Chapter 22

Plant Form and Function

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Introduction: vegetative plant parts

If asked to picture a plant, you probably wouldn't think of unusual examples like a Venus flytrap or a barrel cactus.

Carnivory
(Venus flytrap)

Water storage
(cactus)

Vegetative plant parts

But like other flowering plants, these have roots, stems, leaves, flowers, fruits, and seeds.

Carnivory
(Venus flytrap)

©Win Initiative/Getty Images RF

Water storage
(cactus)

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Section 22.1

Figure 22.3

Vegetative plant parts: modified leaves

Harsh environments have selected for adaptions in these plants, such as modified leaves.

Modified leaves

Pollinator attraction
(poinsettia)

©Design Pics/Don Hammond RF

Carnivory
(Venus flytrap)

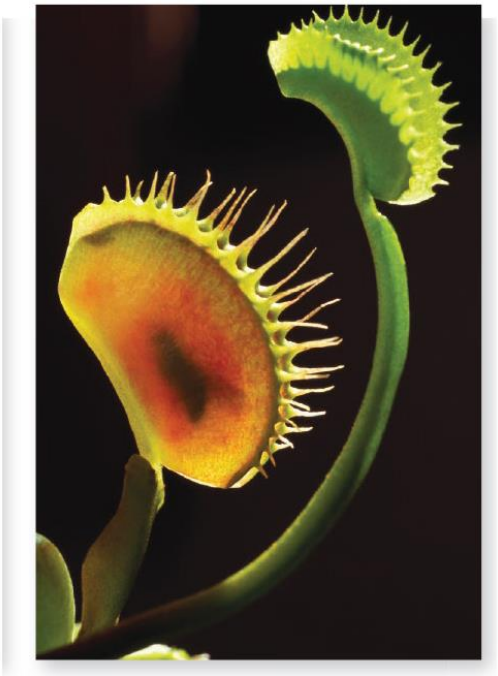
©Win Initiative/Getty Images RF

Section 22.1

Figure 22.3

Vegetative plant parts = nonreproductive plant parts

This chapter explores the anatomy and physiology of **vegetative** (nonreproductive) plant parts.



Carnivory
(Venus flytrap)

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Water storage
(cactus)

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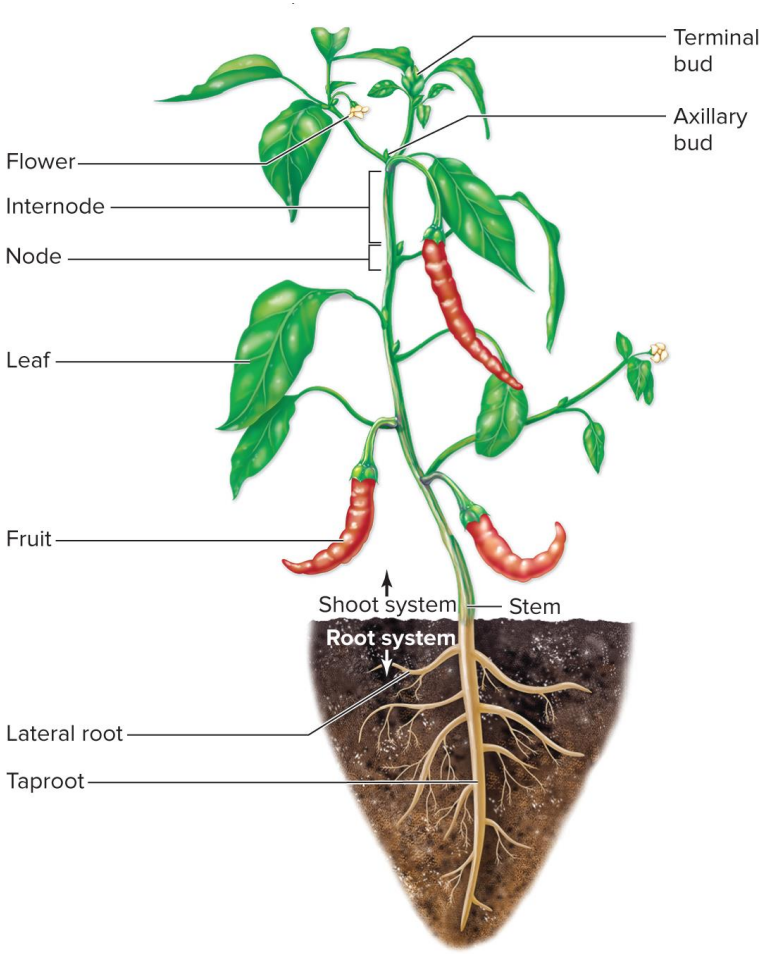
Section 22.1

Figure 22.3

Naming the vegetative plant parts

Vegetative plant parts include stems, leaves, and roots. These organs work together.

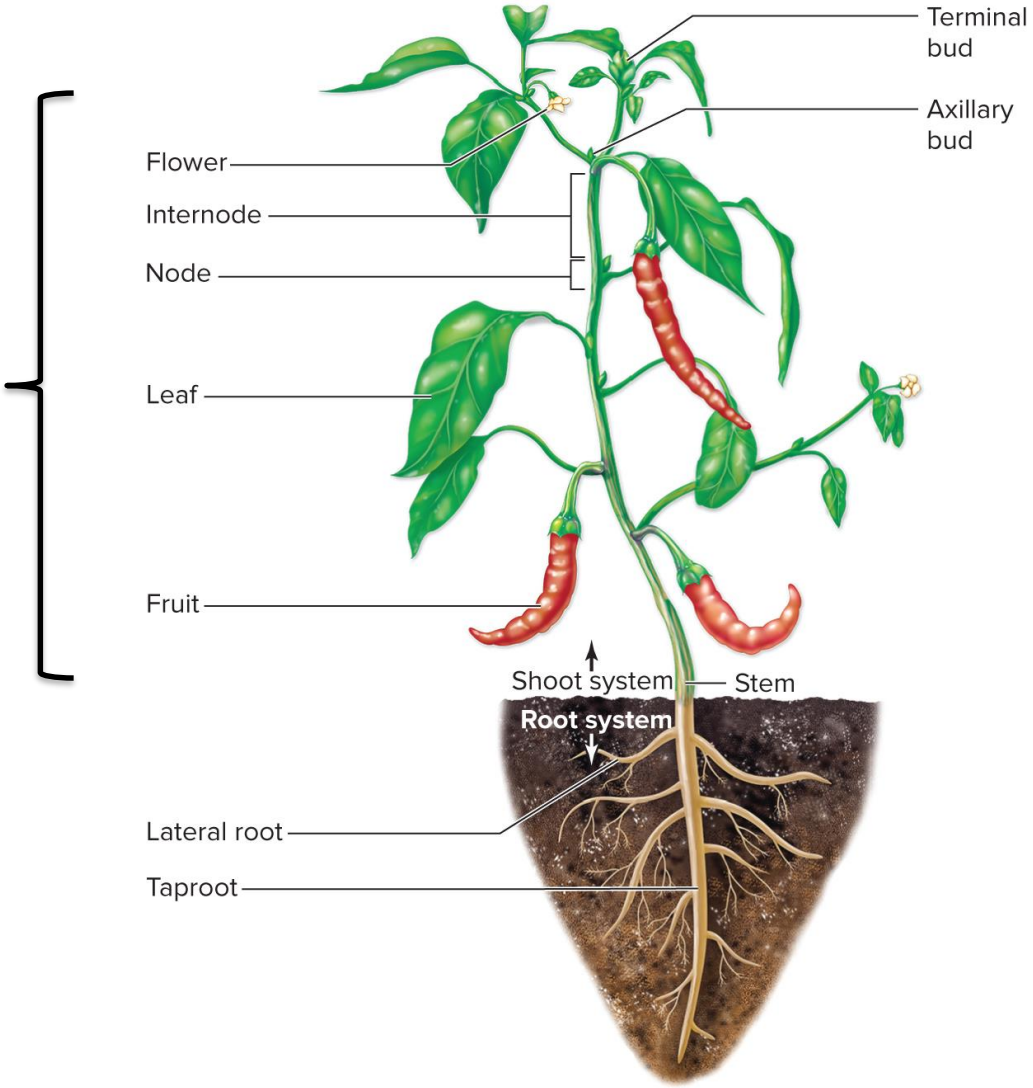


Section 22.1

Figure 22.1

Vegetative plant parts: the shoot

The **shoot** is the aboveground part of the plant.

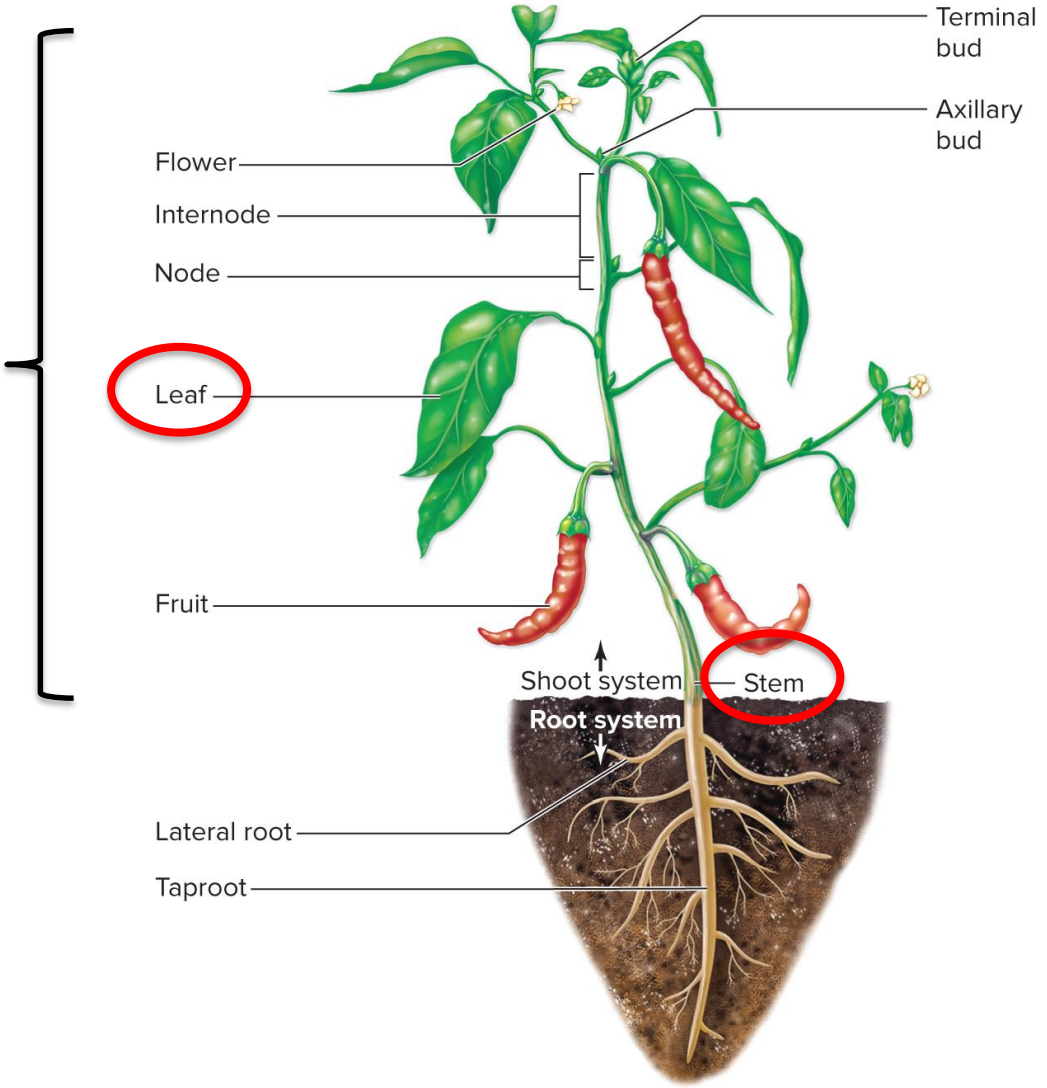


Section 22.1

Figure 22.1

Vegetative plant parts: the stem

The shoot's **stem** supports the **leaves**, which produce carbohydrates by photosynthesis.

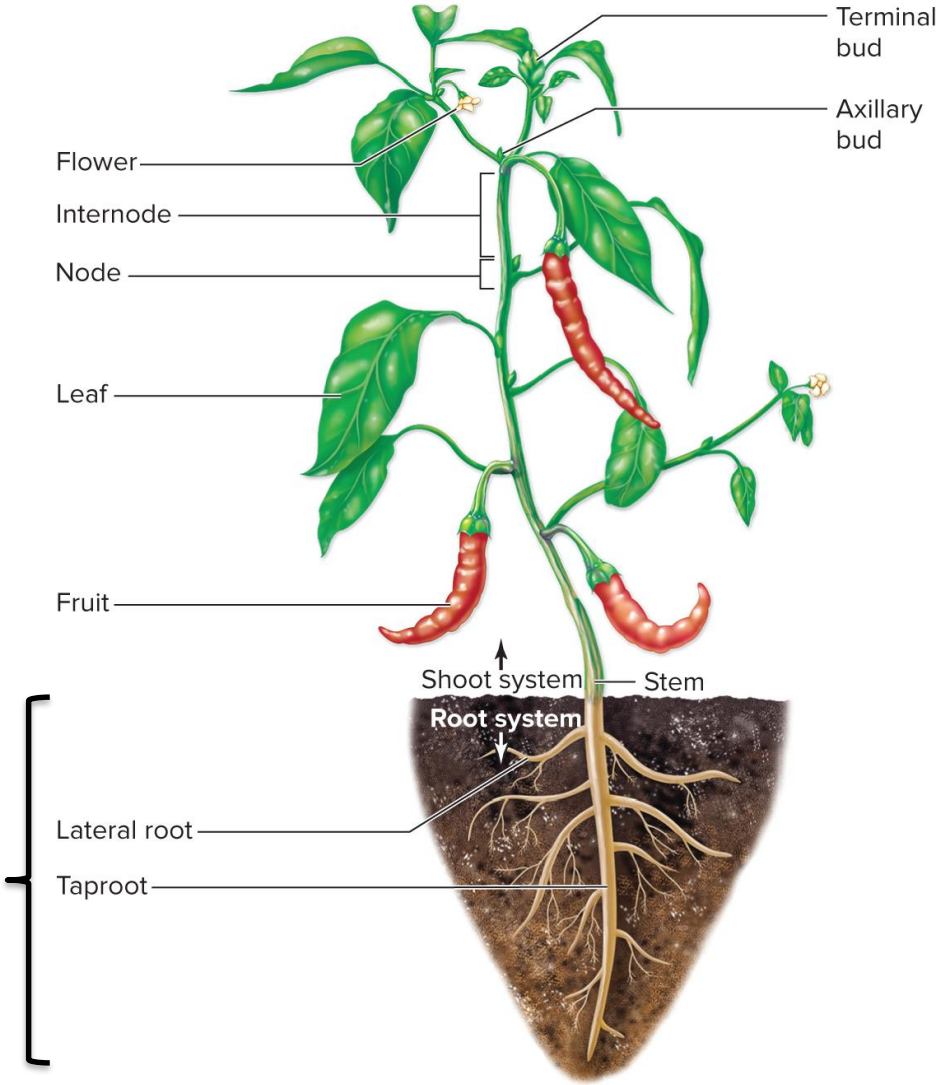


Section 22.1

Figure 22.1

Vegetative plant parts: the roots

Some of the sugar produced in the shoot system travels through the stem to the **roots**, which are usually below ground.



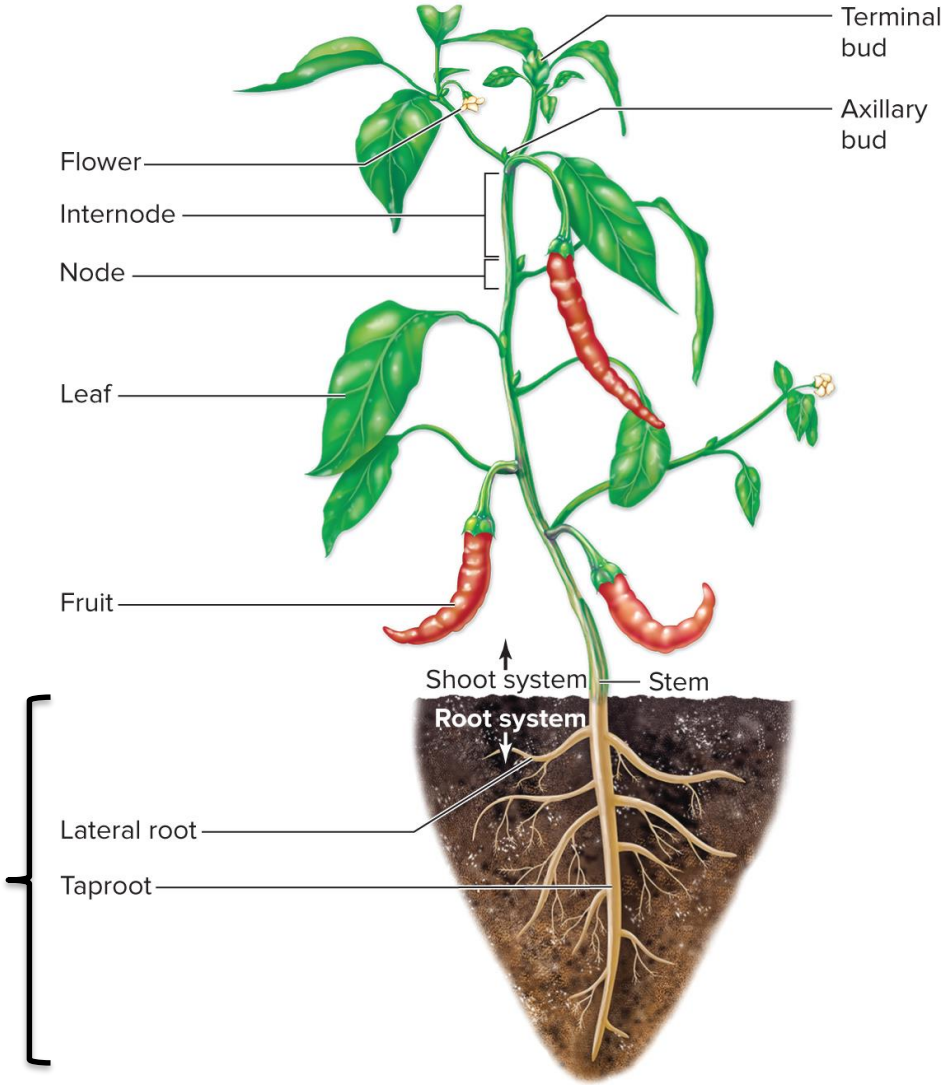
Section 22.1

Figure 22.1

Vegetative plant parts: functions of roots

Roots anchor the plant and absorb water and minerals that move via the stem to the leaves.

Later, we will explore how water, minerals, and sugars travel through plants.

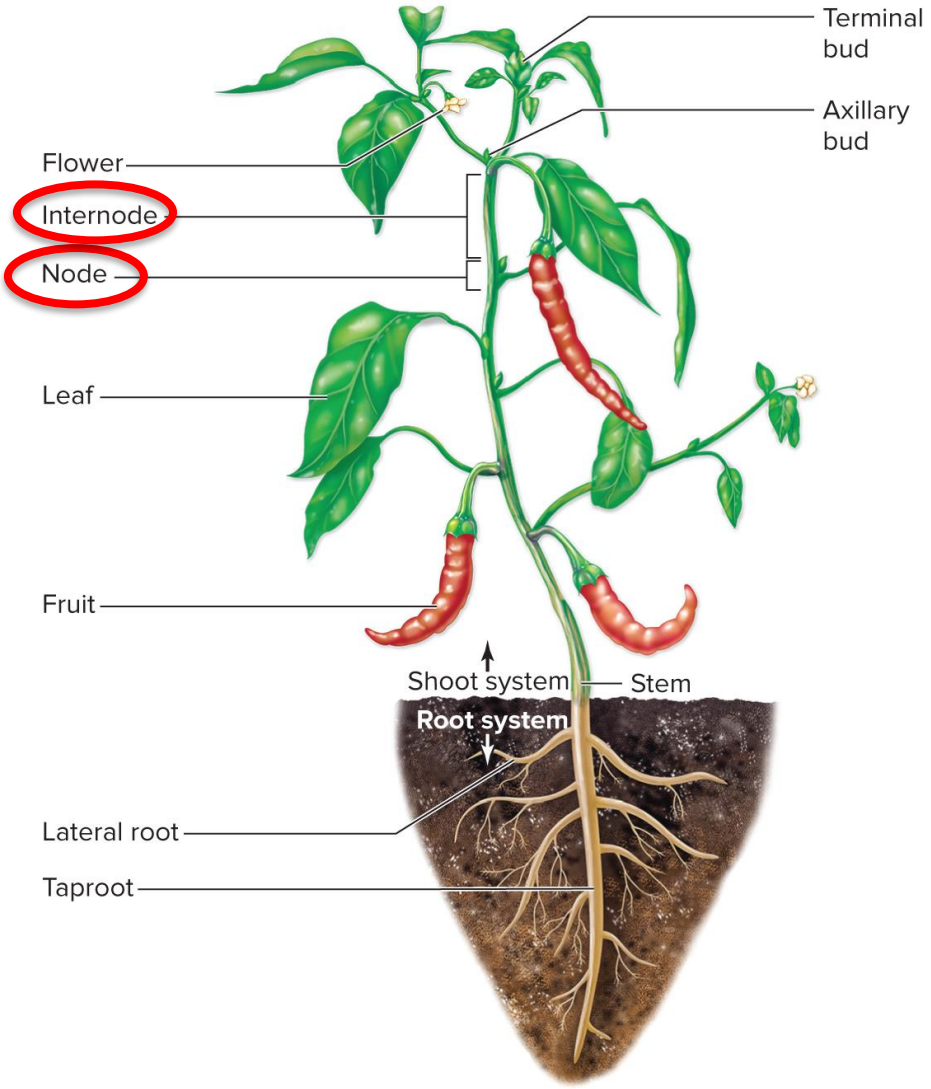


Section 22.1

Figure 22.1

Vegetative plant parts: nodes and internodes

Leaves attach to stems at **nodes**. Spaces between nodes are **internodes**.

