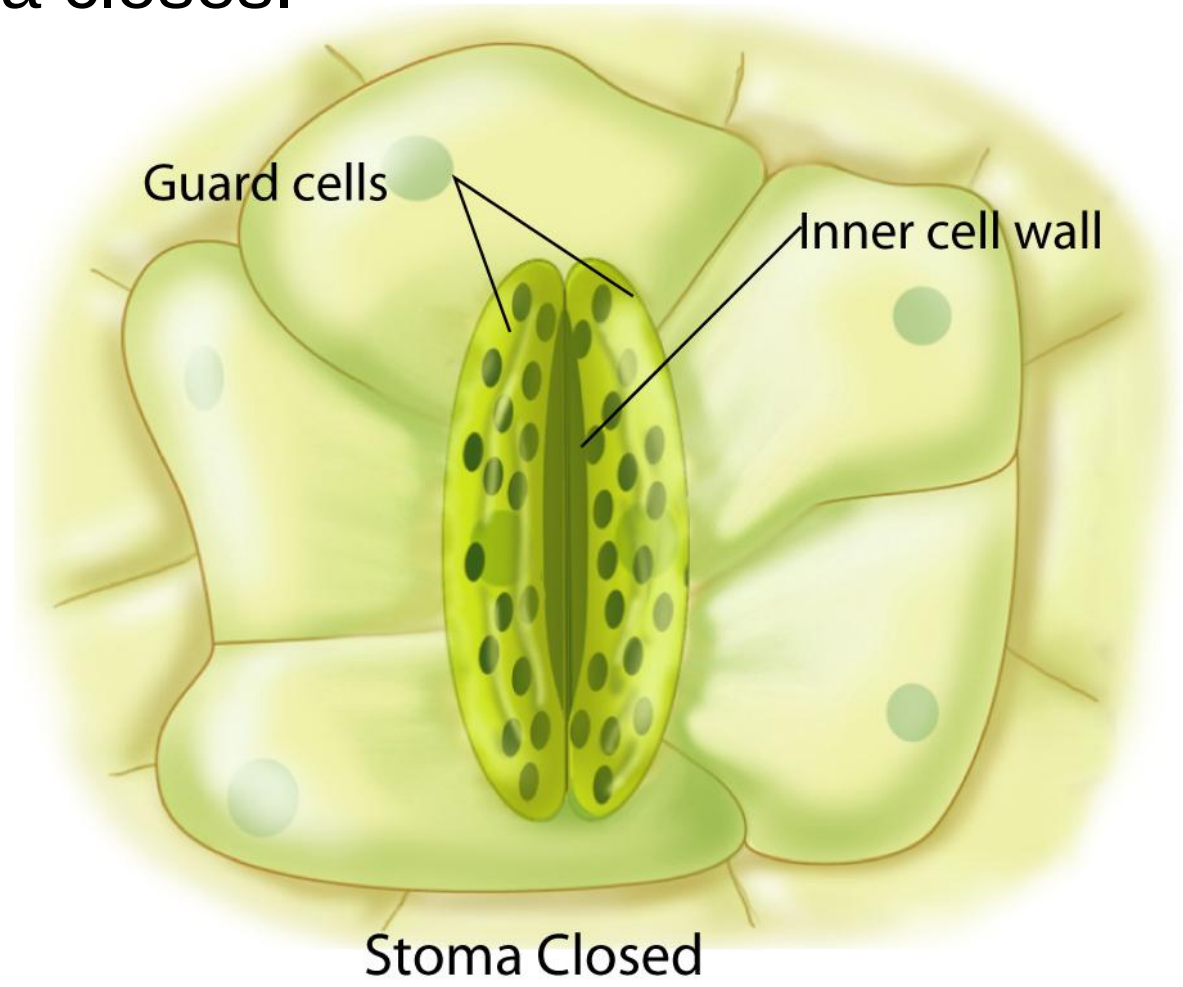
Plant leaves allow gas exchange between air spaces in the spongy mesophyll and the exterior by opening their stomata.

Plants keep their stomata open just enough to allow photosynthesis to take place but not so much that they lose an excessive amount of water.

When water pressure within guard cells is high, the stoma open.



When water pressure within guard cells decreases, the stoma closes.



Plants regulate the opening and closing of their stomata to balance water loss with rates of photosynthesis.

Stomata are open in daytime, when photosynthesis is active, and closed at night, to prevent water loss.

In hot, dry conditions stomata may close even in bright sunlight, to conserve water.

