Fig. 35-7a

# Chapter 35

## Plant Structure, Growth, and Development

PowerPoint® Lecture Presentations for

**Biology**

*Eighth Edition*

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Fig. 35-3

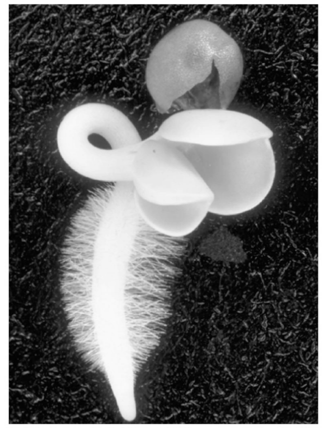




Fig. 35-4

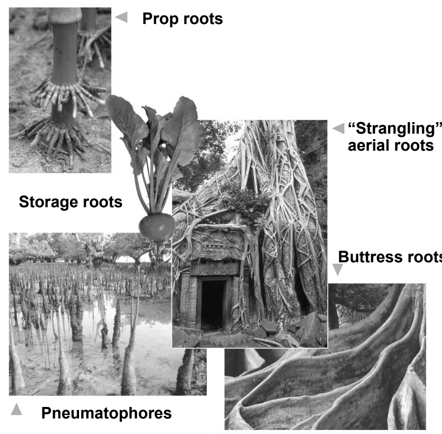
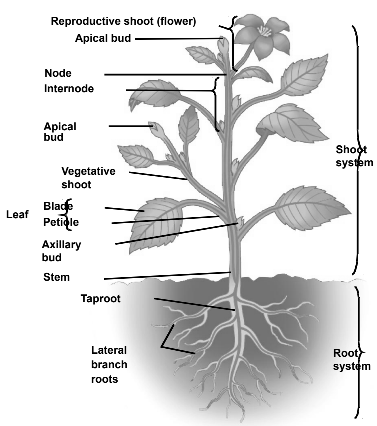





Fig. 35-2






## *Stems*

- A **stem** is an organ consisting of
  - An alternating system of **nodes**, the points at which leaves are attached
  - **Internodes**, the stem segments between nodes

- An **axillary bud** is a structure that has the potential to form a lateral shoot, or branch
- An **apical bud**, or terminal bud, is located near the shoot tip and causes elongation of a young shoot
- **Apical dominance** helps to maintain dormancy in most nonapical buds



## *Leaves*

- The **leaf** is the main photosynthetic organ of most vascular plants
- Leaves generally consist of a flattened **blade** and a stalk called the **petiole**, which joins the leaf to a node of the stem



- Many plants have modified stems



- Monocots and eudicots differ in the arrangement of **veins**, the vascular tissue of leaves
  - Most monocots have parallel veins
  - Most eudicots have branching veins
- In classifying angiosperms, taxonomists may use leaf morphology as a criterion



Fig. 35-5

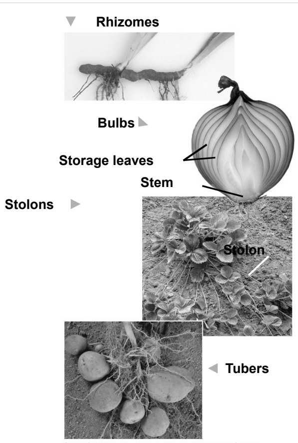
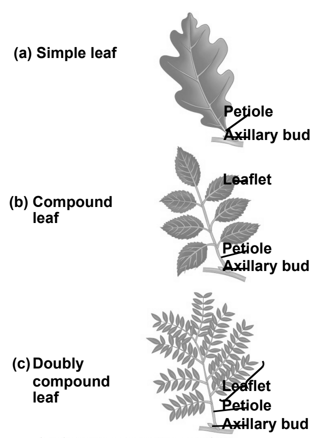



Fig. 35-6



- Some plant species have evolved modified leaves that serve various functions



Fig. 35-8

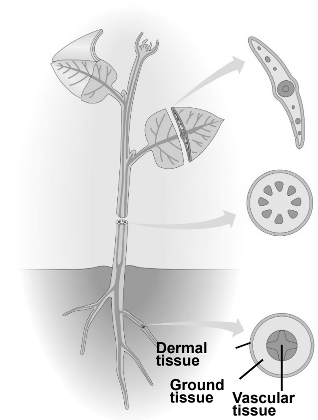
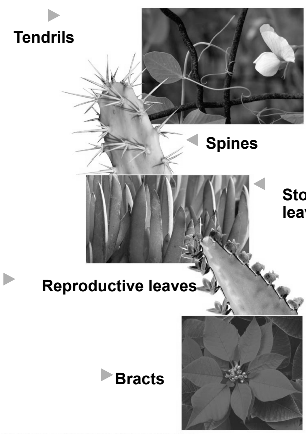