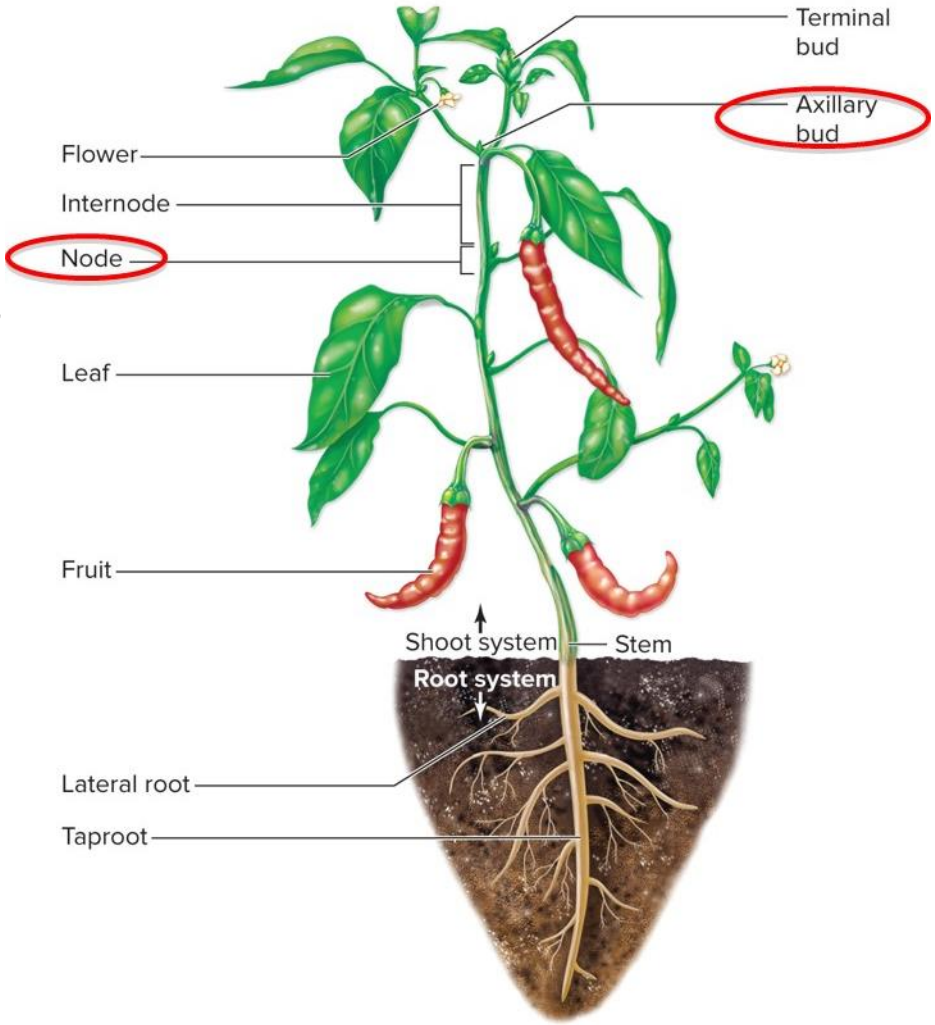


Section 22.1

Figure 22.1

Vegetative plant parts: axillary buds

Each node also features an **axillary bud**, an undeveloped shoot that could form a new branch or flower.

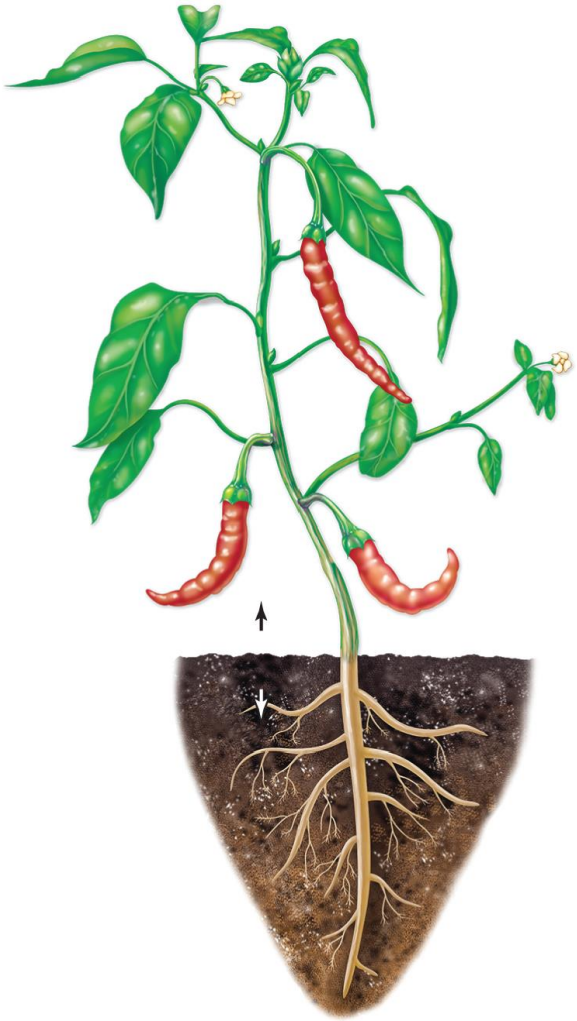


Section 22.1

Figure 22.1

Two types of plants

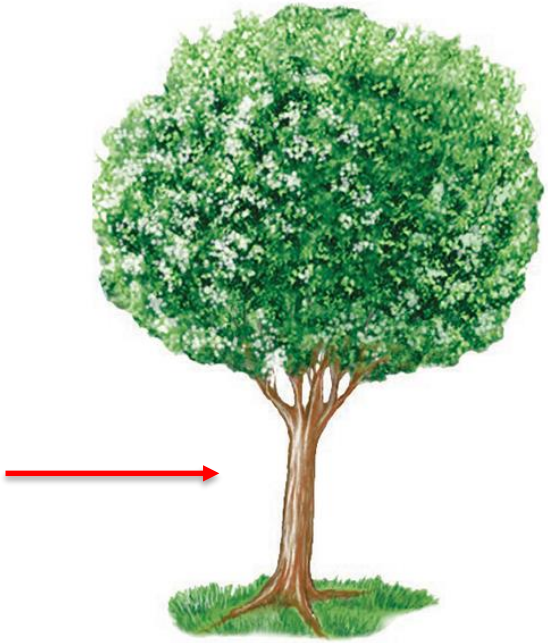
Biologists divide plants into two categories based on the characteristics of the stem.

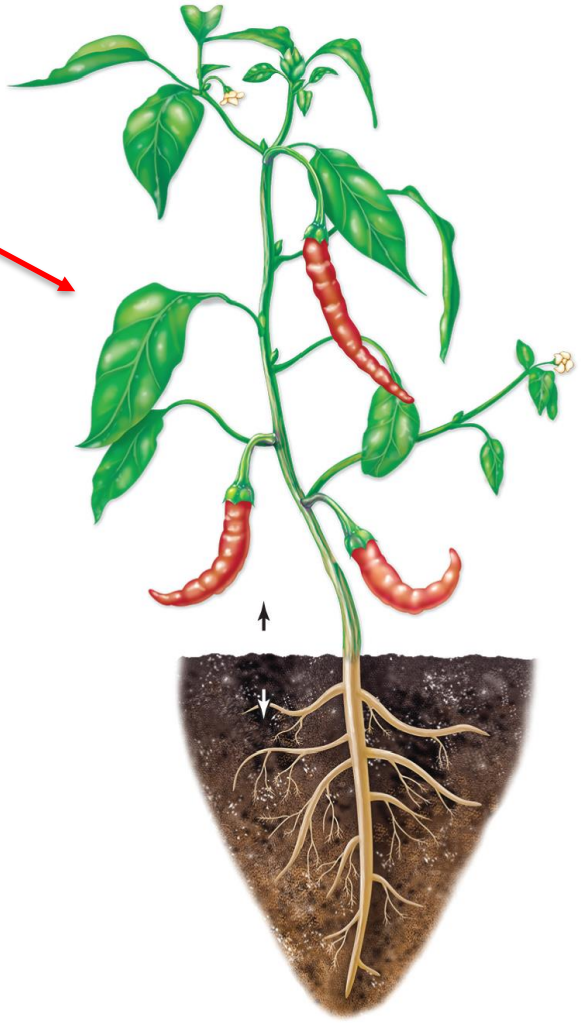


Herbaceous and woody plants

A **herbaceous plant** has a green, soft stem.

A **woody plant** is made of tough, bark-covered wood.





Vegetative plant parts: specialized stems

Natural selection produces stems, leaves, and roots with various forms.

a. Specialized stems

Climbing
(grape tendrils)

Underground nutrient storage
(iris rhizomes)

Water storage
(cactus)

Defense
(honey locust thorns)

(a, vine): ©Franz Krenn/Science Source; (a, iris): ©Dwight Kuhn; (a, cactus): ©G.C. Kelly/Science Source; (a, thorns): ©Kenneth W. Fink/Science Source

Vegetative plant parts: specialized leaves

Natural selection produces stems, leaves, and roots with various forms.

(b, onion): ©YAY Media AS/Alamy RF; (b, poinsettia): ©Design Pics/Don Hammond RF; (b, flytrap): ©Win Initiative/Getty Images RF; (b, kalanchoe)

Vegetative plant parts: specialized roots

Natural selection produces stems, leaves, and roots with various forms.

c.Specialized roots

Nutrient storage
(carrot)

Oxygen absorption
(mangrove trees)

Photosynthesis
(orchid aerial roots)

Support
(prop roots of screw pine)

(c, carrots): ©Huw Jones/Photolibrary/Getty Images; (c, mangrove): ©Tim Laman/Getty Images RF; (c, orchid): ©Settawut Visedbubpha/123R; (c, screw pine): ©Steven P. Lynch/McGraw-Hill Education

Clicker question #1

Roots depend on shoots because shoots _____, which is transported to the roots.

A. absorb water
B. absorb O_2
C. produce sugar
D. release CO_2
E. All of the choices are correct.

Clicker question #1, solution

Roots depend on shoots because shoots ____, which is transported to the roots.

C. produce sugar

22.1 Mastering concepts

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What are the major parts of the plant body?

Plant cells build tissues

We've seen the organs and organ systems of plants. Now let's zoom in and learn about the cells and tissues that make up these organs.

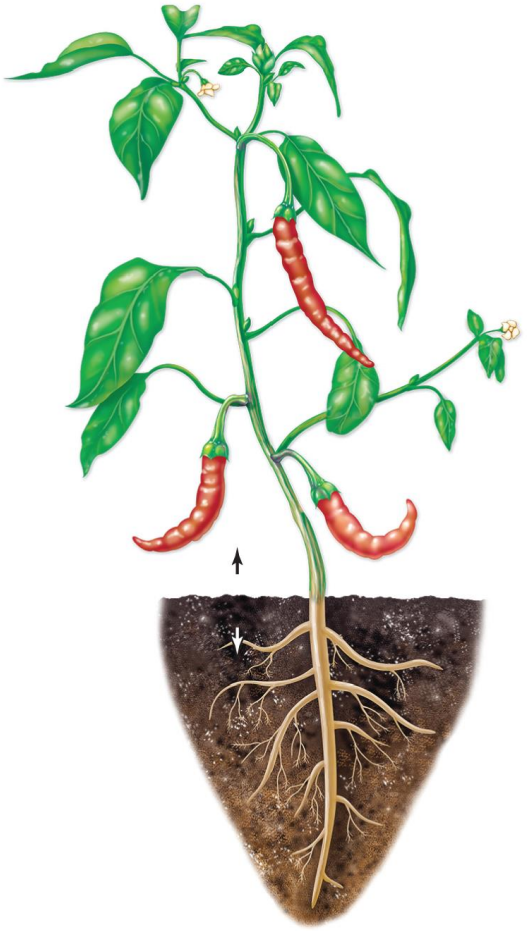


Figure 22.1

Three main tissue types

Plants have three main tissue types:

- **Ground tissue** makes up most of the plant body.
- **Vascular tissues** (**xylem** and **phloem**) transport materials within the plant.
- **Dermal tissue** covers the plant.

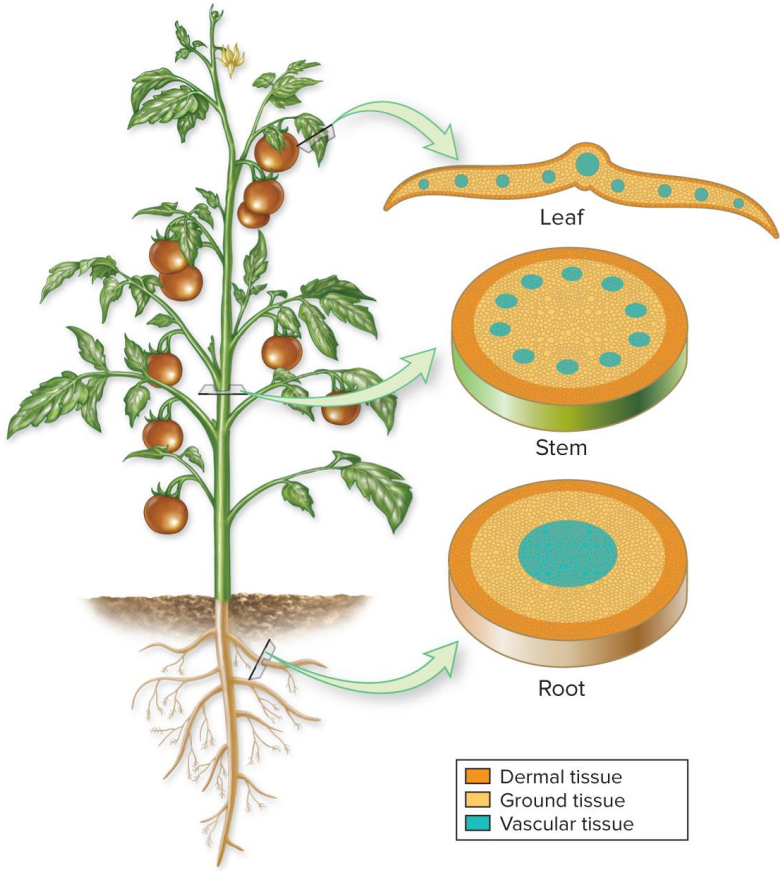
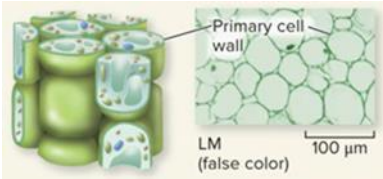
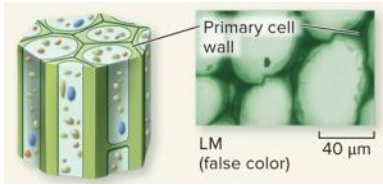
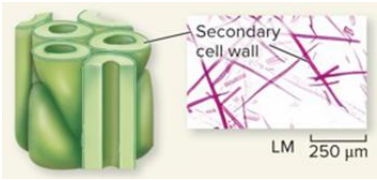
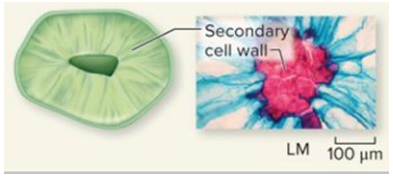


Figure 22.6

Ground tissue

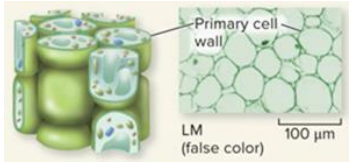
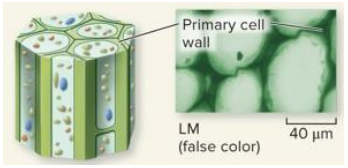
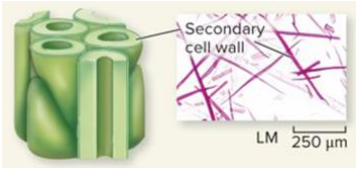
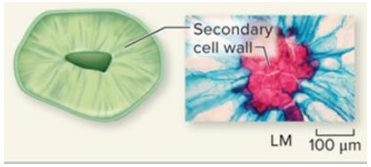
Ground tissue consists of three main cell types: **parenchyma**, **collenchyma**, and **sclerenchyma**.

Cell Type	Description	Alive at Maturity	Functions	
Parenchyma	• Most abundant cell type in primary plant body • Thin primary cell walls • Unspecialized • Can divide at maturity	Yes	Make up most nonwoody tissues; carry out photosynthesis, respiration, gas exchange, secretion, wound repair, and storage	
Collenchyma	• Elongated cells • Unevenly thickened primary cell walls	Yes	Elastic support for growing stems and leaves	
Sclerenchyma: Fiber	• Long, slender cells • Thick secondary cell walls high in lignin	No	Inelastic support for nongrowing plant parts	
Sclerenchyma: Sclereid	• Variable shapes, generally not elongated • Thick secondary cell walls high in lignin	No	Inelastic support for nongrowing plant parts	

(parenchyma): ©Malcolm Park microimages/Alamy; (collenchyma): ©Biophoto Associates/Science Source;
(fibers): ©Steven P. Lynch/McGraw-Hill Education; (sclereid): ©Garry Delong/Oxford Scientific/Getty Images

Functions of ground tissue

The cells that compose ground tissue are important sites of photosynthesis, respiration, storage, and support.

Cell Type	Description	Alive at Maturity	Functions	
Parenchyma	• Most abundant cell type in primary plant body • Thin primary cell walls • Unspecialized • Can divide at maturity	Yes	Make up most nonwoody tissues; carry out photosynthesis, respiration, gas exchange, secretion, wound repair, and storage	
Collenchyma	• Elongated cells • Unevenly thickened primary cell walls	Yes	Elastic support for growing stems and leaves	
Sclerenchyma: Fiber	• Long, slender cells • Thick secondary cell walls high in lignin	No	Inelastic support for nongrowing plant parts	
Sclerenchyma: Sclereid	• Variable shapes, generally not elongated • Thick secondary cell walls high in lignin	No	Inelastic support for nongrowing plant parts	

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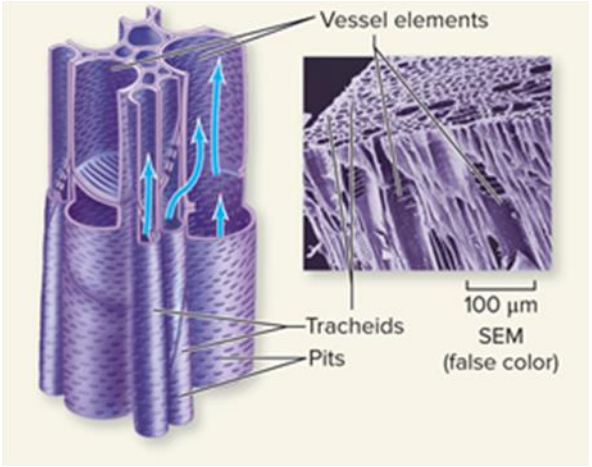
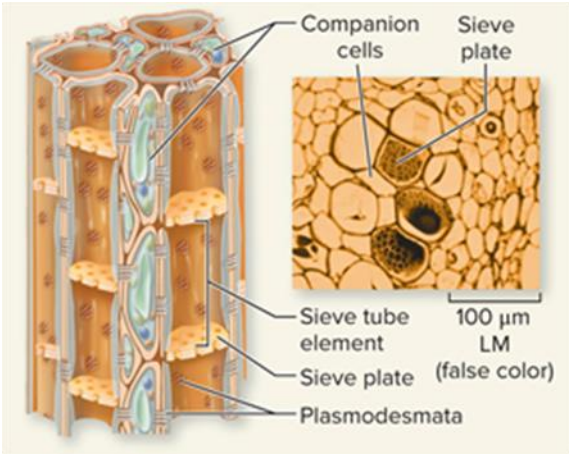
Vascular tissue

Vascular tissues transport water, minerals, carbohydrates, and other dissolved compounds.