23–4 Section QUIZ

Continue to:

Section QUIZ

- or -

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23–4 Section QUIZ

1 A compound leaf is one that has

a. a blade attached by several petioles.

b. two or more blades.

A c. a blade that is divided into many leaflets.

d. many blades, each with its own petiole.

2 The layer of cells in a leaf that absorb light is the

a. phloem.

A b. vein.

c. palisade mesophyll.

d. epidermis.

3 The structure of a leaf allows it to

a. maximize sun exposure and maximize water loss.

A b. maximize sun exposure and minimize water loss.

c. minimize sun exposure and maximize water loss.

d. minimize sun exposure and minimize water loss.

4 A process in which water is lost through the leaves of a plant is called

A a. transpiration.

b. photosynthesis.

c. glycolysis.

d. cellular respiration.

5 Gas exchange in a leaf occurs through the

a. cuticle.

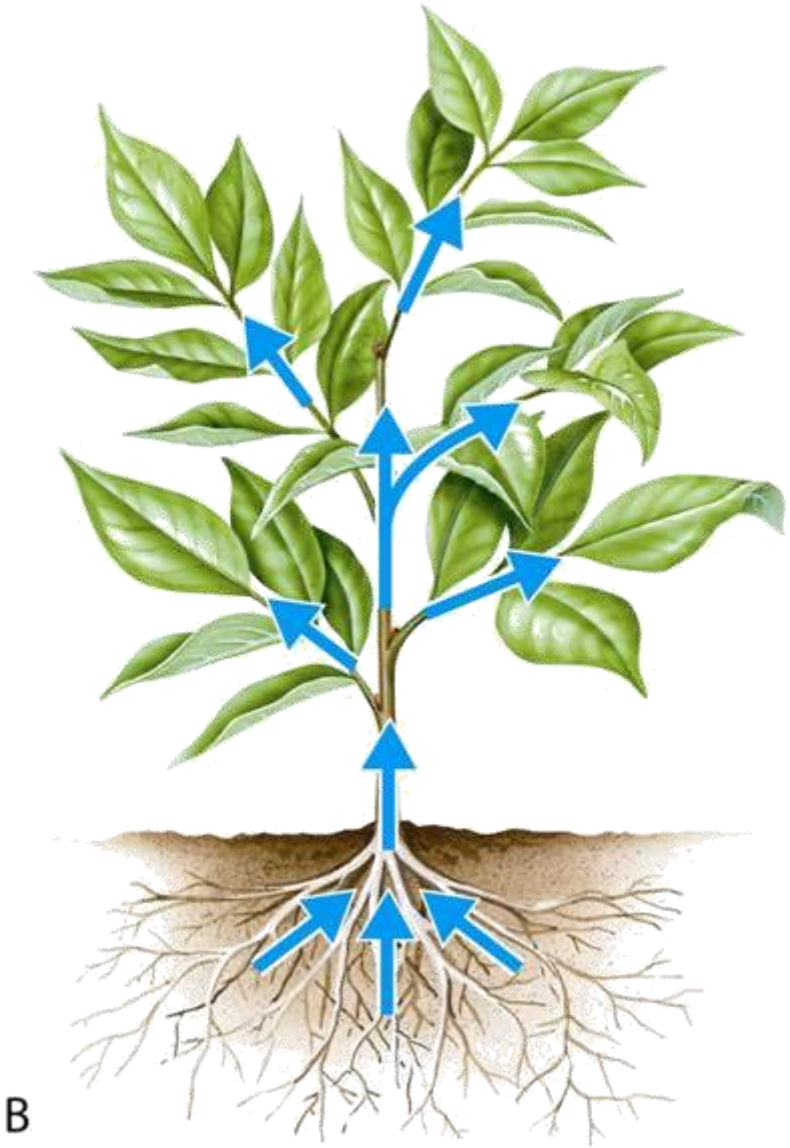
b. epidermis.

c. mesophyll.

A d. stomata.