Fig. 35-7




- In nonwoody plants, the **dermal tissue system** consists of the **epidermis**
- A waxy coating called the **cuticle** helps prevent water loss from the epidermis
- In woody plants, protective tissues called **periderm** replace the epidermis in older regions of stems and roots
- *Trichomes* are outgrowths of the shoot epidermis and can help with insect defense



## Dermal, Vascular, and Ground Tissues

- Each plant organ has dermal, vascular, and ground tissues
- Each of these three categories forms a **tissue system**



- The **vascular tissue system** carries out long-distance transport of materials between roots and shoots
- The two vascular tissues are xylem and phloem
- **Xylem** conveys water and dissolved minerals upward from roots into the shoots
- **Phloem** transports organic nutrients from where they are made to where they are needed

- The vascular tissue of a stem or root is collectively called the **stele**
- In angiosperms the stele of the root is a solid central *vascular cylinder*
- The stele of stems and leaves is divided into *vascular bundles*, strands of xylem and phloem



- Some major types of plant cells:
  - Parenchyma
  - Collenchyma
  - Sclerenchyma
  - Water-conducting cells of the xylem
  - Sugar-conducting cells of the phloem



- Tissues that are neither dermal nor vascular are the **ground tissue system**
- Ground tissue internal to the vascular tissue is **pith**; ground tissue external to the vascular tissue is **cortex**
- Ground tissue includes cells specialized for storage, photosynthesis, and support



**Parenchyma Cells**

- Mature **parenchyma cells**
  - Have thin and flexible primary walls
  - Lack secondary walls
  - Are the least specialized
  - Perform the most metabolic functions
  - Retain the ability to divide and differentiate



## Common Types of Plant Cells

- Like any multicellular organism, a plant is characterized by cellular differentiation, the specialization of cells in structure and function



Fig. 35-10a

**Parenchyma cells in *Elodea* leaf, with chloroplasts (LM)** **60 µm**

## Collenchyma Cells

- **Collenchyma cells** are grouped in strands and help support young parts of the plant shoot
- They have thicker and uneven cell walls
- They lack secondary walls
- These cells provide flexible support without restraining growth



Fig. 35-10c

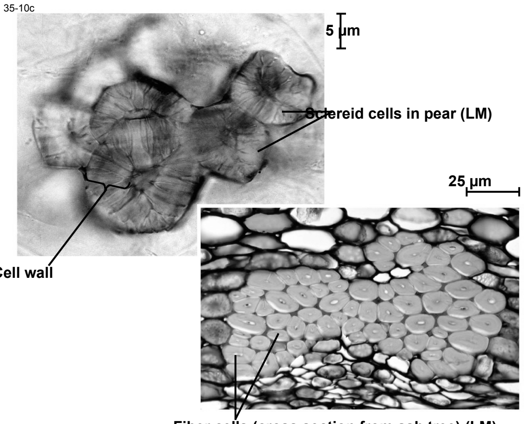
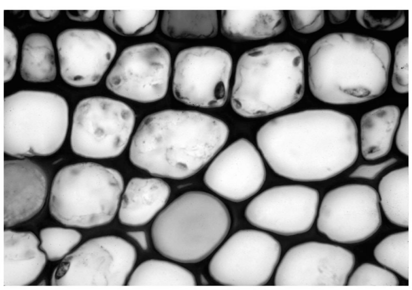




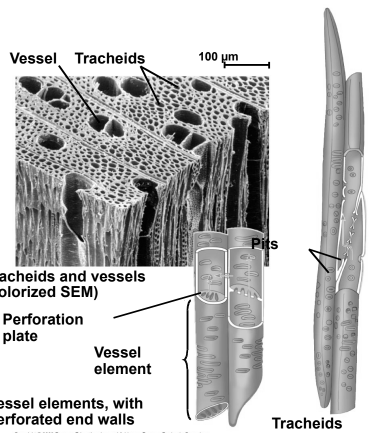

Fig. 35-10b




Collenchyma cells (in *Helianthus* stem) (LM)



Fig. 35-10d






## Sclerenchyma Cells

- **Sclerenchyma cells** are rigid because of thick secondary walls strengthened with lignin
- They are dead at functional maturity
- There are two types:
  - **Sclereids** are short and irregular in shape and have thick lignified secondary walls
  - **Fibers** are long and slender and arranged in threads



## Water-Conducting Cells of the Xylem

- The two types of water-conducting cells, **tracheids** and **vessel elements**, are dead at maturity
- Tracheids are found in the xylem of all vascular plants

- Vessel elements are common to most angiosperms and a few gymnosperms
- Vessel elements align end to end to form long micropipes called **vessels**