Cell Type	Functions
XYLEM	
Tracheid	Conduct water and minerals through pits
Vessel element	Conduct water and minerals through pits and perforated end walls
PHLOEM	
Sieve tube element	Conduct dissolved sucrose and other organic compounds through sieve plates
Companion cell	Transfer materials into and out of sieve tube elements





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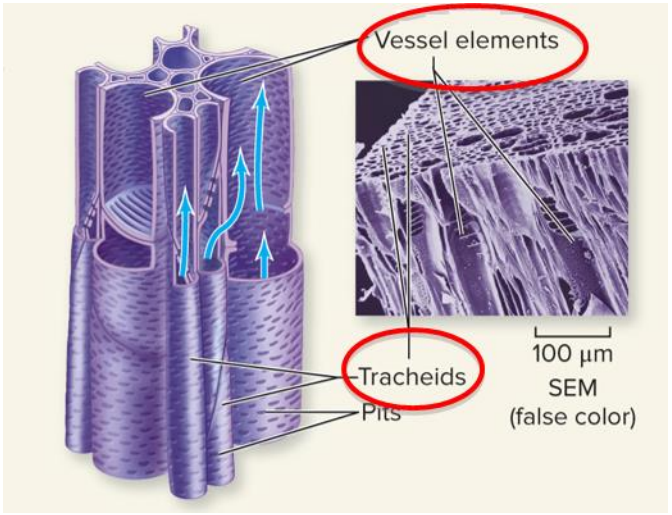
Section 22.2

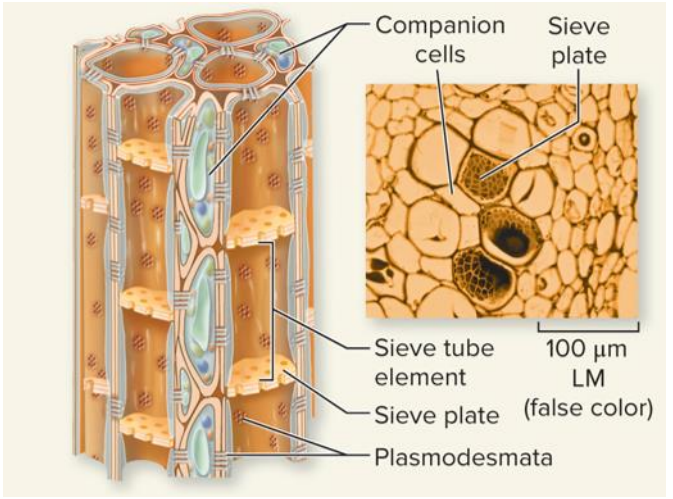
Figure 22.5

Vascular tissue: xylem

Xylem tissue transports water and minerals from the roots to other plant parts. It consists of long, narrow cells called **tracheids** and wide, barrel-shaped cells called **vessel elements.**

Cell Type	Functions
XYLEM	
Tracheid	Conduct water and minerals through pits
Vessel element	Conduct water and minerals through pits and perforated end walls
PHLOEM	
Sieve tube element	Conduct dissolved sucrose and other organic compounds through sieve plates
Companion cell	Transfer materials into and out of sieve tube elements





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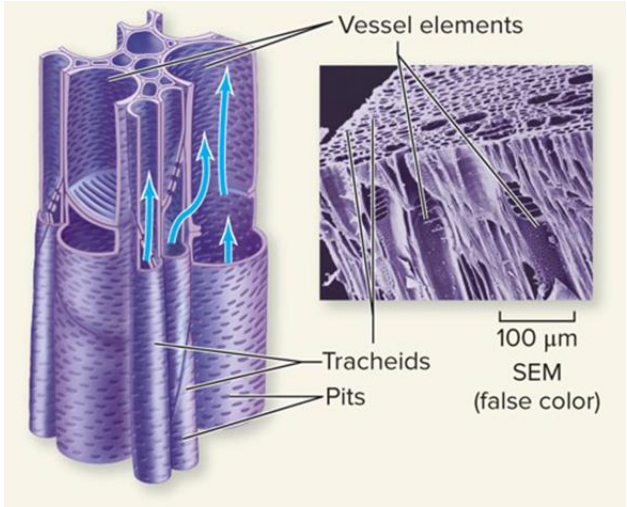
Section 22.2

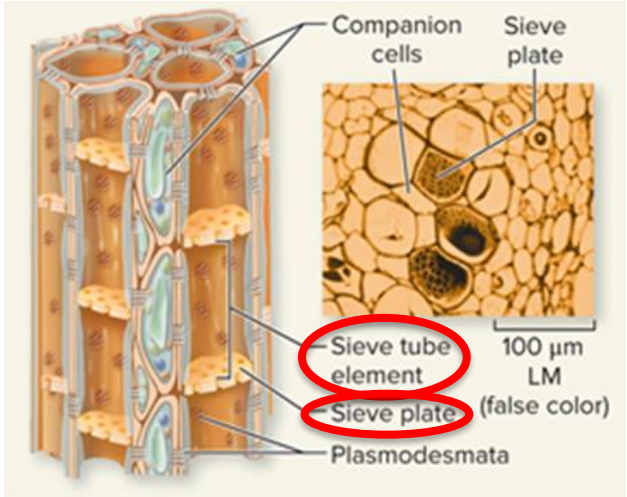
Figure 22.5

Vascular tissue: phloem

Phloem tissue transports dissolved organic compounds like sugars. **Sieve tube elements** are the conducting cells; they are separated by **sieve plates**.

Cell Type	Functions
XYLEM	
Tracheid	Conduct water and minerals through pits
Vessel element	Conduct water and minerals through pits and perforated end walls
PHLOEM	
Sieve tube element	Conduct dissolved sucrose and other organic compounds through sieve plates
Companion cell	Transfer materials into and out of sieve tube elements





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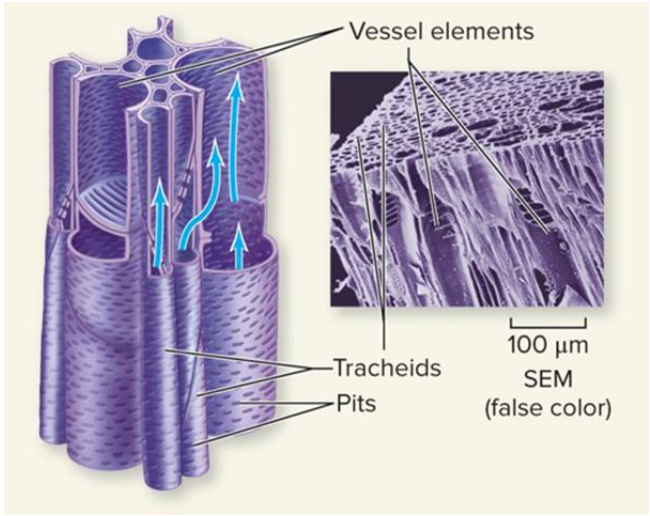
Section 22.2

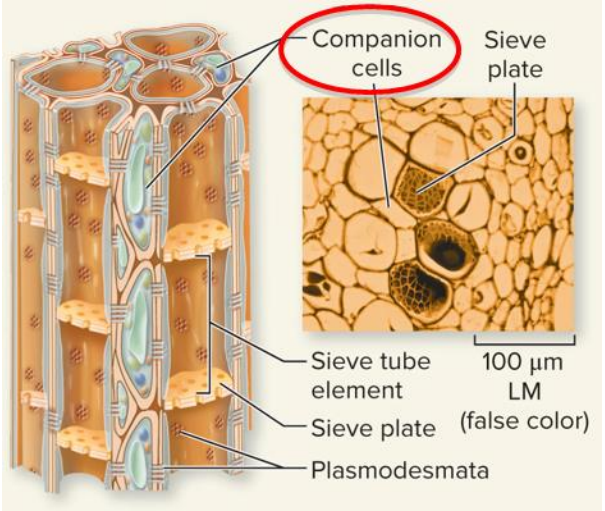
Figure 22.5

Vascular tissue: phloem cells

Companion cells transfer materials in and out of sieve tubes.

Cell Type	Functions
XYLEM	
Tracheid	Conduct water and minerals through pits
Vessel element	Conduct water and minerals through pits and perforated end walls
PHLOEM	
Sieve tube element	Conduct dissolved sucrose and other organic compounds through sieve plates
Companion cell	Transfer materials into and out of sieve tube elements





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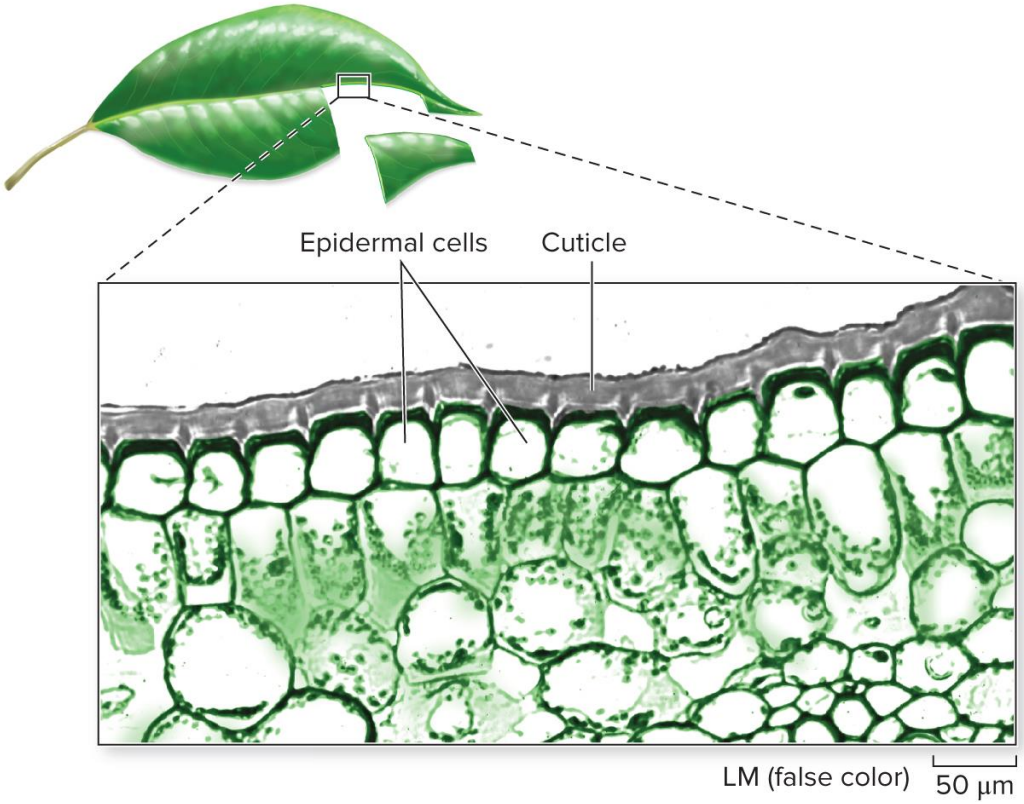
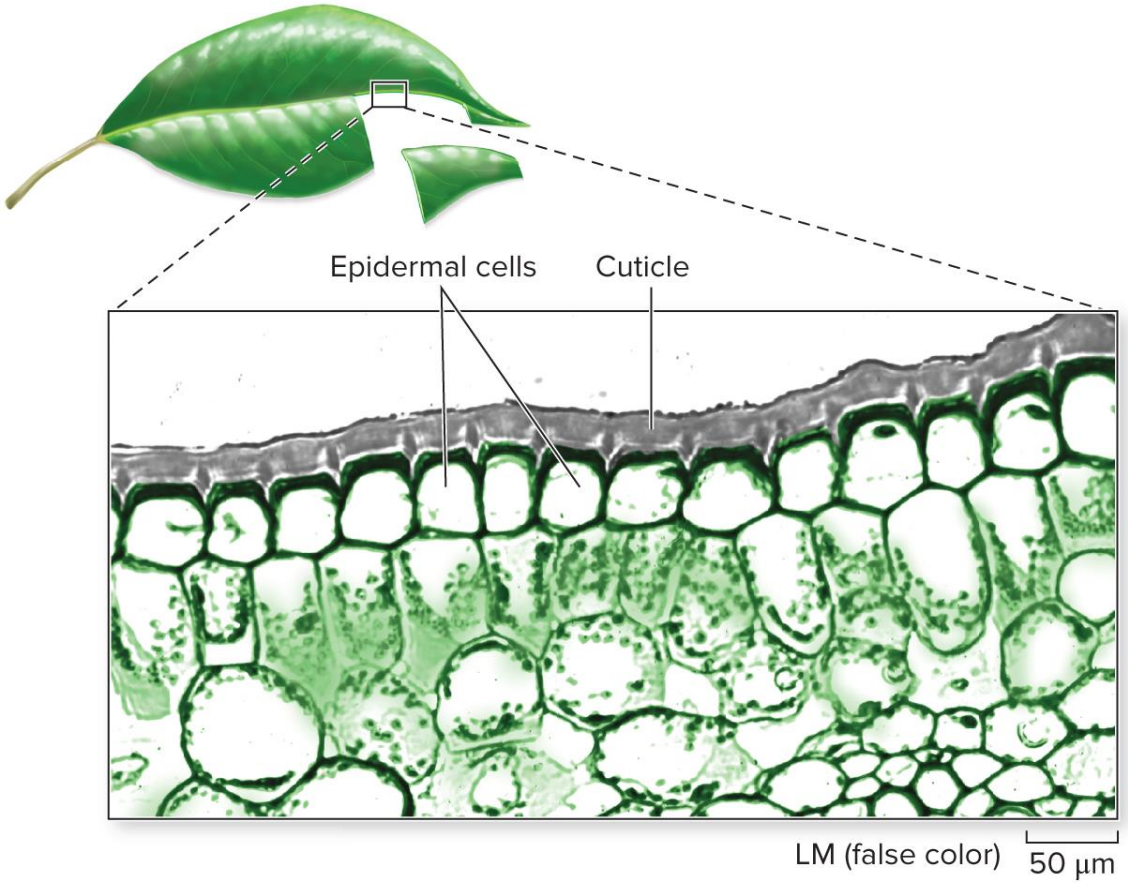
Dermal tissues

Dermal tissue covers the plant; it consists of the **epidermis**, which is coated with a waxy cuticle.



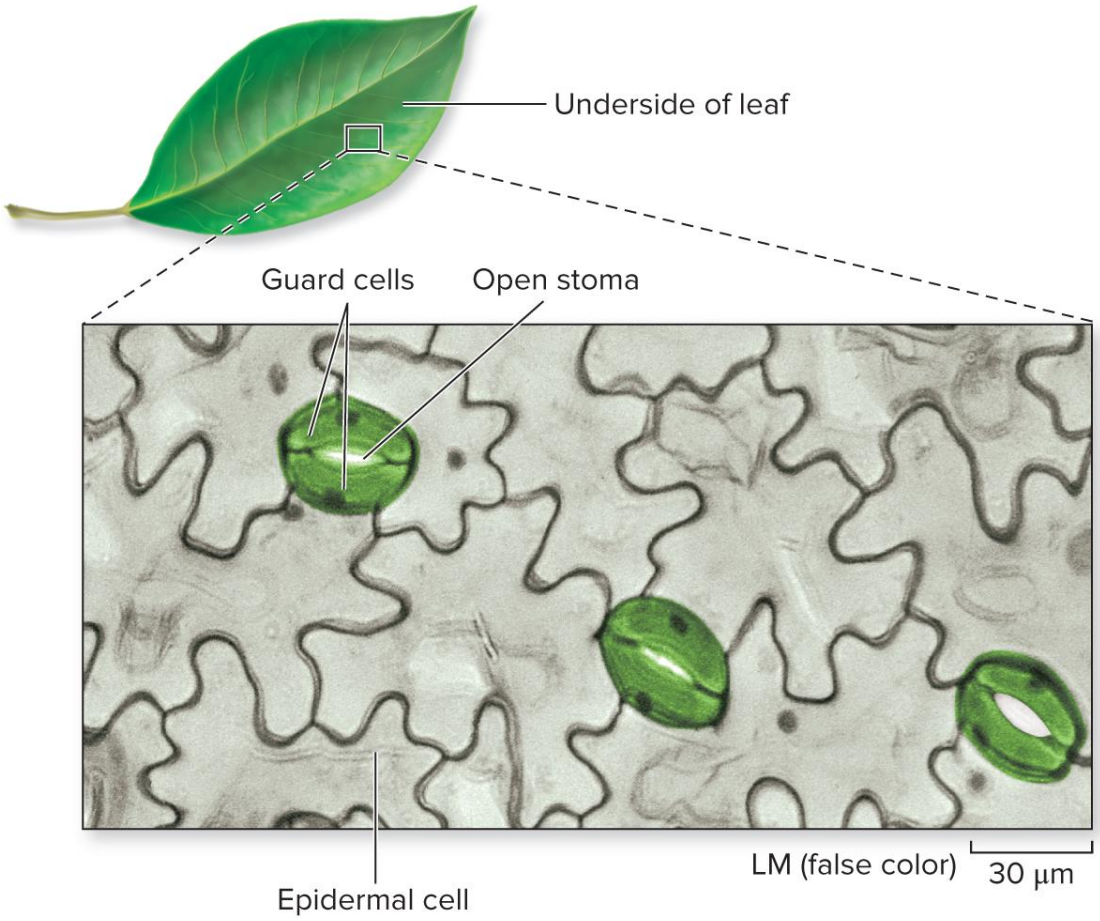
Cuticle and stomata

The **cuticle** conserves water and protects the plant. Pores in the cuticle, called **stomata**, allow leaves to exchange gases with the atmosphere.



Guard cells

Guard cells surround each stoma and control its opening and closing.



Clicker question #2

If you cut a stalk of celery and put the bottom of it in a glass of water containing red food coloring, the next morning the celery will be red. The food coloring is taken up through the

A. phloem.
B. stomata.
C. xylem.
D. epidermis.
E. ground tissue.

Clicker question #2, solution

If you cut a stalk of celery and put the bottom of it in a glass of water containing red food coloring, the next morning the celery will be red. The food coloring is taken up through the

C. xylem.

22.2 Mastering concepts

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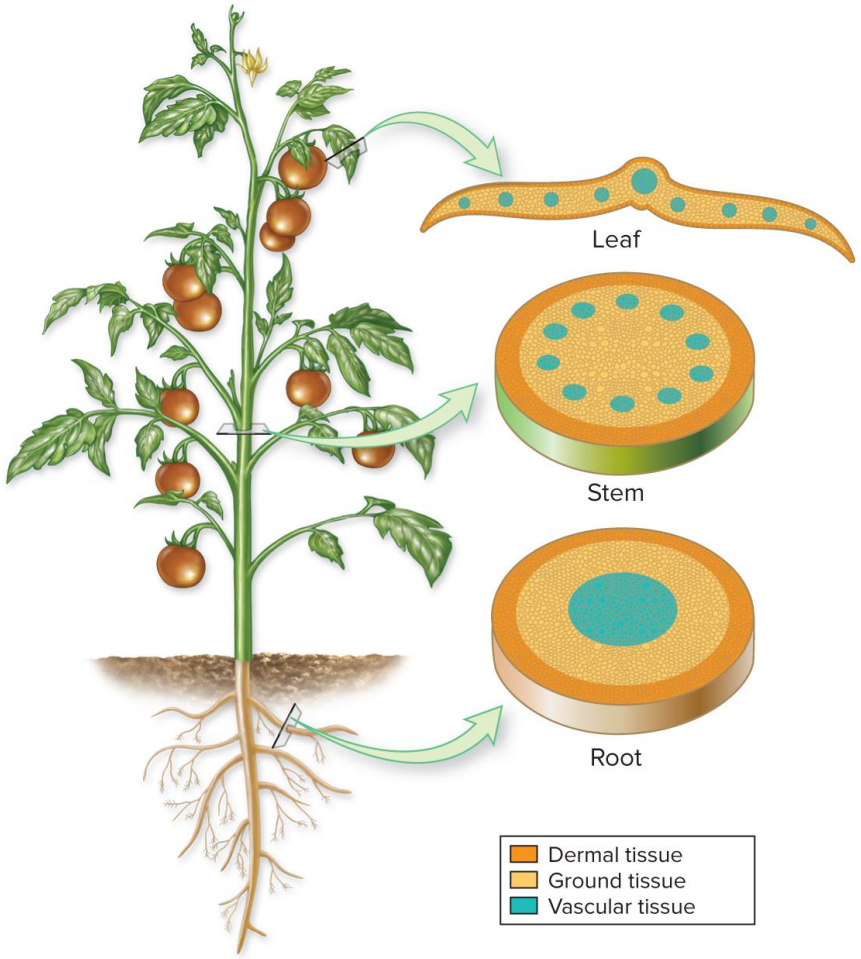
What are the functions of dermal tissue and vascular tissue?

Tissues build stems, leaves, and roots

The three tissue types make up the stems, leaves, and roots of the plant.

Let's look at each of these organs, starting with the stem.