END OF SECTION

23-5 Transport in Plants



B

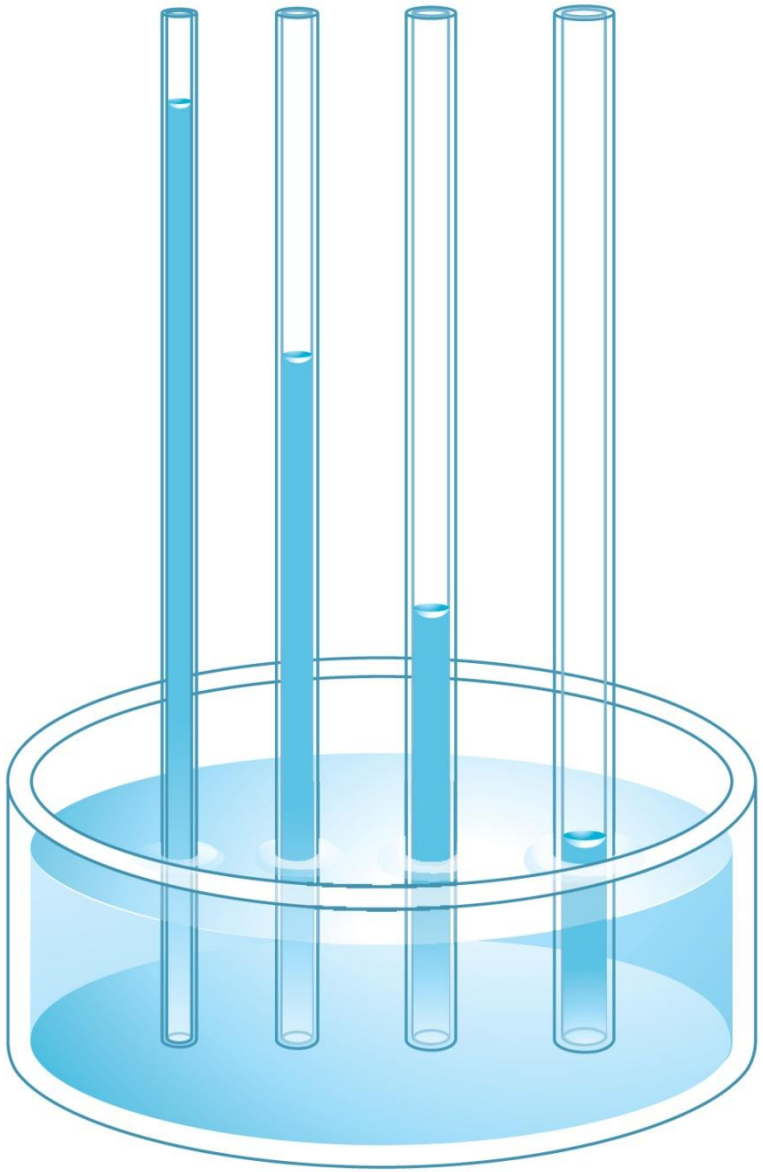
The combination of root pressure, capillary action, and transpiration provides enough force to move water through the xylem tissue of even the tallest plant.

Cohesion is the attraction of molecules of the same substance to each other.

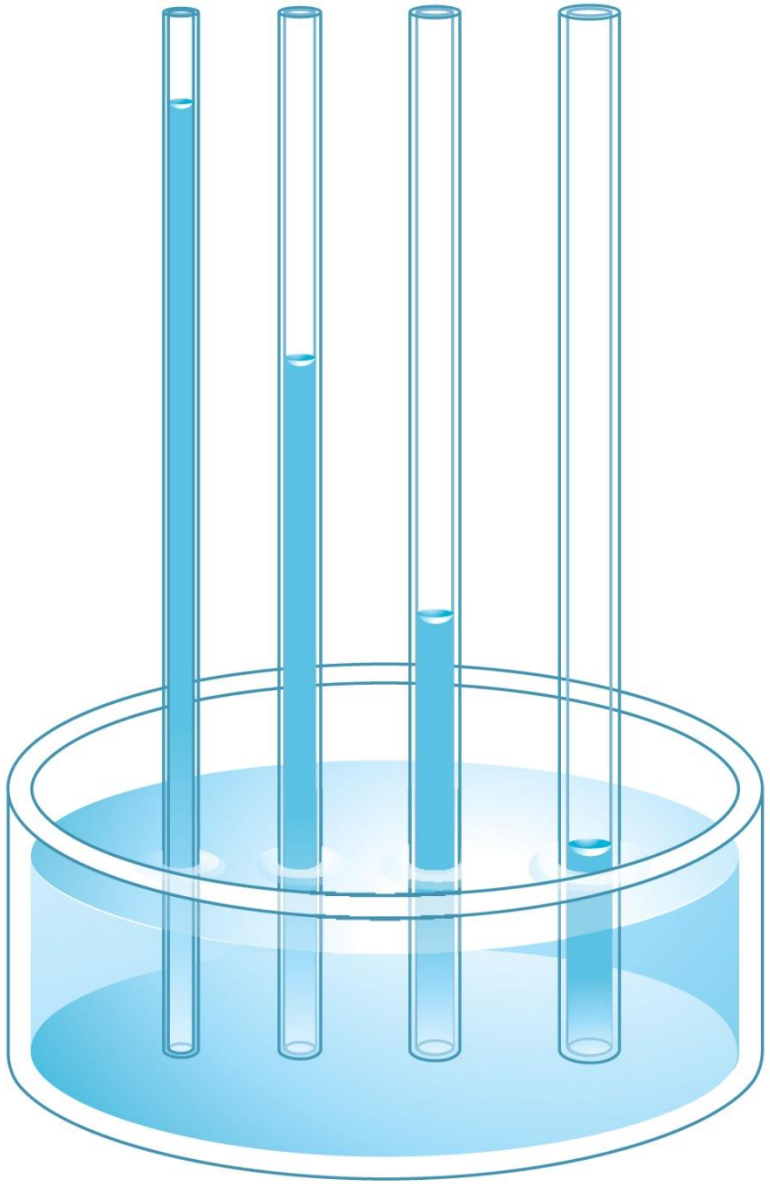
Adhesion is the attraction between unlike molecules.

The tendency of water to rise in a thin tube is calle **capillary action**.

Water is attracted to the walls of the tube, and water molecules are attracted to one another.



Capillary action causes water to move much higher in a narrow tube than in a wide tube.



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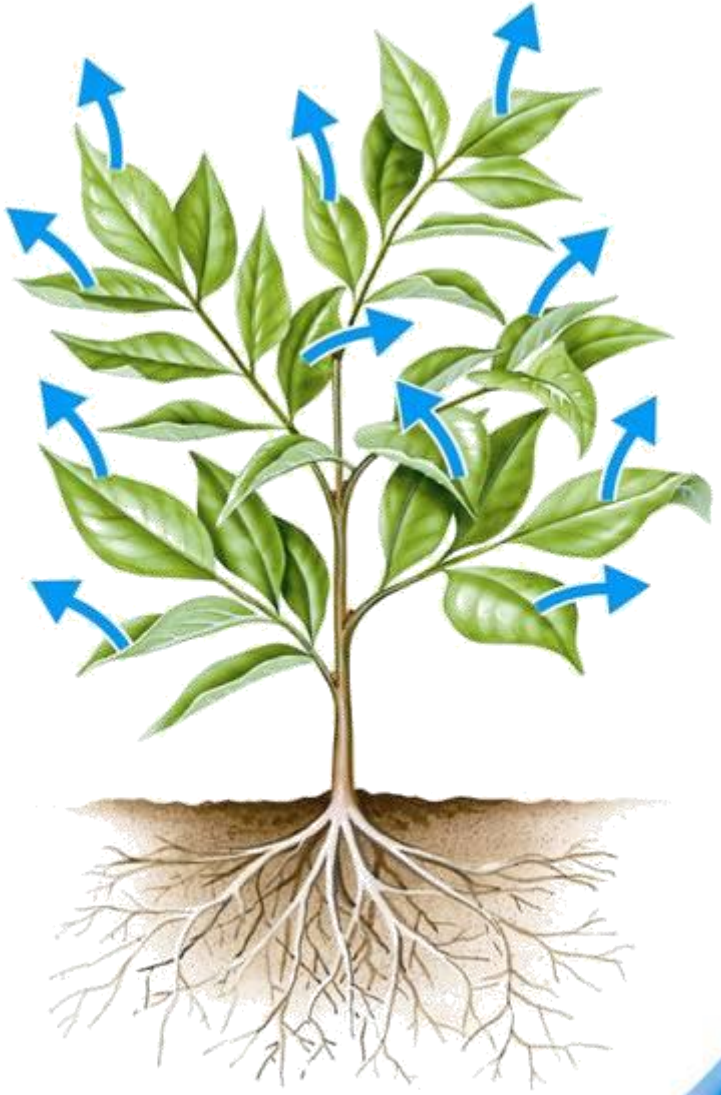
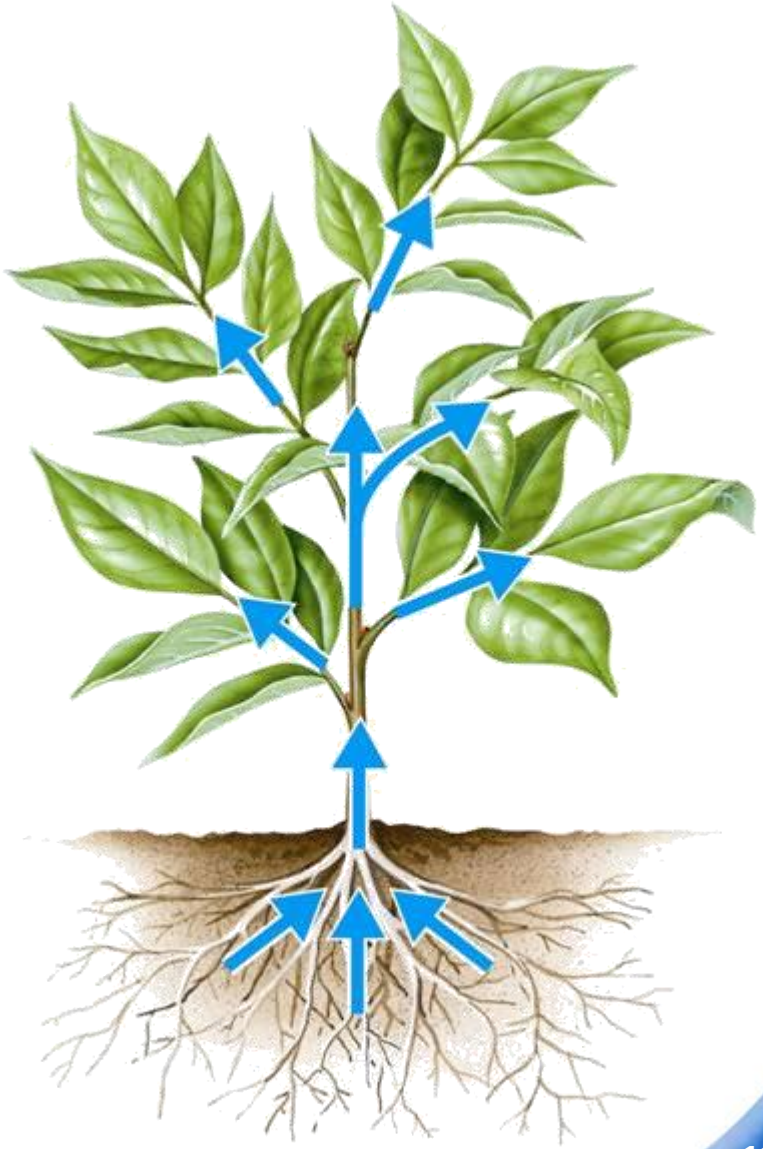
When water is lost through transpiration, osmotic pressure moves water out of the vascular tissue of the leaf.