Section 22.3

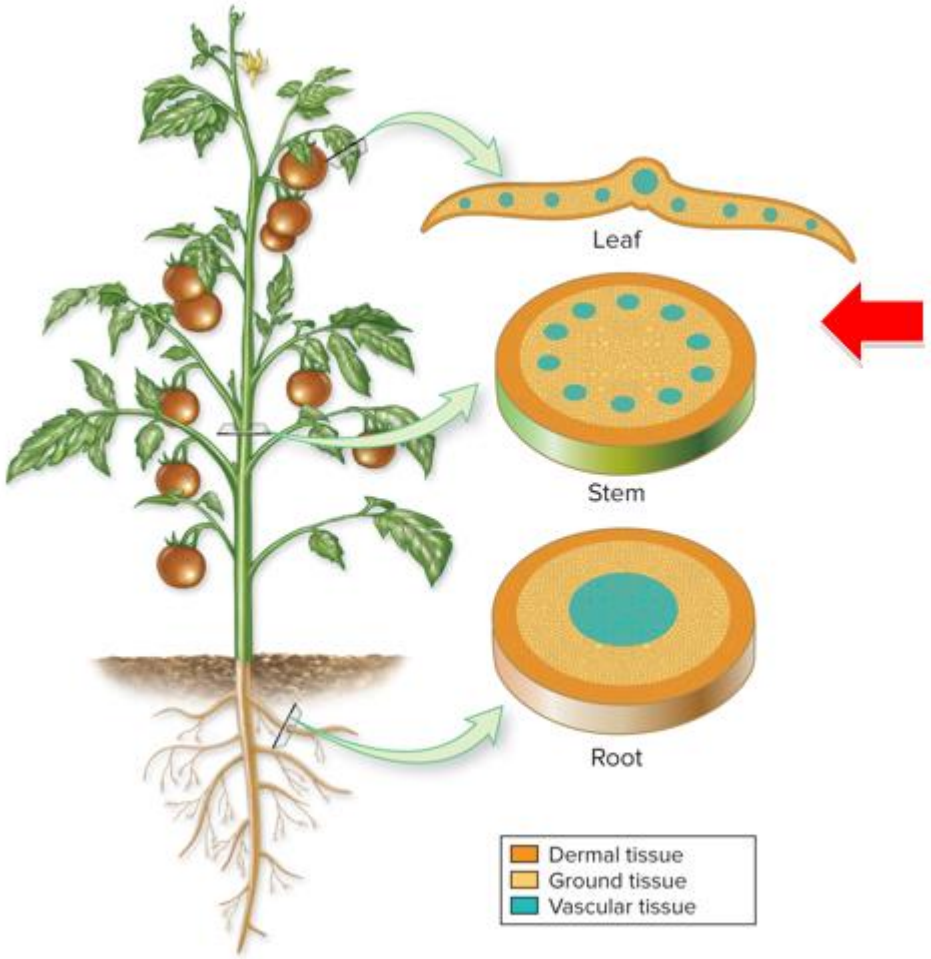
Figure 22.6

Tissue types found in a stem

Ground tissue occupies most of the **stem** of a herbaceous plant.

Vascular bundles are embedded in the ground tissue.

Dermal tissue covers the stem.

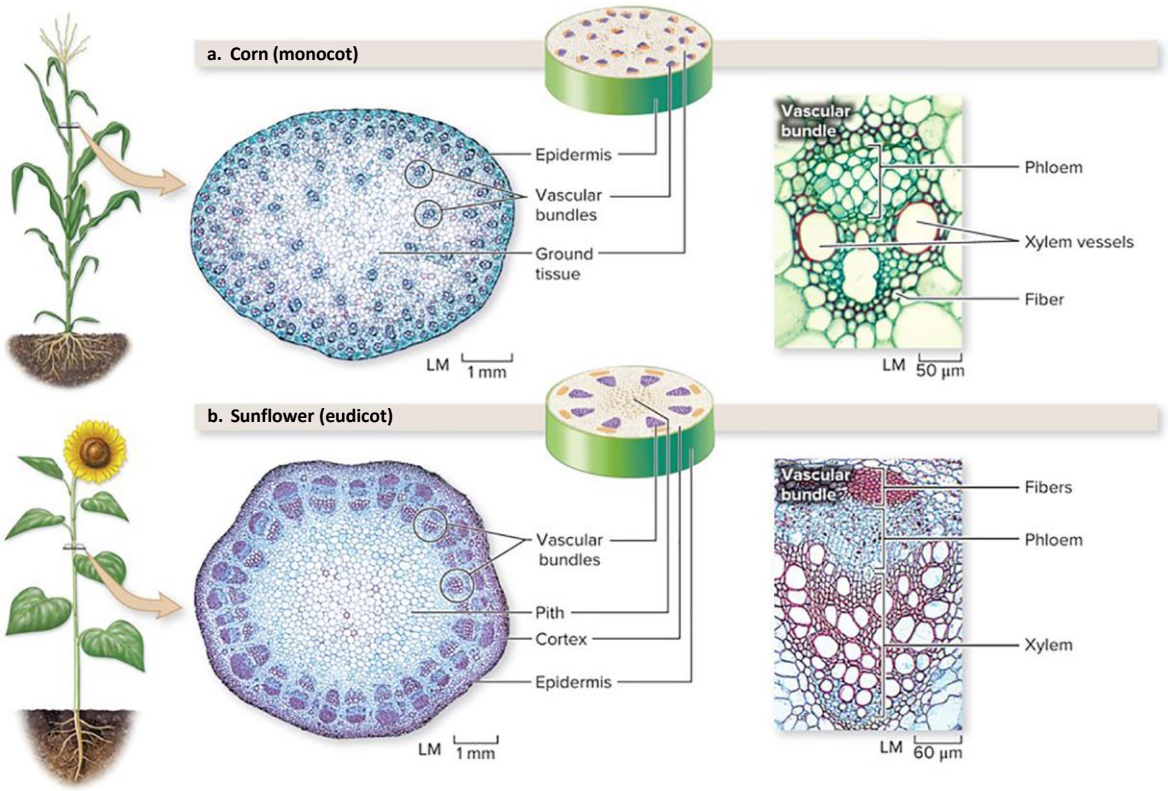


Section 22.3

Figure 22.6

Arrangement of tissues differs in monocots and eudicots

Monocots and eudicots have different arrangements of vascular tissue and ground tissue in their stems.



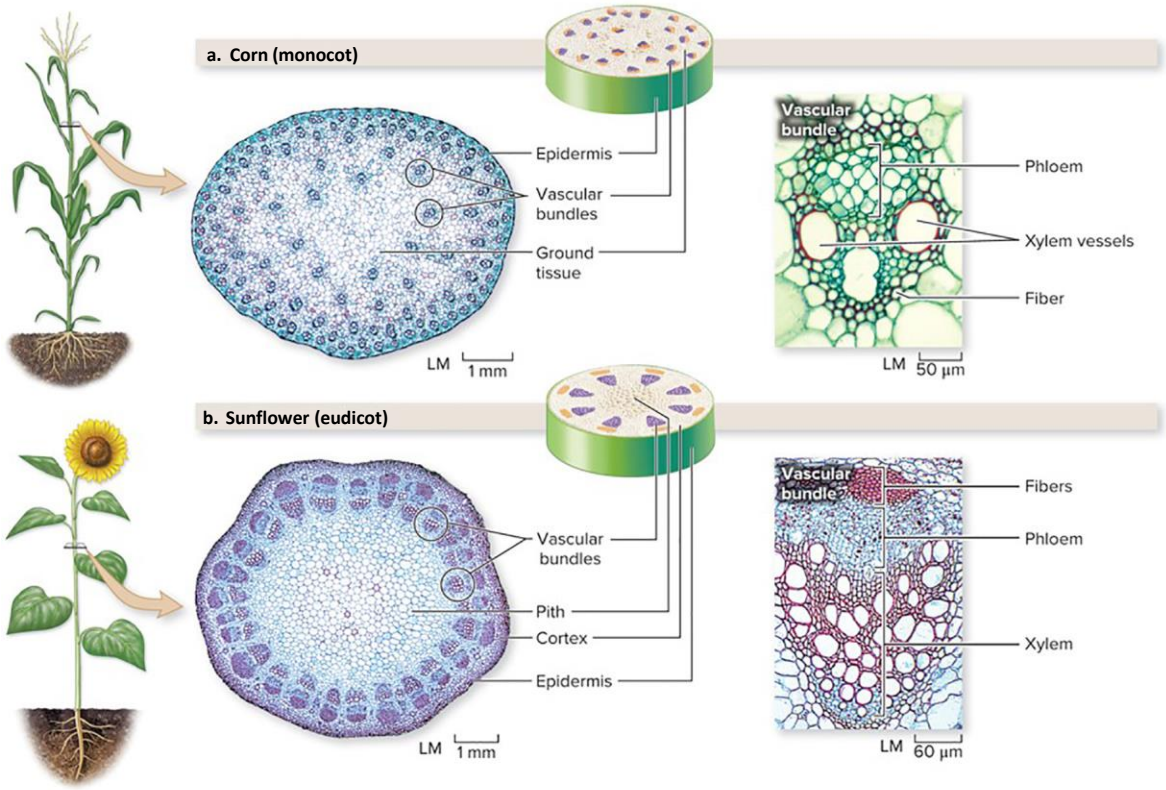
(a, stem): ©Steven P. Lynch/RF; (a, corn close up; b, both): ©Steven P. Lynch/McGraw-Hill Education

Vascular bundles in monocot and eudicot stems

In monocots, vascular bundles are scattered throughout the stem.

In eudicots, vascular bundles are arranged in a ring near the epidermis.

The **cortex** is ground tissue that fills the space between the epidermis and vascular bundles. The **pith** occupies the center of the stem.



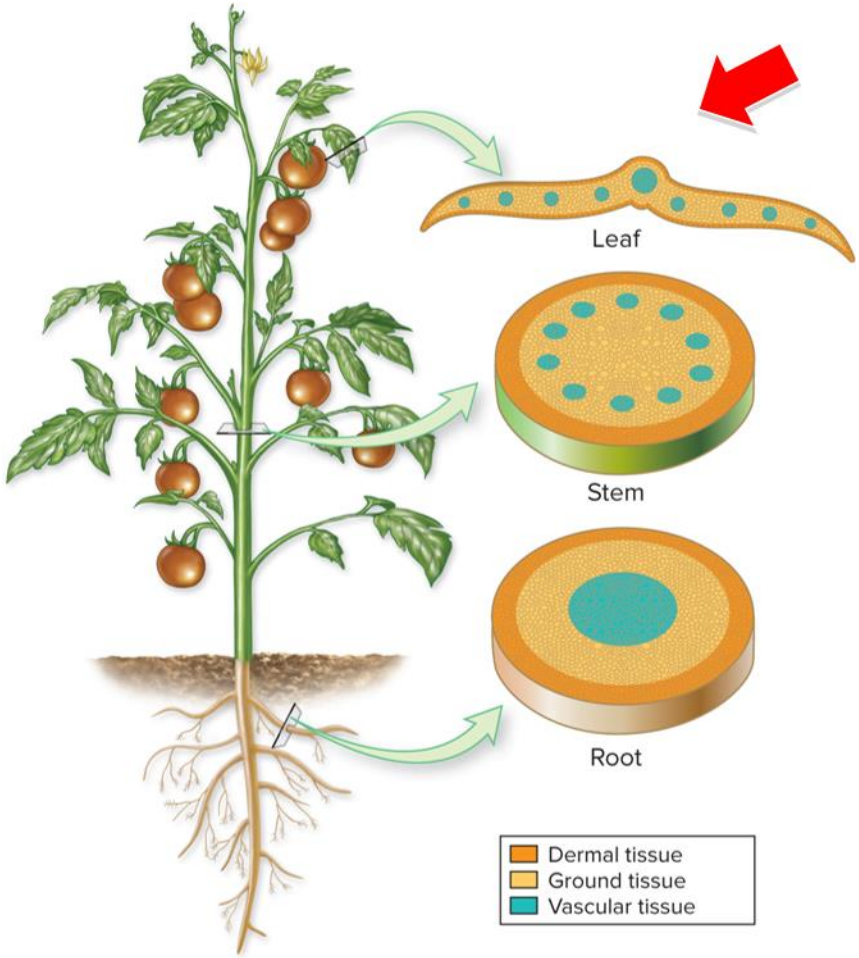
(a, stem): ©Steven P. Lynch/RF; (a, corn close up; b, both): ©Steven P. Lynch/McGraw-Hill Education

Tissues found in leaves

Ground tissue occupies most of a **leaf**.

Vascular bundles are embedded in the ground tissue.

Dermal tissue covers the leaf.

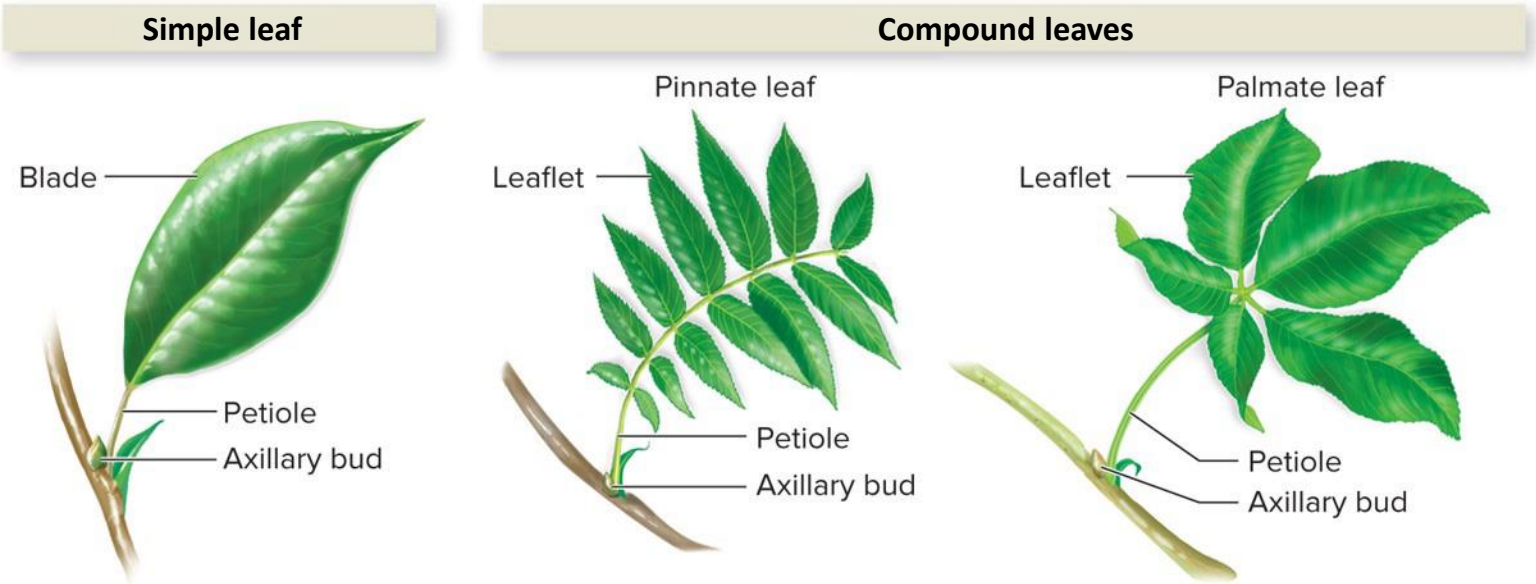


Section 22.3

Figure 22.6

The structure of leaves

Leaves are flattened **blades** supported with a stalklike **petiole**.

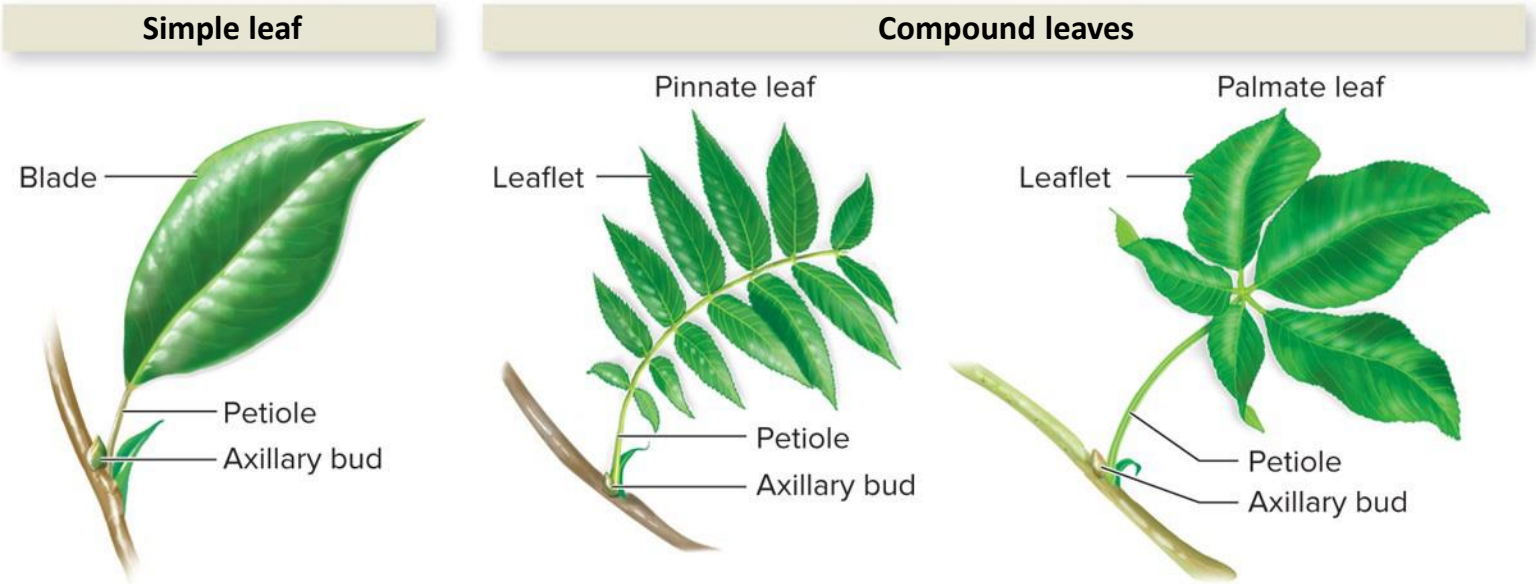


Section 22.3

Figure 22.10

Simple vs. compound leaves

Simple leaves have undivided blades.
Compound leaves are divided into leaflets attached to one petiole.



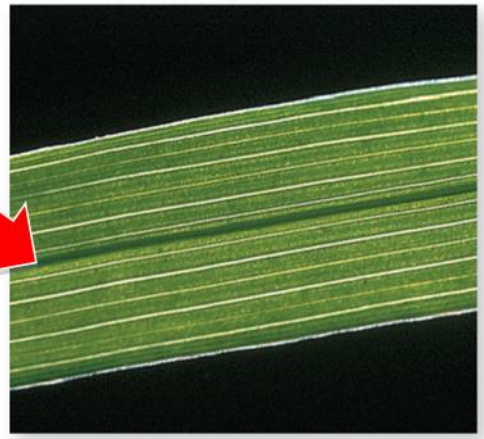
Section 22.3

Figure 22.10

Vein patterns on monocot and eudicot leaves

Veins are vascular bundles inside leaves. Many monocots have parallel veins; most eudicots have netted veins.

Veins on typical monocot leaf



a.

b.

Veins on typical eudicot leaf

(both): ©Dwight Kuhn

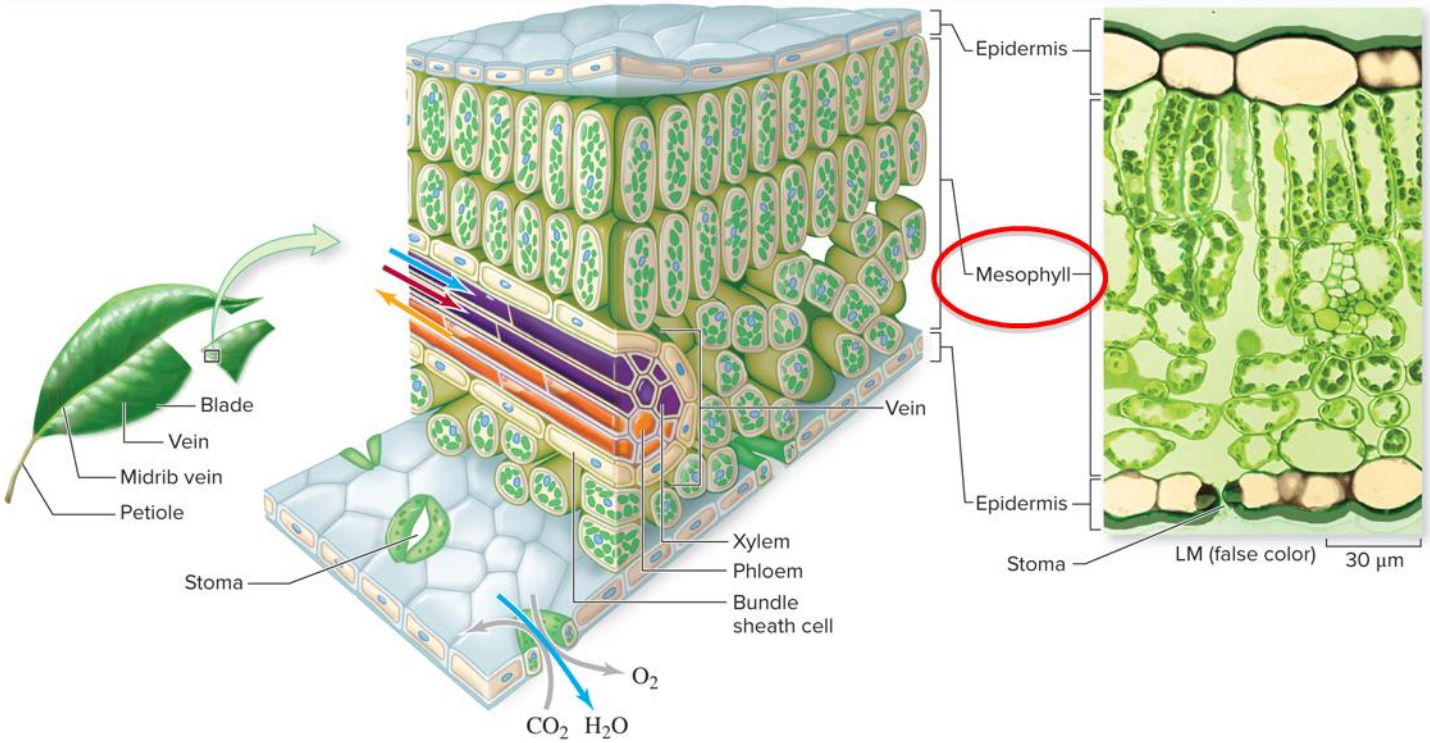
Section 22.3

Figure 22.11

Mesophyll: the middle of a leaf

Leaf anatomy shown here is that of a eudicot plant.

The ground tissue inside a leaf is called **mesophyll**, which consists of cells with abundant chloroplasts that produce sugars by photosynthesis.



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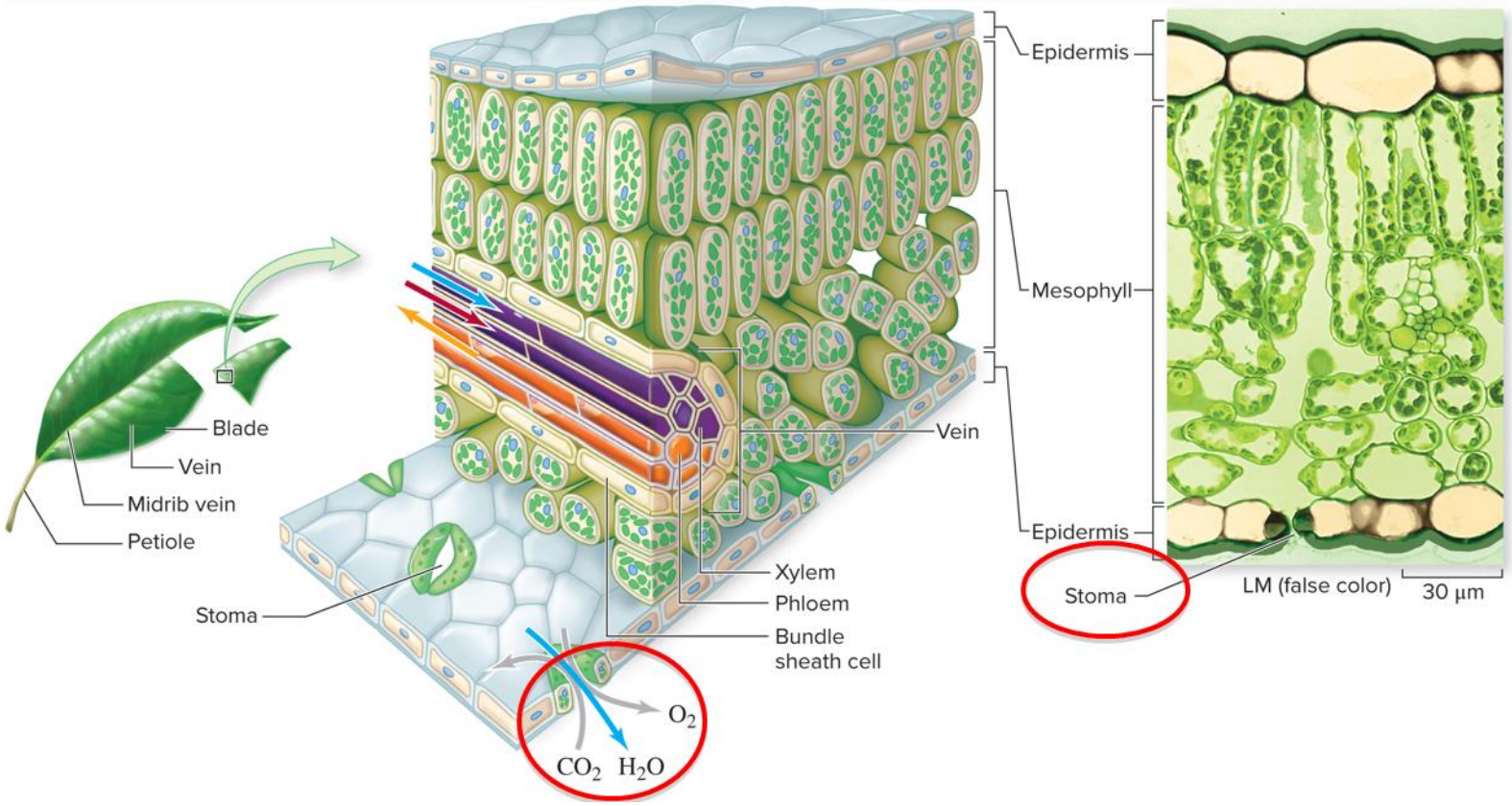
Stomata: locations of gas exchange

When **stomata** are open, mesophyll cells exchange gases with the atmosphere.



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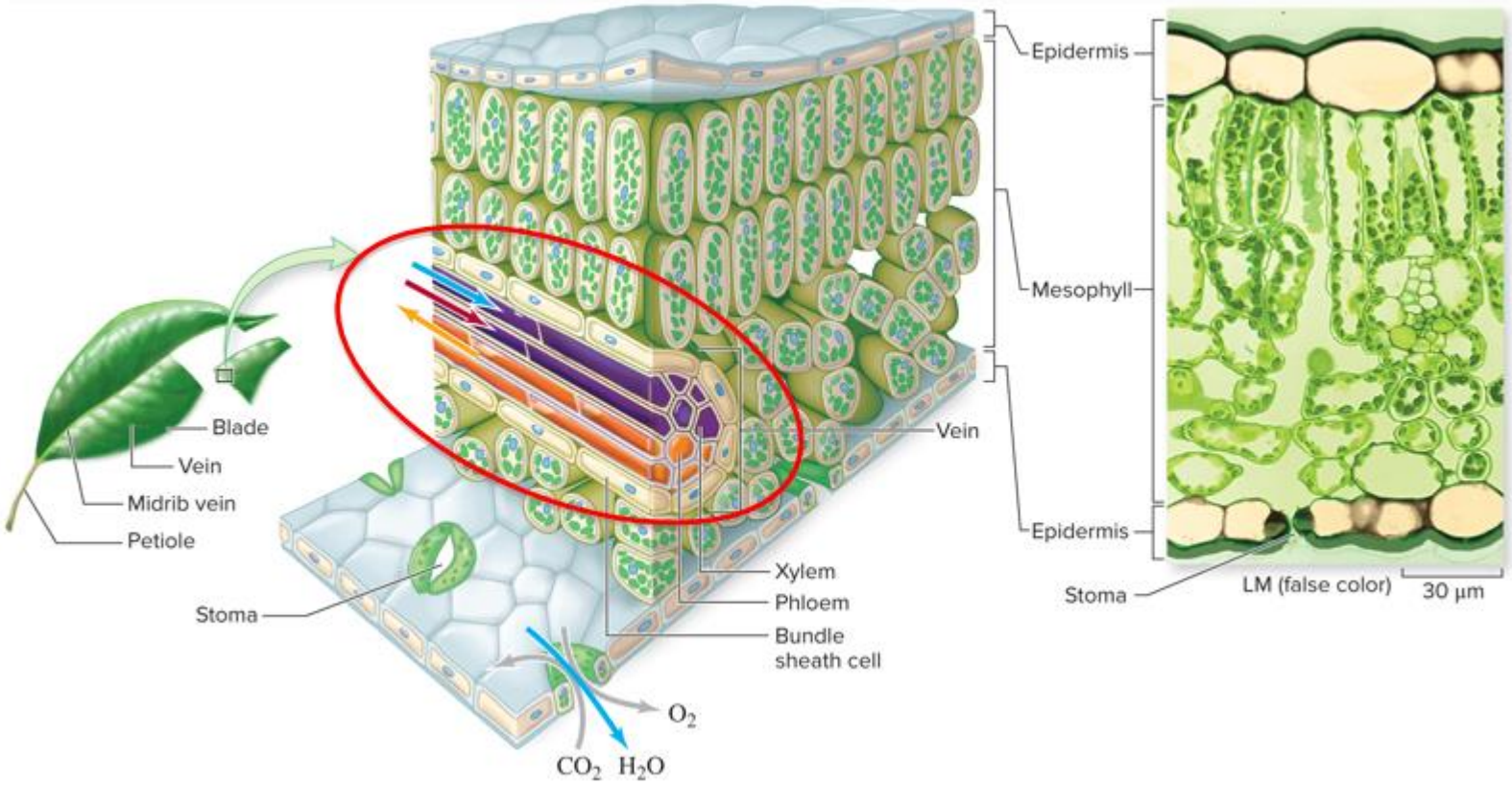
Section 22.3

Figure 22.12

Mesophyll cells interact with vascular tissue

Mesophyll cells also exchange materials with vascular tissues.



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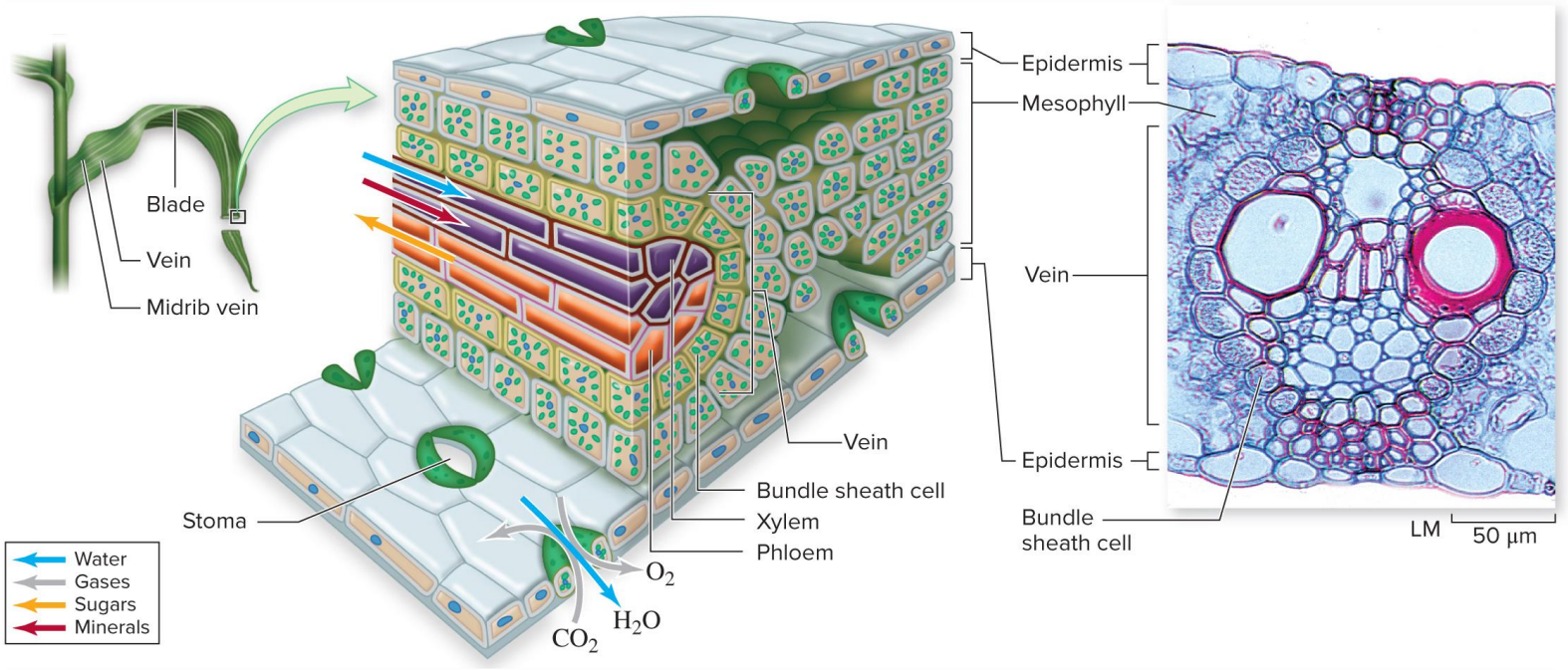
Section 22.3

Figure 22.12

Monocot leaf structures

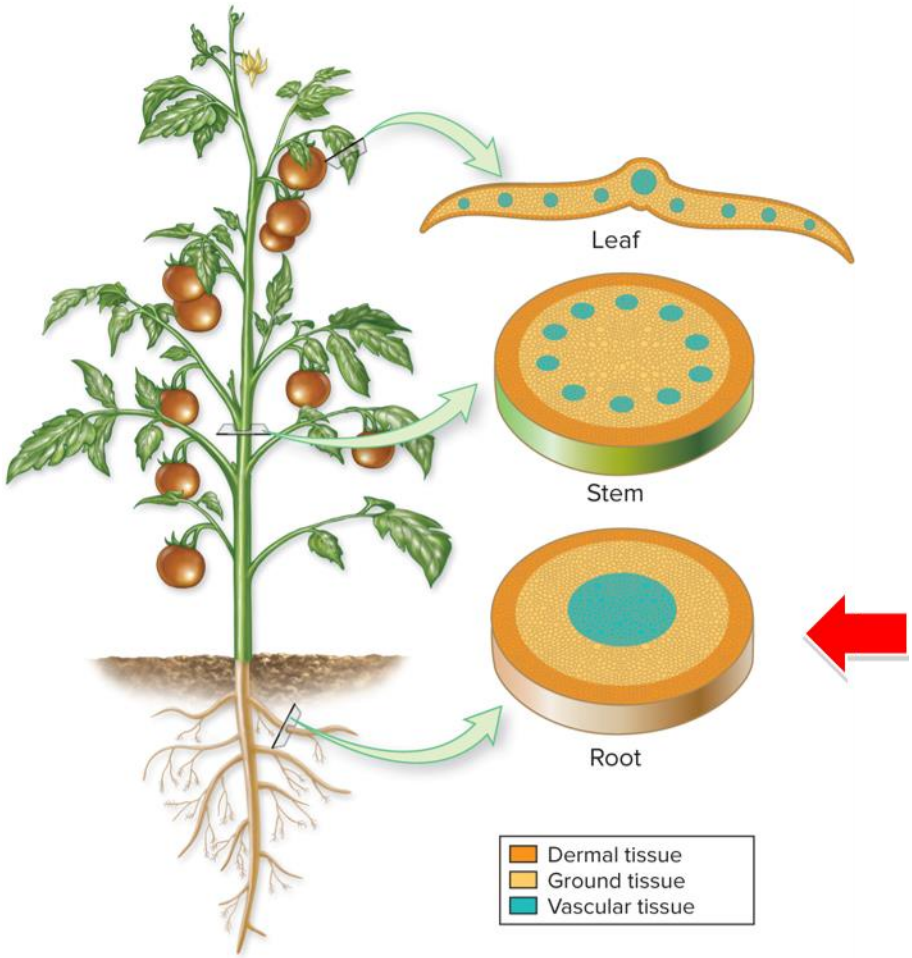
Monocots have similar leaf anatomy to dicots. Note the prominent bundle sheath cells in this monocot leaf, surrounded by a layer of mesophyll.



Tissues of the root

In a **root,** ground tissue surrounds a central core of vascular tissue.

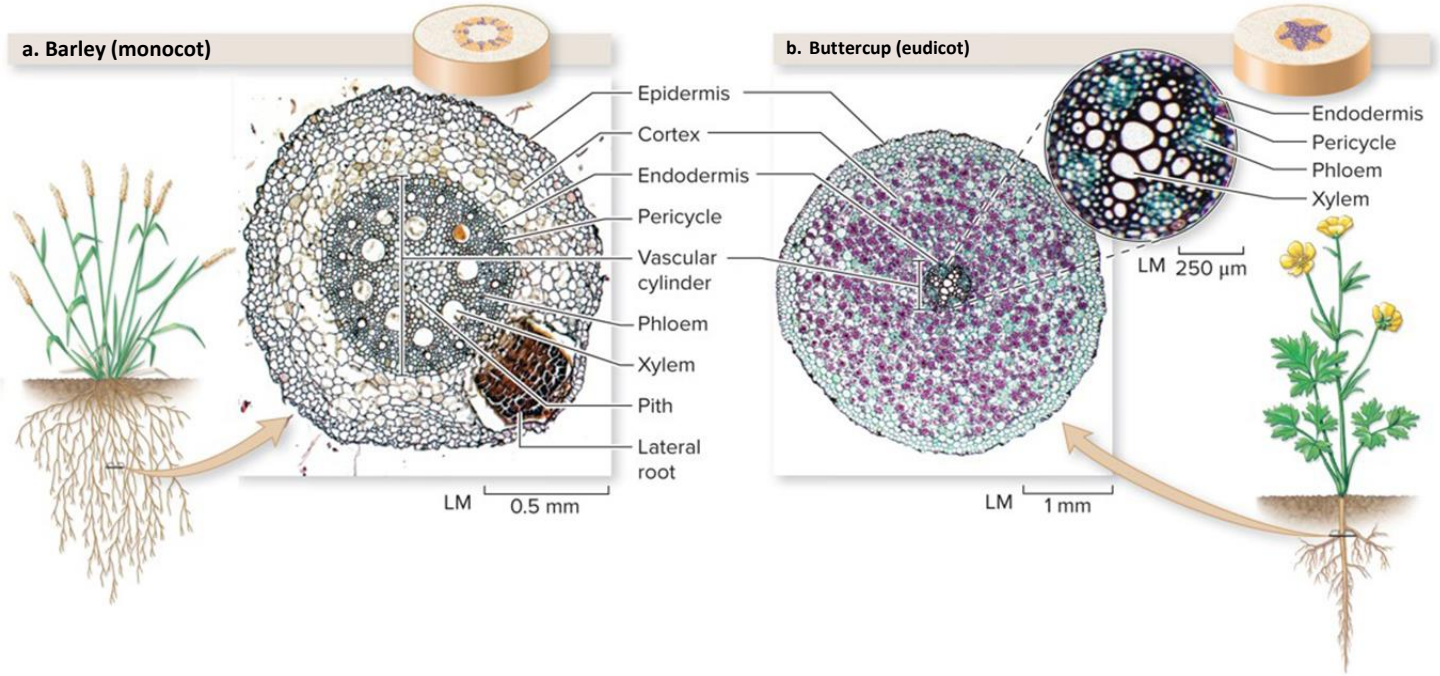
Dermal tissue forms the root epidermis.



Fibrous roots vs. taproots

Roots might form a **fibrous root system** or a **taproot system**.

- Fibrous roots are slender, shallow, and arise from the base of the stem.
- Taproots are thick, deep, and have fewer branches than fibrous roots.



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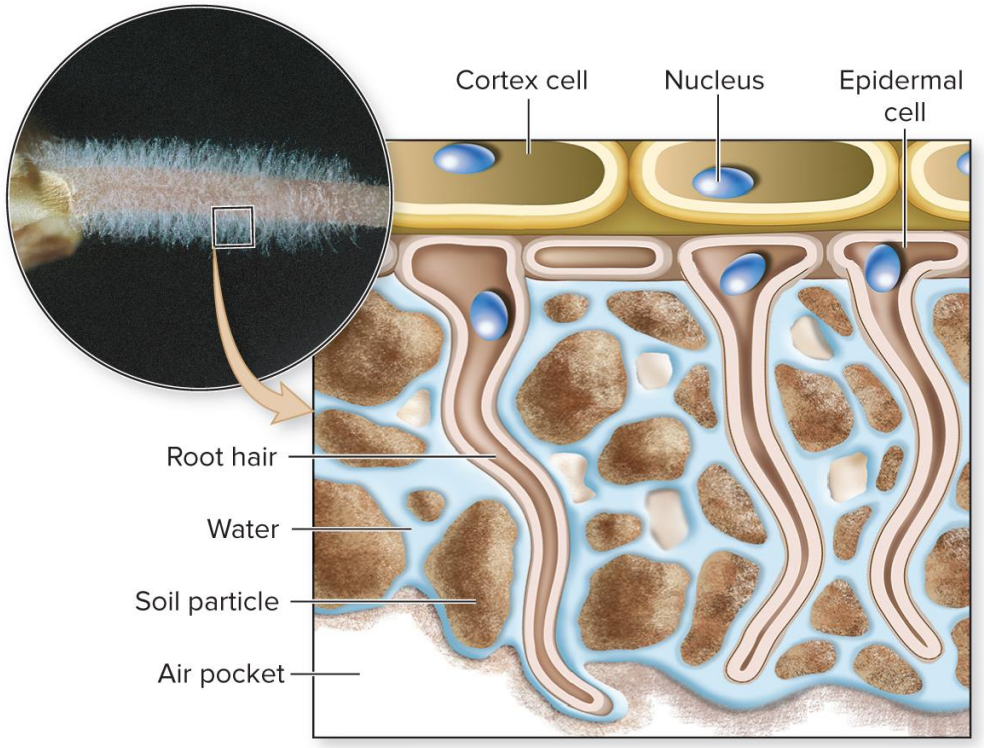
Section 22.3

Figure 22.13

Root hairs

Near each root's tip, **root hairs** are extensions of the epidermis that absorb water and minerals.