The movement of water out of the leaf “pulls” water upward through the vascular system all the way from the roots.

This process is known as transpirational pull.



Controlling Transpiration

The water content of the leaf is kept relatively constant.

When there is a lot of water, water pressure in the guard cells is increased and the stomata open.

Excess water is then lost through the open stomata by transpiration.

Nutrient Transport

Many plants pump sugars into their fruits.

In cold climates, plants pump food into their roots for winter storage.

This stored food must be moved back into the trunk and branches of the plant before growth begins again in the spring.

Movement from Source to Sink

A process of phloem transport moves sugars through a plant from a source to a sink.

A *source* is any cell in which sugars are produced by photosynthesis.

A *sink* is any cell where the sugars are used or stored.

When nutrients are pumped into or removed from the phloem system, the change in concentration causes a movement of fluid in that same direction.

As a result, phloem is able to move nutrients in either direction to meet the nutritional needs of the plant.

23–5 Section QUIZ

Continue to:

Section QUIZ

- or -

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23–5 Section QUIZ

1 In a plant stem, water moves from

a. leaves to roots through xylem.

A b. roots to leaves through xylem.

c. leaves to roots through phloem.

d. roots to leaves through phloem.

2 Which of the following is NOT involved in the movement of water in xylem tissue?

a. cohesion

A b. osmosis

c. capillary action

d. adhesion

3 When nutrients are pumped into the phloem system of a plant, the increased concentration

A a. causes fluid to move into the system.

b. causes fluid to move out of the system.

c. has no effect on the movement of fluid.

d. causes fluid to move into the xylem vessels.

4 In a plant, sugar is moved from source cells to sink cells by a process of

A a. phloem transport.

b. xylem transport.

c. osmosis.

d. diffusion.

5 In very tall trees, which of the following is primarily involved in moving water to the top of the tree?

A a. transpirational pull

b. capillary action

c. root pressure

d. osmosis

END OF SECTION