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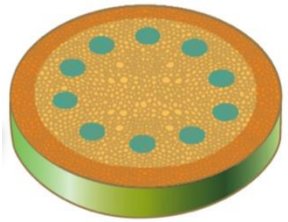
Clicker question #3

The cross section shown at right comes from

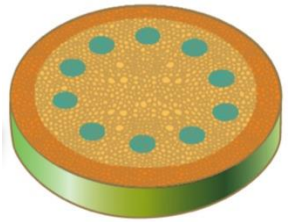


A. eudicot root.
B. eudicot stem.
C. monocot root.
D. monocot stem.

Figure 22.6

Clicker question #3, solution

The cross section shown at right comes from



B. eudicot stem.

Figure 22.6

22.3 Mastering concepts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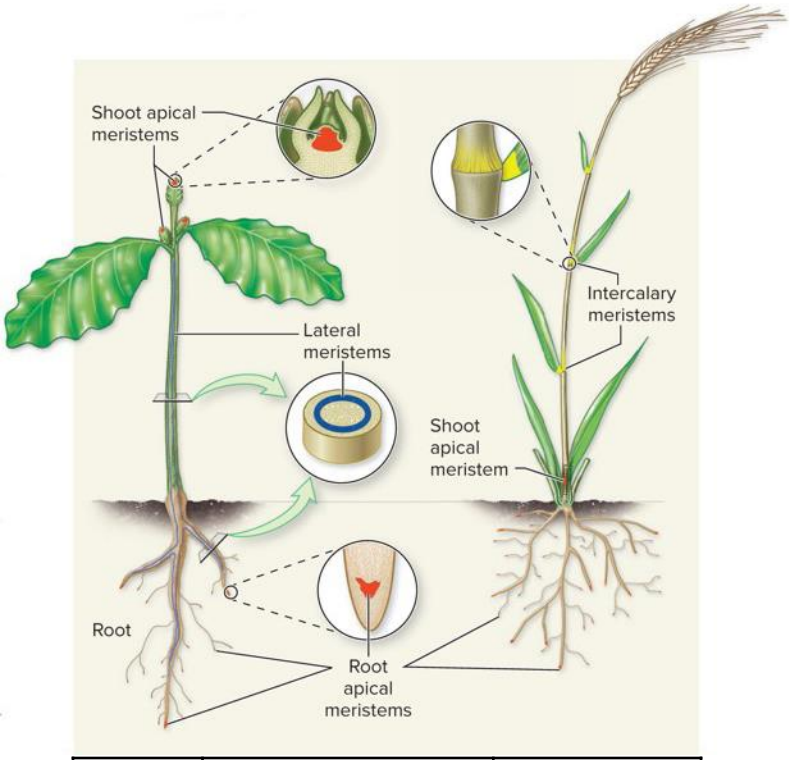
Describe the internal anatomy of a stem, leaf, and root.

Plants have flexible growth patterns

Some plants never stop growing. These plants have **indeterminate growth**.

Plants that stop growing when they reach their mature size have **determinate growth**.

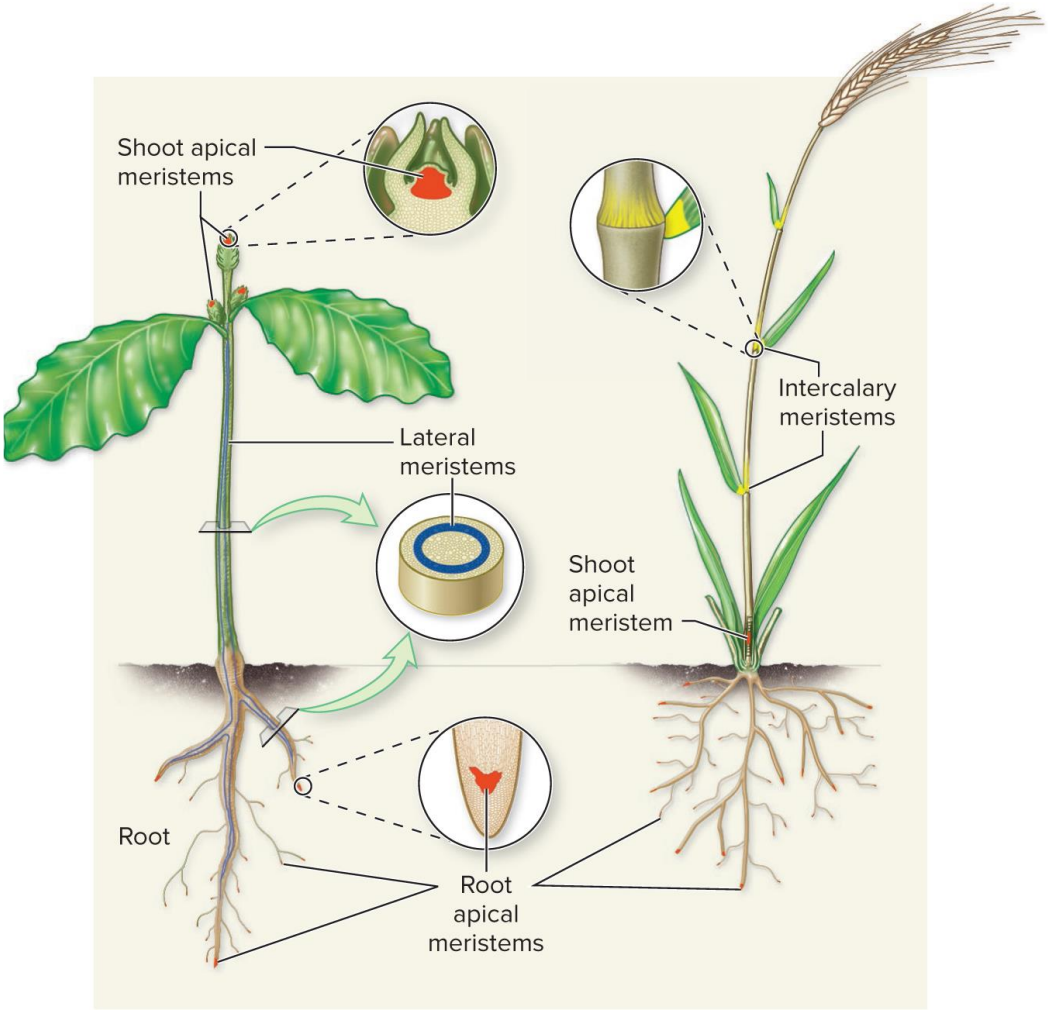


T A B L E 22.3 Meristem Types: A Summary

Type	Locations	Function
Apical	Terminal and axillary buds of shoots; root tips	Produces tissues that lengthen the tips of shoots and roots
Lateral	Internal cylinder along the length of roots and stems of woody plants	Thickens roots and stems
Intercalary	Between nodes of mature stems in grasses and other monocots	Regrowth of tissue if tip of stem is removed

Meristems

Plants grow by adding units, or modules, consisting of repeated nodes and internodes. Growth occurs at **meristems**, regions of active cell division.

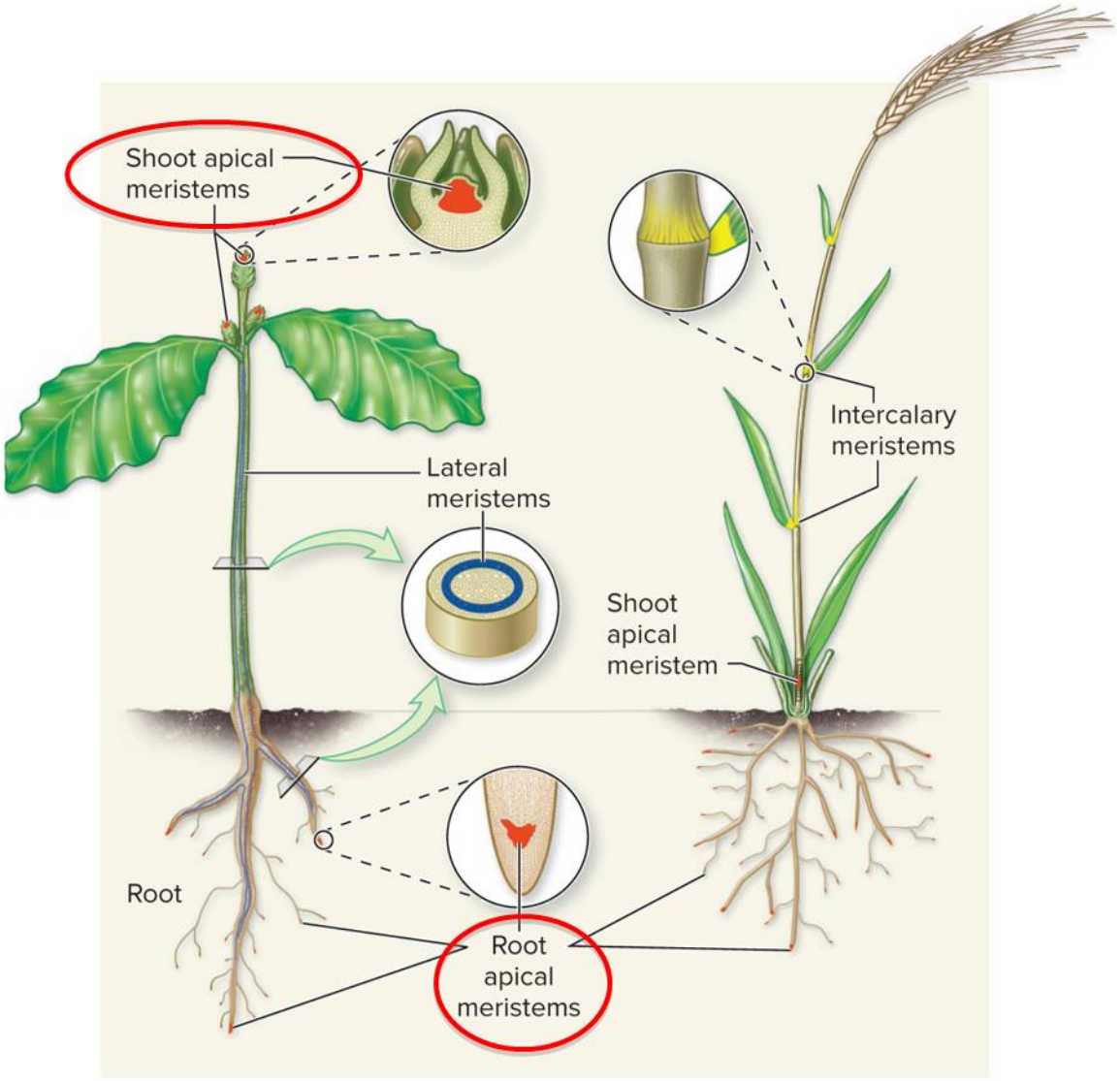


Section 22.4

Table 22.3

Apical meristems

Apical meristems produce tissues that lengthen the tips of shoots and roots.

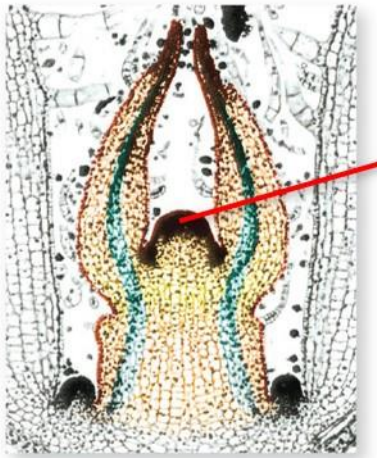


Section 22.4

Table 22.3

Primary growth

Primary growth occurs at the apical meristems. New cells can differentiate into any tissue type.



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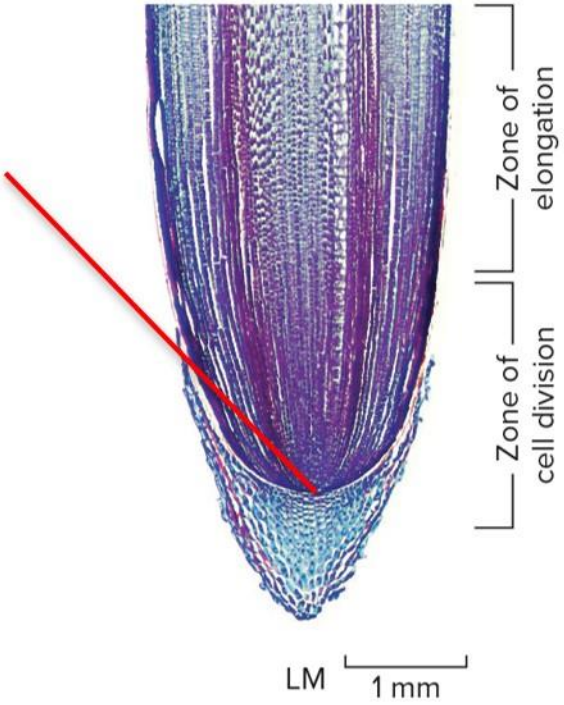
Apical meristems



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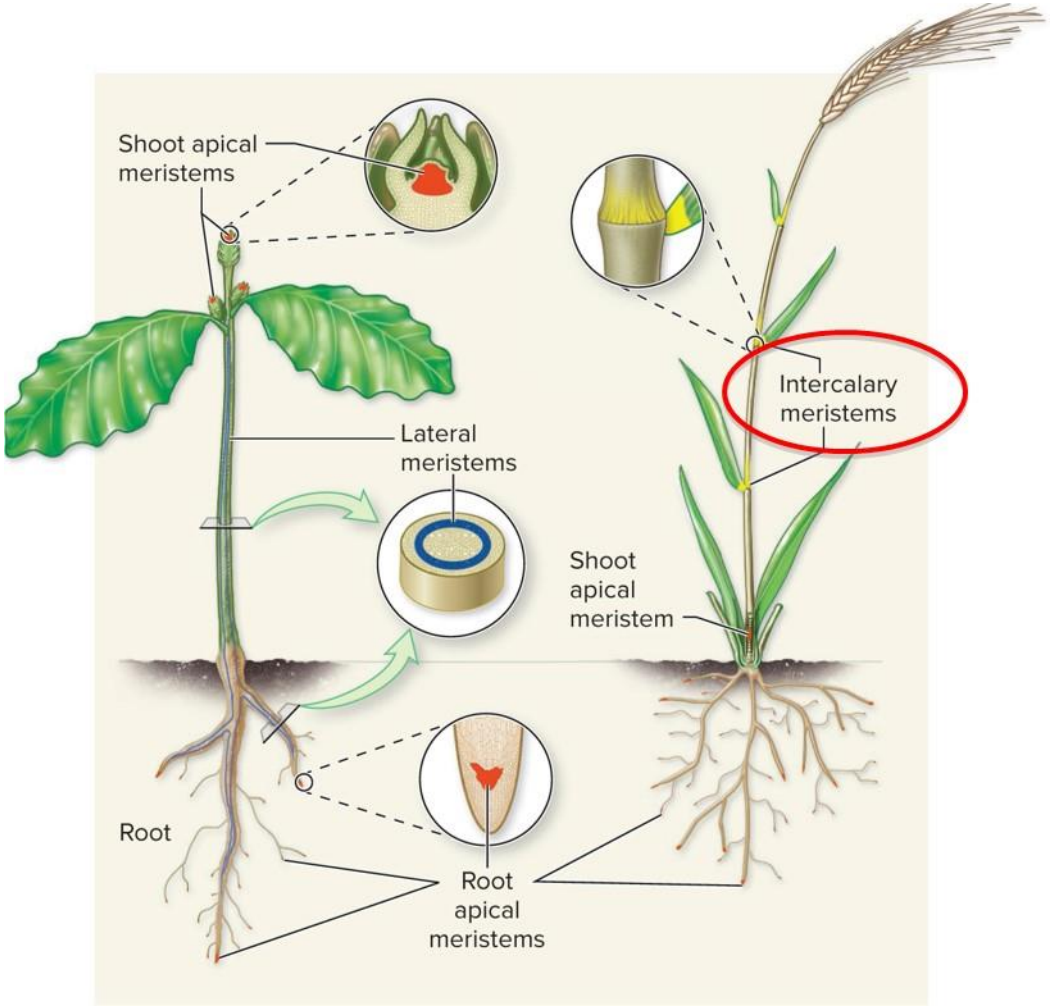
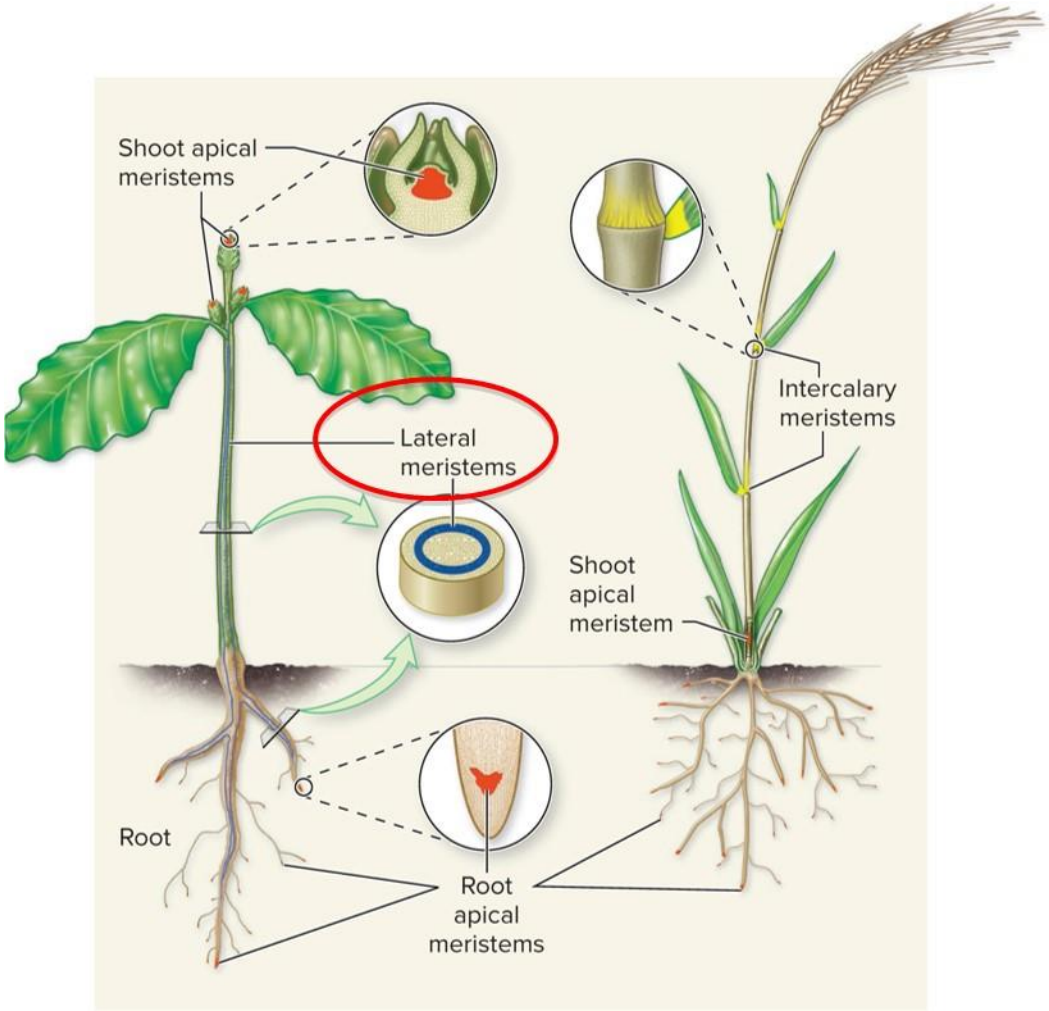
Intercalary meristems

Intercalary meristems occur at the base of a leaf blade. Grasses tolerate grazing because they have intercalary meristems that regrow a leaf from its base when the tip is munched off.



Secondary growth

Secondary growth thickens roots and stems; this growth occurs at **lateral meristems.**



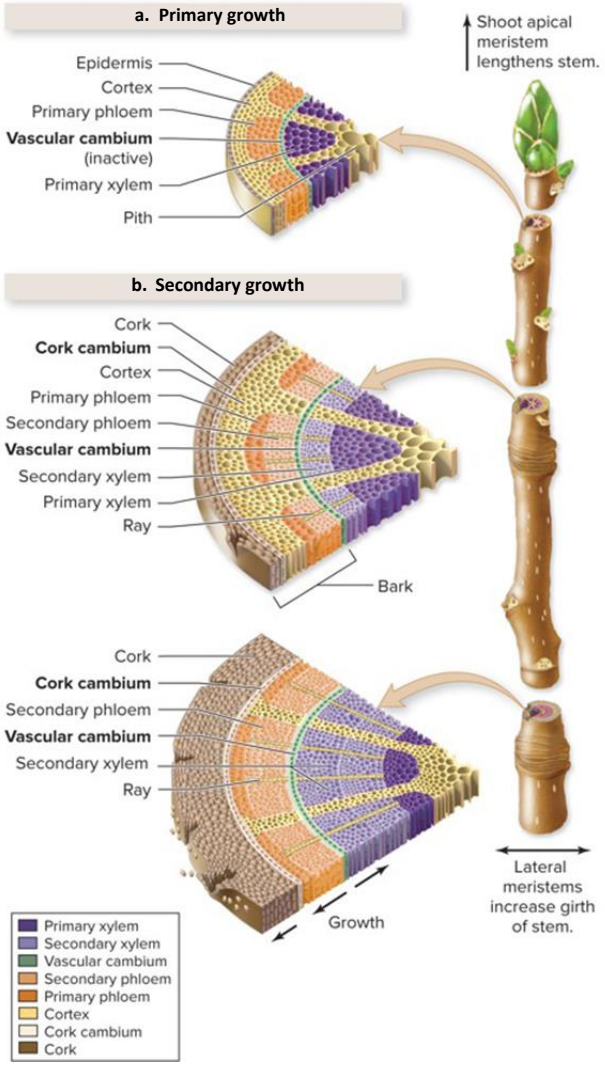
Section 22.4

Table 22.3

Secondary growth in woody plants

Secondary growth occurs in woody plants. Two types of lateral meristems produce wood and bark:

- Vascular cambium
- Cork cambium

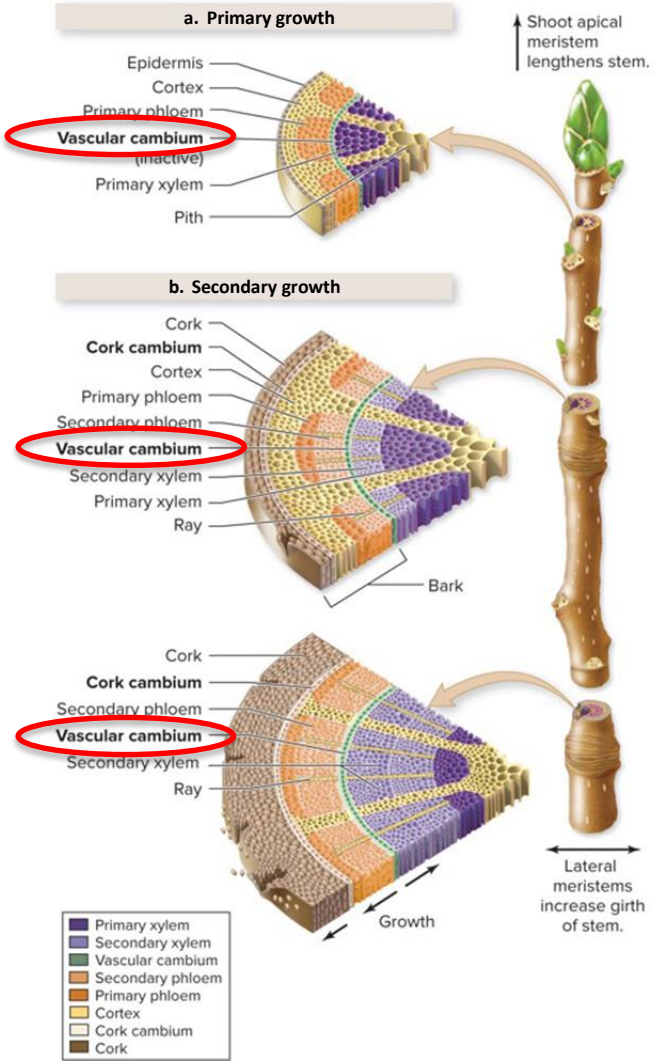


Section 22.4

Figure 22.17

Vascular cambium

The **vascular cambium** (highlighted green) produces secondary xylem toward the inside of the stem and secondary phloem toward the outside.

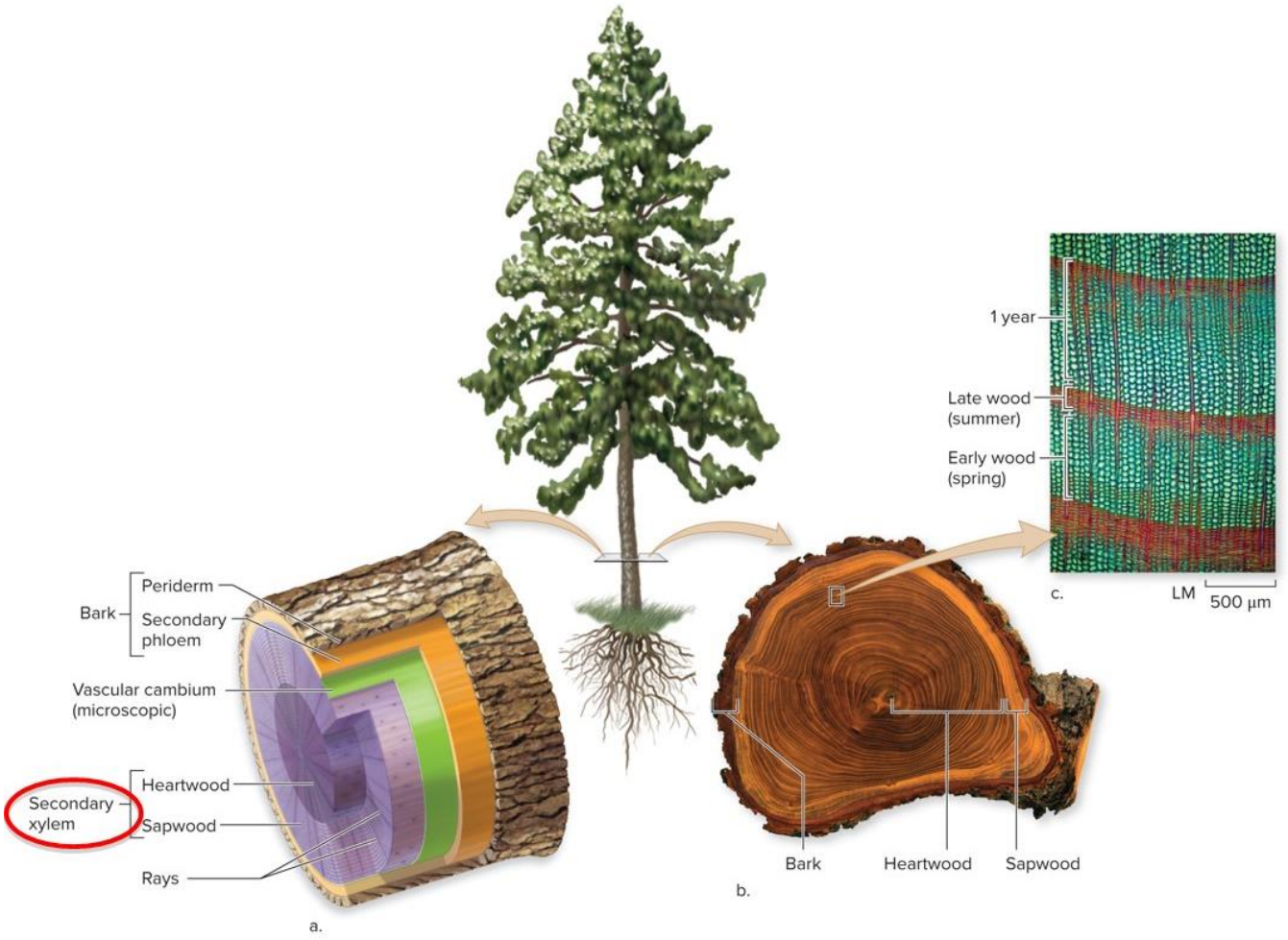


Section 22.4

Figure 22.17

Wood

Secondary xylem is more commonly called **wood**.



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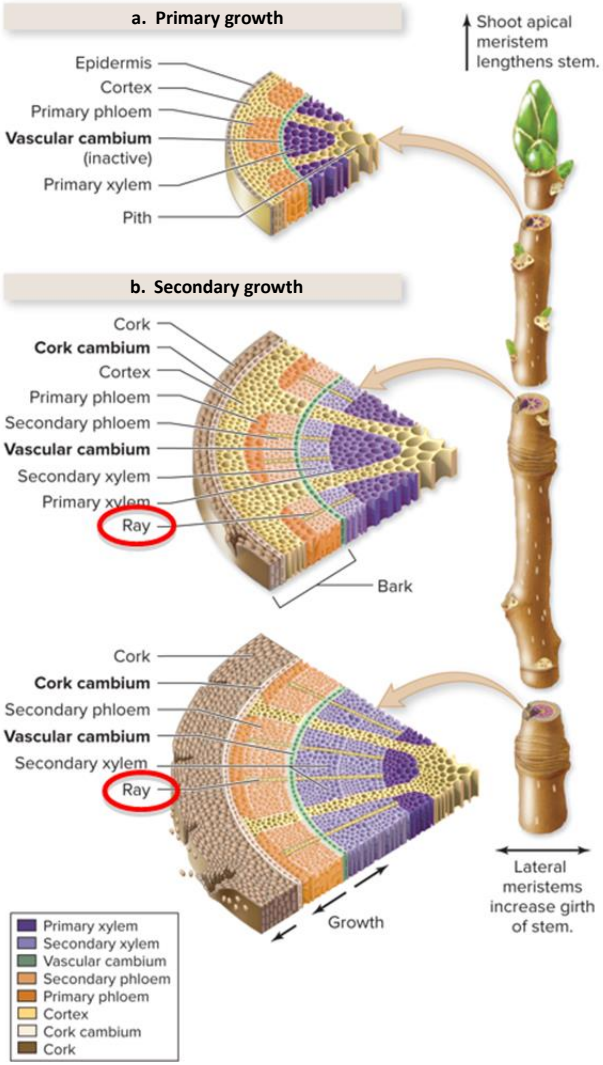
Section 22.4

Figure 22.18

Rays

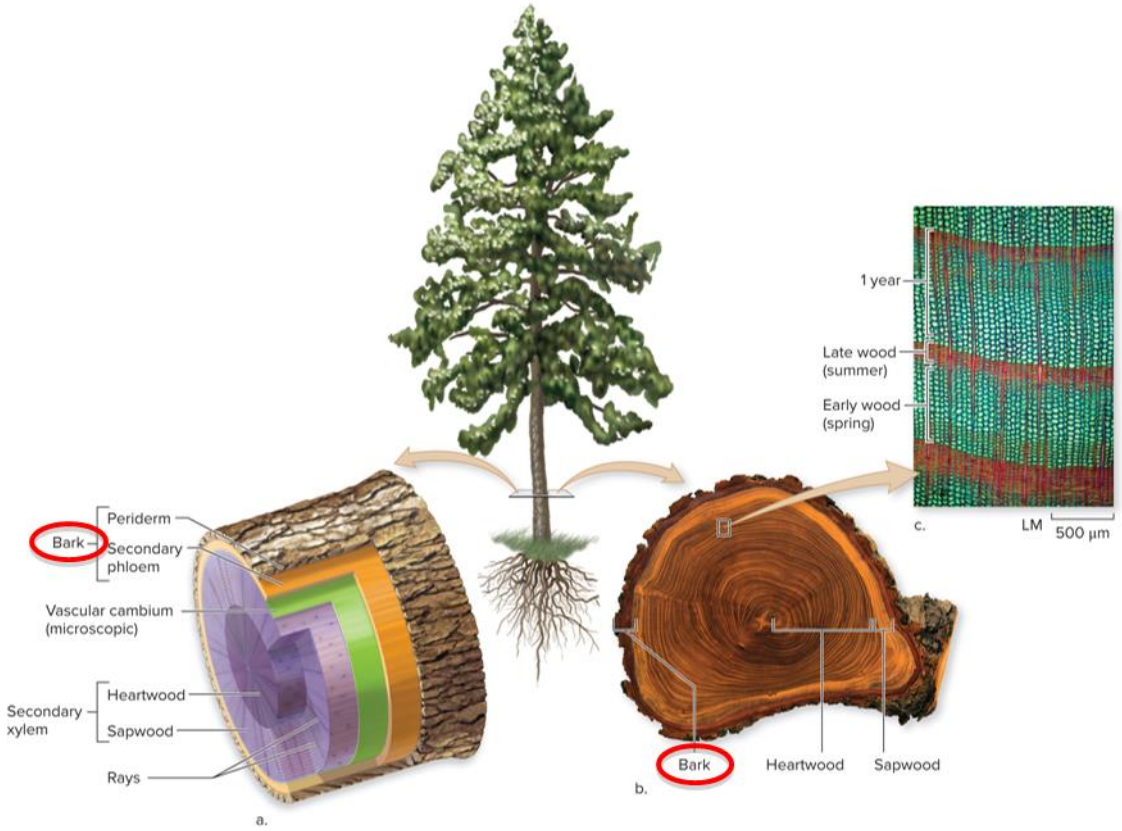
The vascular cambium also produces **rays** (highlighted with yellow), bands of parenchyma that extend from the center of the stem or root and transport nutrients laterally.



Section 22.4

Figure 22.17

Bark



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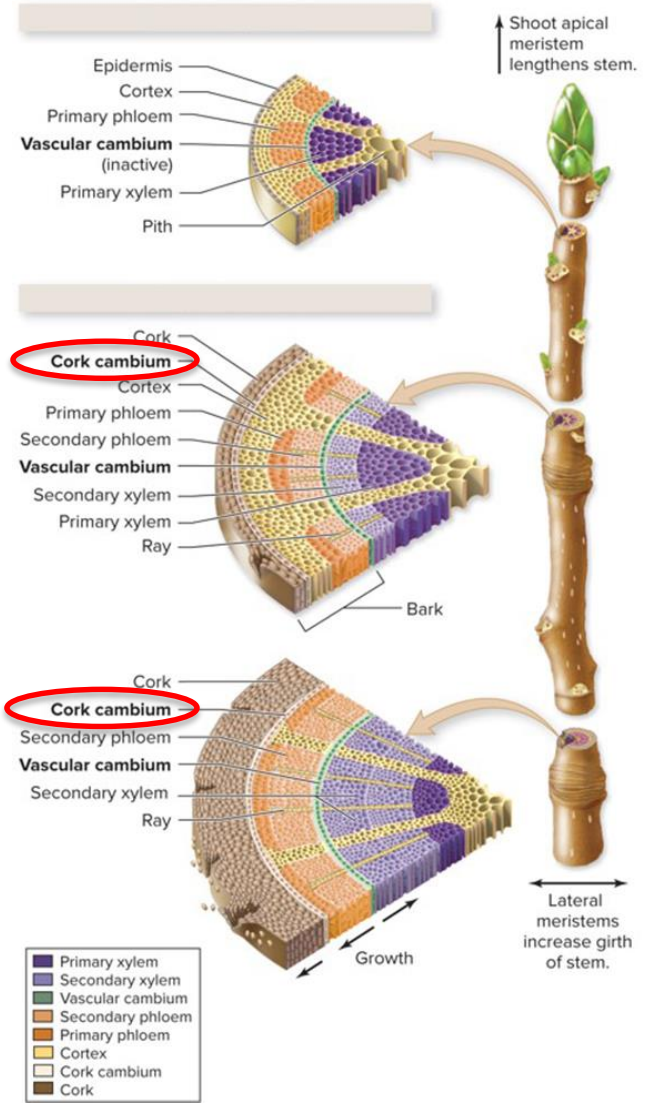
Secondary growth produces **bark**, a collective term for all tissues outside of the vascular cambium.

Cork cambium

The **cork cambium** (highlighted white) produces parenchyma cells toward the inside and dense, waxy cells called cork toward the outside.

Cork is the outer protective layer of bark.

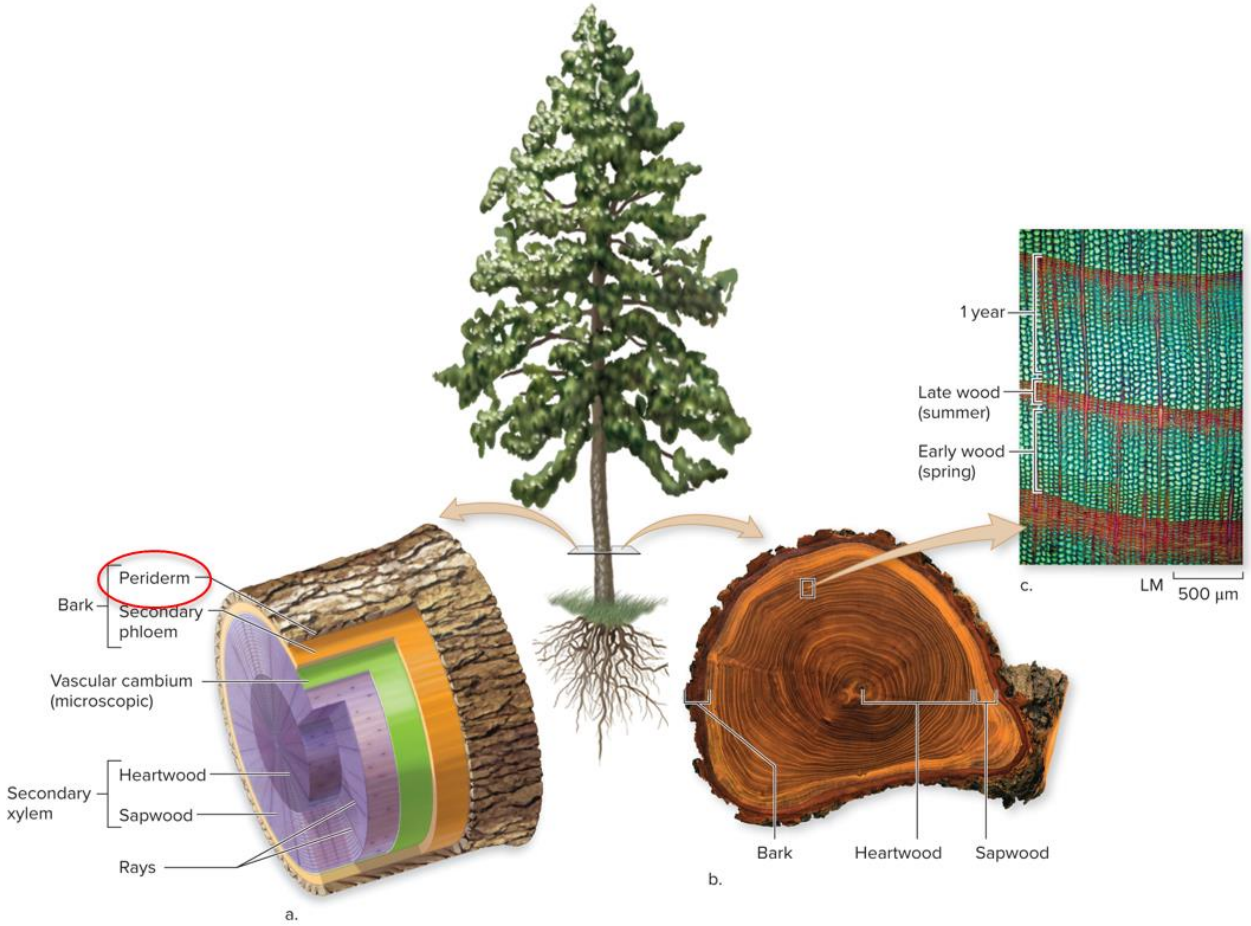


Section 22.4

Figure 22.17

Periderm

Together, the cork cambium, parenchyma cells, and nonliving cork make up the **periderm**, a protective layer that covers a woody stem or root.



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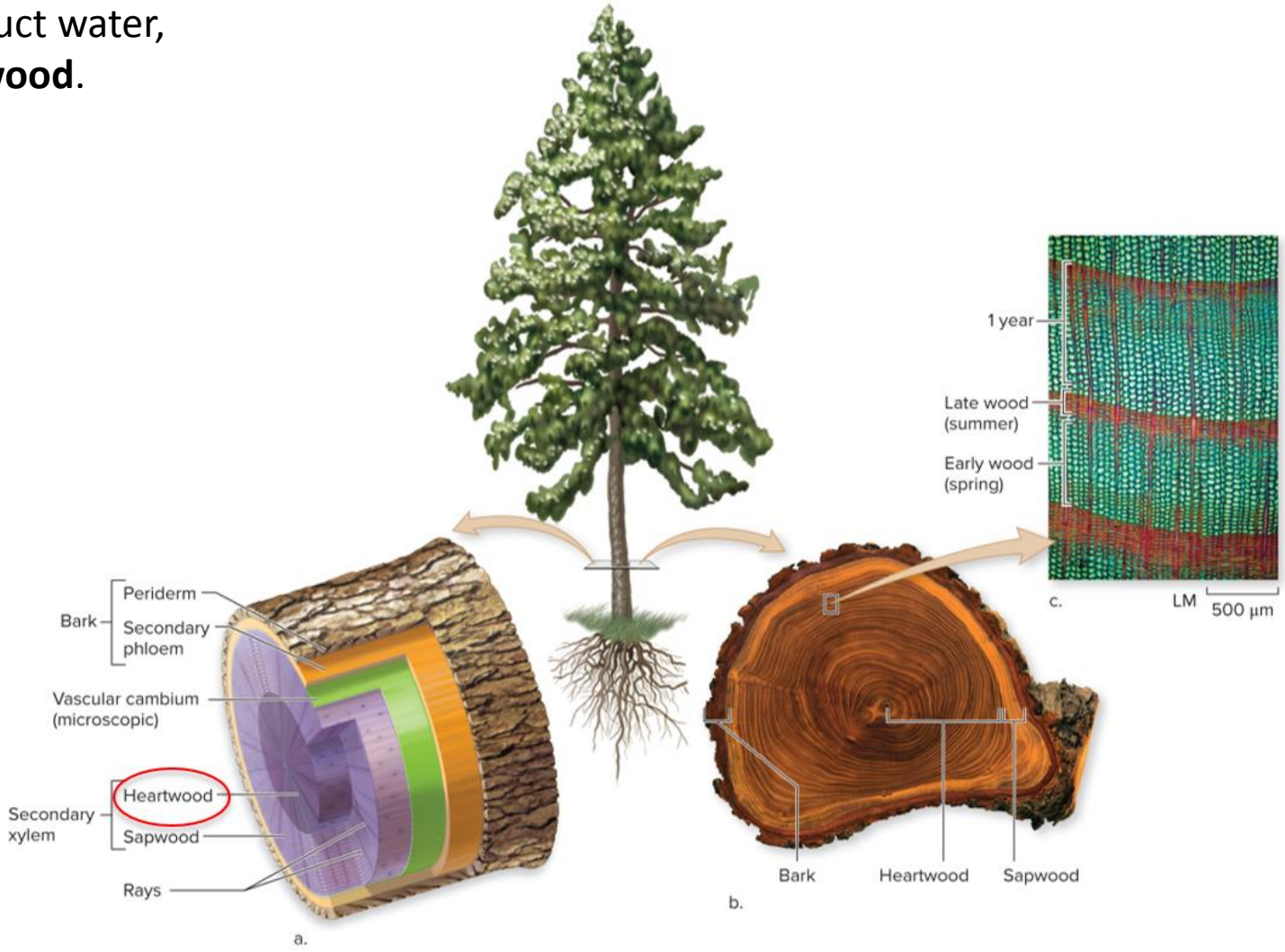
Section 22.4

Figure 22.18

Heartwood

Secondary xylem eventually becomes unable to conduct water, forming **heartwood**.



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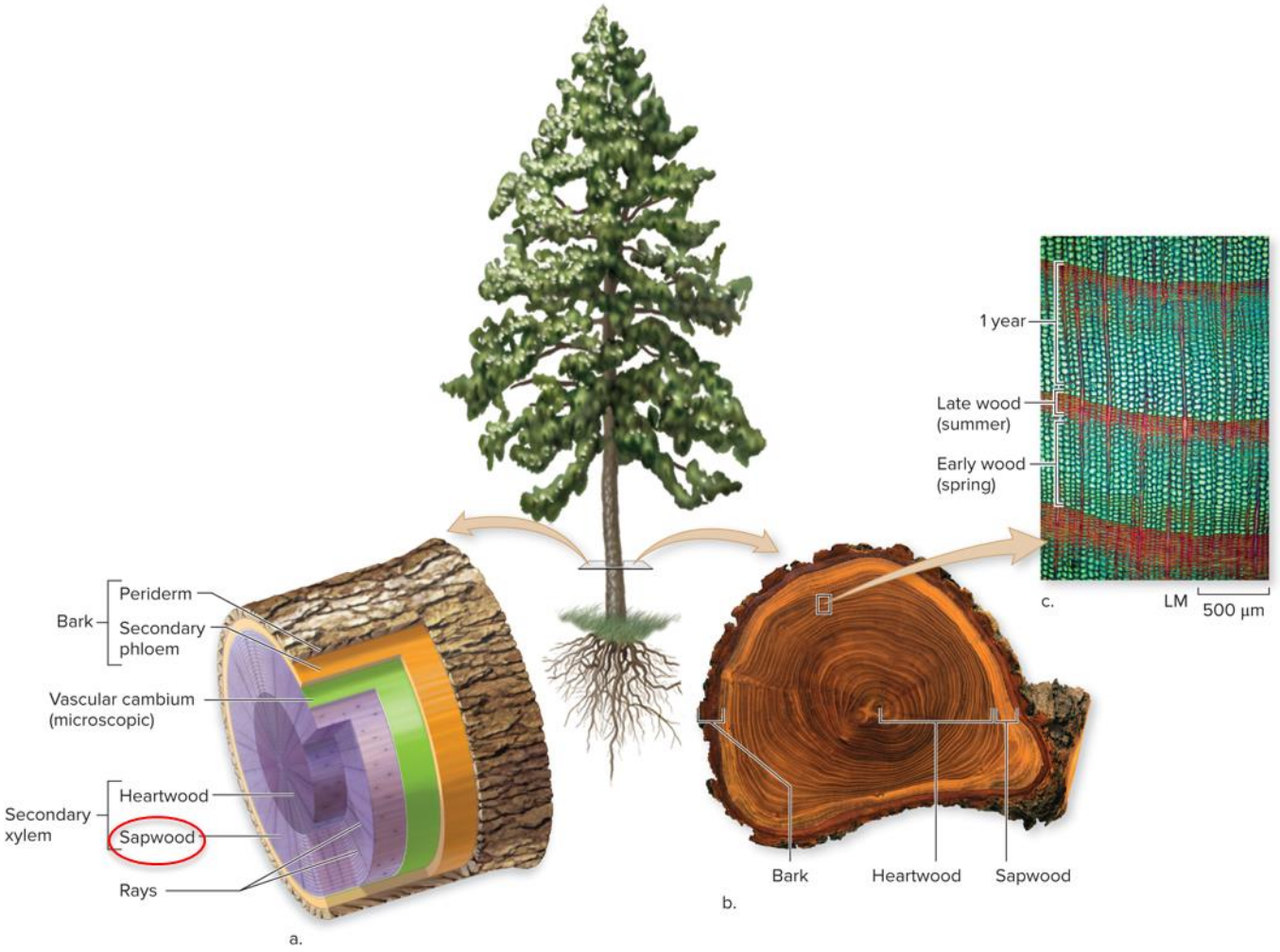
Section 22.4

Figure 22.18

Sapwood

The lighter **sapwood** transports water and dissolved minerals.



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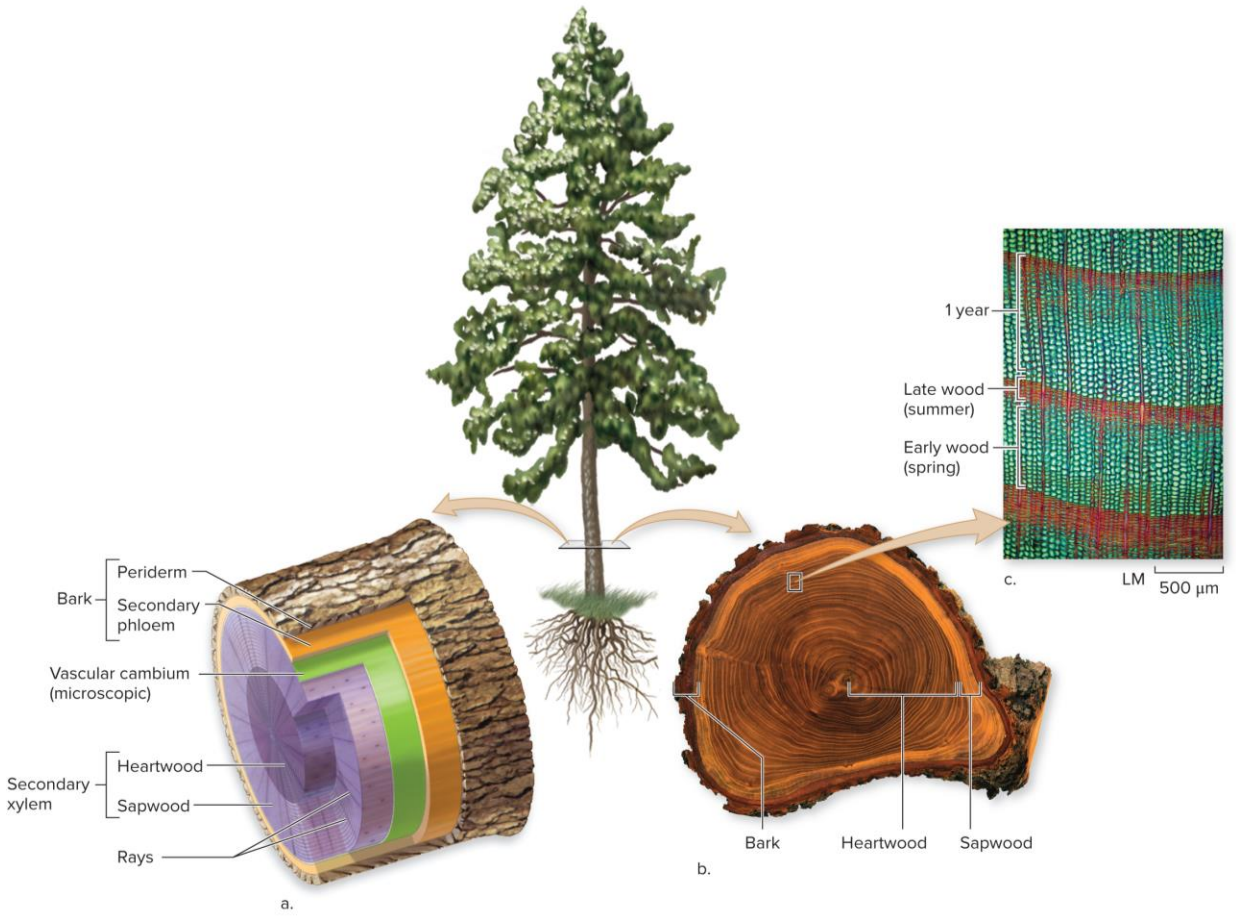
Section 22.4

Figure 22.18

Tree rings

Tree rings arise from alternating moist and dry seasons. Wood that forms in the spring has larger cells than wood that forms in the summer.



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Section 22.4

Figure 22.18

Clicker question #4

If you have ever used a microscope to study cells undergoing mitosis, you may have examined onion root tips. Why are root tips ideal specimens?

A. They contain lots of rapidly dividing cells.
B. They carry out photosynthesis.
C. They have root hairs that absorb water.
D. They don't require O_2.
E. They don't contain vascular tissue.

Clicker question #4, solution

If you have ever used a microscope to study cells undergoing mitosis, you may have examined onion root tips. Why are root tips ideal specimens?

A. They contain lots of rapidly dividing cells.

22.4 Mastering concepts

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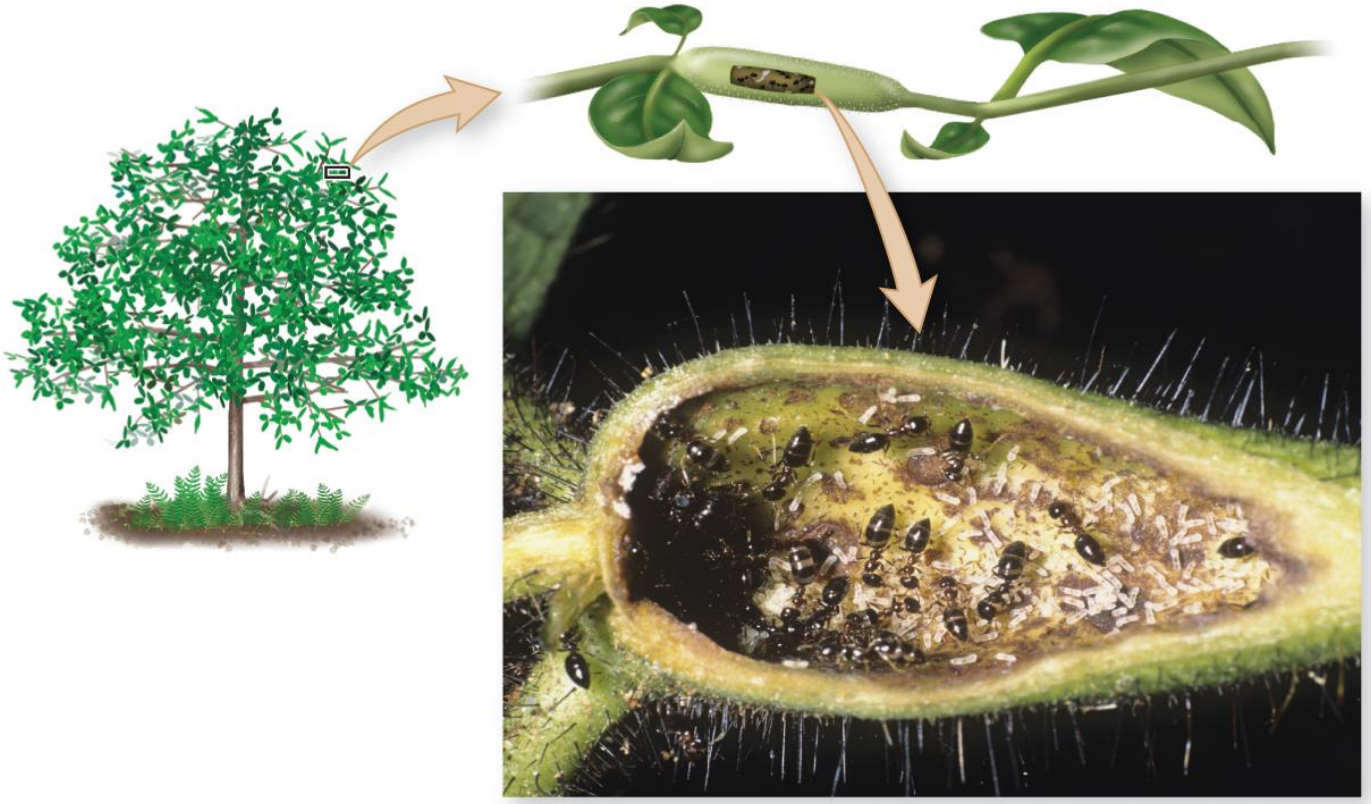
What are the locations and functions of meristems?

Investigating life: an army of tiny watchdogs

In some plants, evolution has selected adaptations in anatomy that benefit ants.



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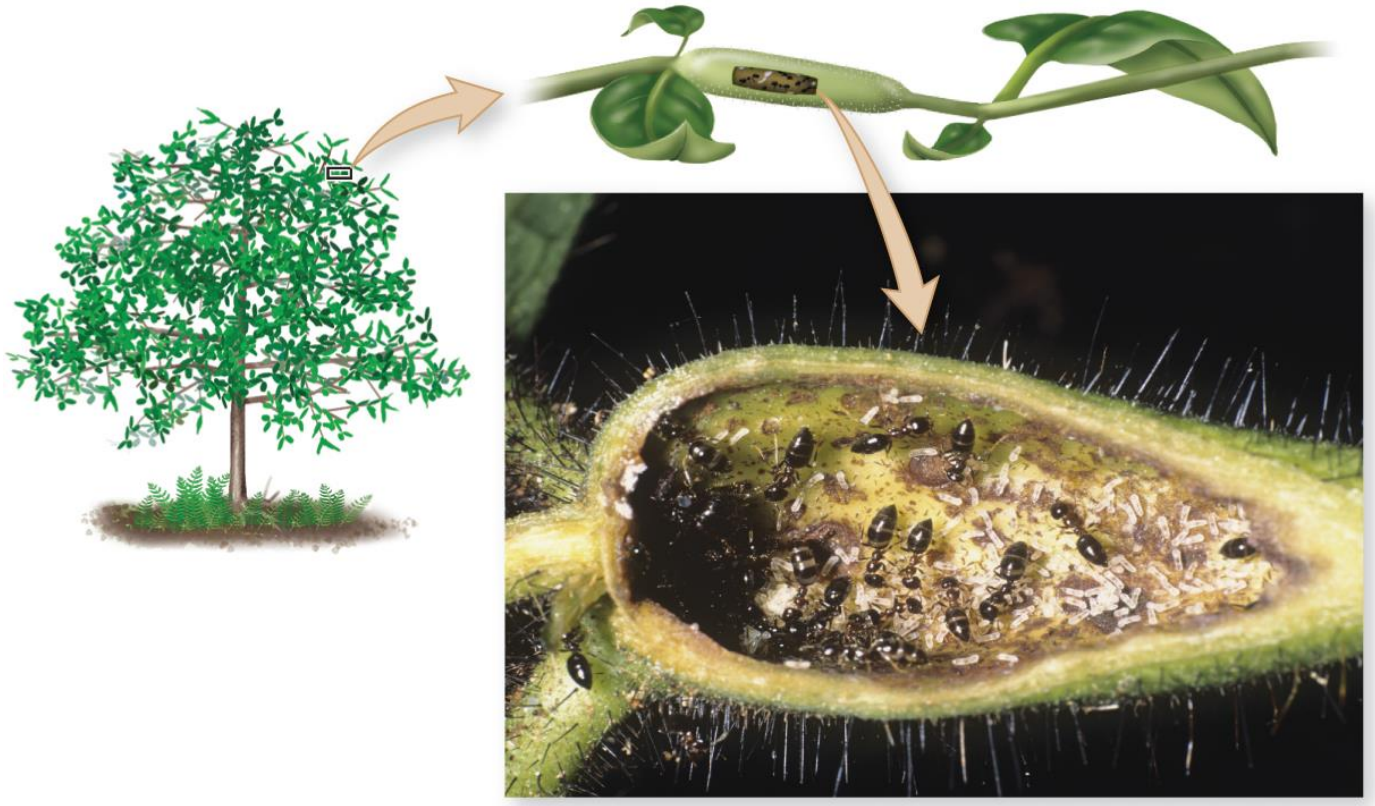
Section 22.5

Figure 22.19

A mutualistic relationship

The ants make their homes in hollow stems called domatia. The ants also eat the nectar of the plant's young leaves.



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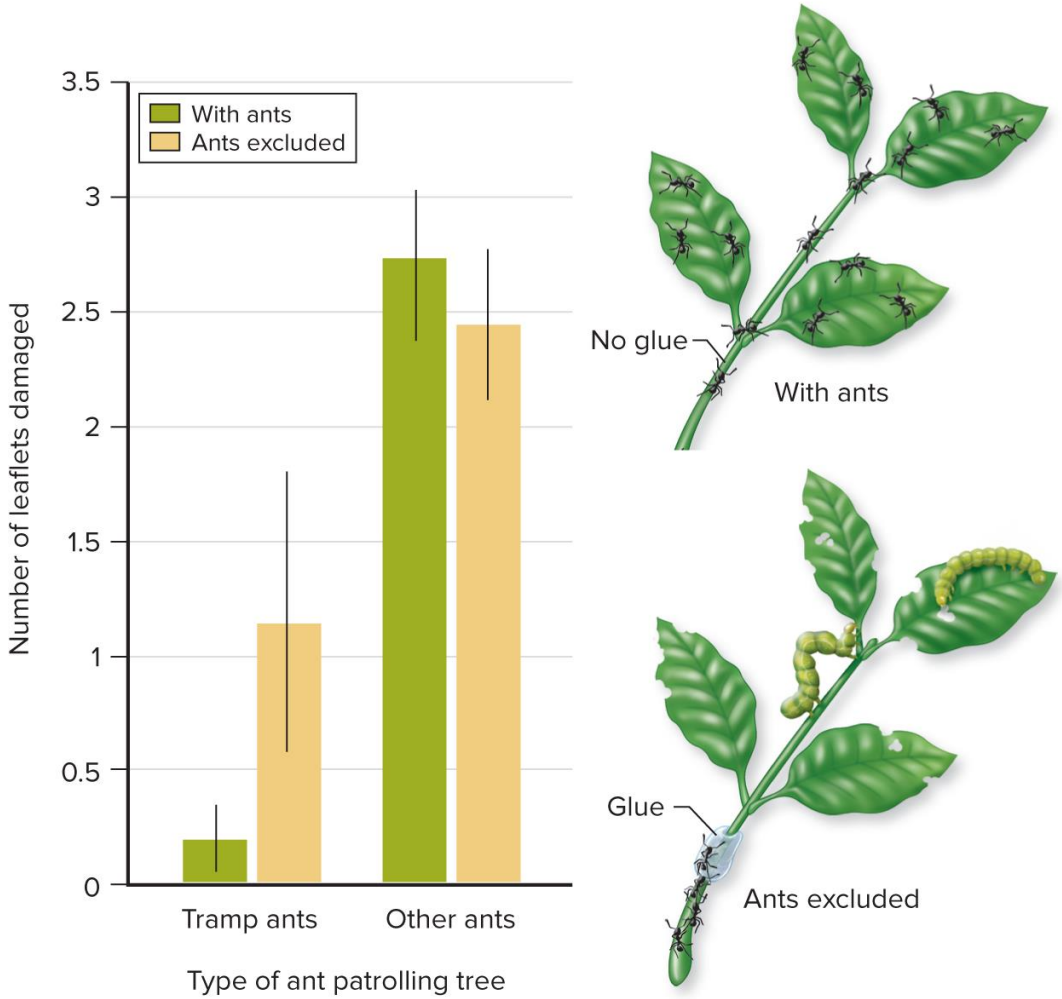
Section 22.5

Figure 22.19

The ants protect the tree

How does the tree benefit from the ants' presence?

Protection. Trees with ant residents sustained less damage by intruders than trees without ant residents.



Section 22.5

Figure 22.20