Fig. 35-10e2

**Sieve-tube elements: longitudinal view (LM)**

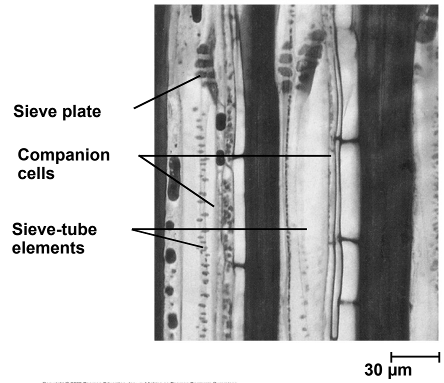





Fig. 35-10e

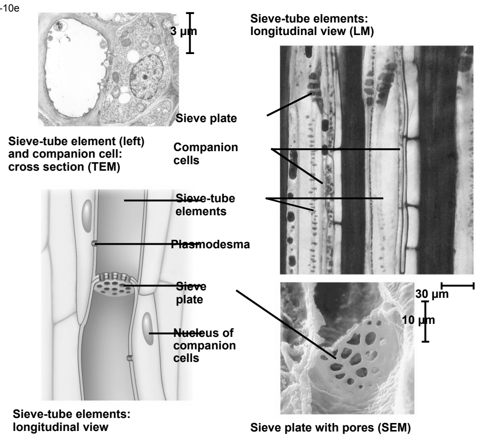
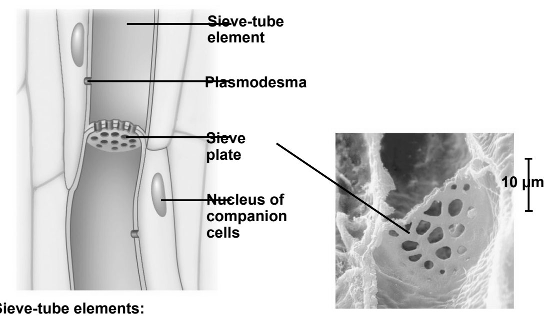





Fig. 35-10e3




Sieve-tube elements: longitudinal view

Sieve plate with pores (SEM)



### Sugar-Conducting Cells of the Phloem

- **Sieve-tube elements** are alive at functional maturity, though they lack organelles
- **Sieve plates** are the porous end walls that allow fluid to flow between cells along the sieve tube
- Each sieve-tube element has a **companion cell** whose nucleus and ribosomes serve both cells



- **Meristems** are perpetually embryonic tissue and allow for indeterminate growth
- **Apical meristems** are located at the tips of roots and shoots and at the axillary buds of shoots
- Apical meristems elongate shoots and roots, a process called **primary growth**

- **Lateral meristems** add thickness to woody plants, a process called **secondary growth**
- There are two lateral meristems: the vascular cambium and the cork cambium
- The **vascular cambium** adds layers of vascular tissue called secondary xylem (wood) and secondary phloem
- The **cork cambium** replaces the epidermis with periderm, which is thicker and tougher



- The primary growth of roots produces the epidermis, ground tissue, and vascular tissue
- In most roots, the stele is a vascular cylinder
- The ground tissue fills the cortex, the region between the vascular cylinder and epidermis
- The innermost layer of the cortex is called the **endodermis**



## Concept 35.3: Primary growth lengthens roots and shoots

- Primary growth produces the **primary plant body**, the parts of the root and shoot systems produced by apical meristems



- Lateral roots arise from within the **pericycle**, the outermost cell layer in the vascular cylinder



## Primary Growth of Roots

- The root tip is covered by a **root cap**, which protects the apical meristem as the root pushes through soil
- Growth occurs just behind the root tip, in three zones of cells:
  - Zone of cell division
  - Zone of elongation
  - Zone of maturation



Fig. 35-15-1

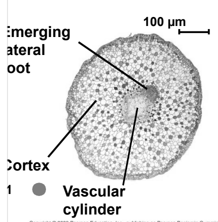


Fig. 35-15-2

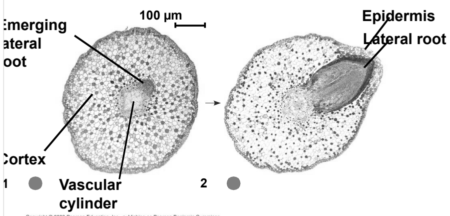
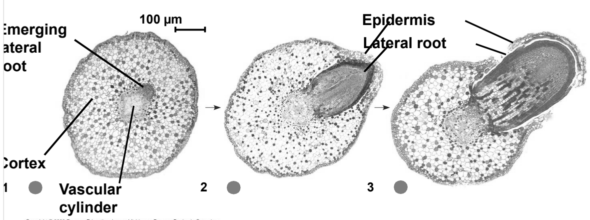





Fig. 35-15-3



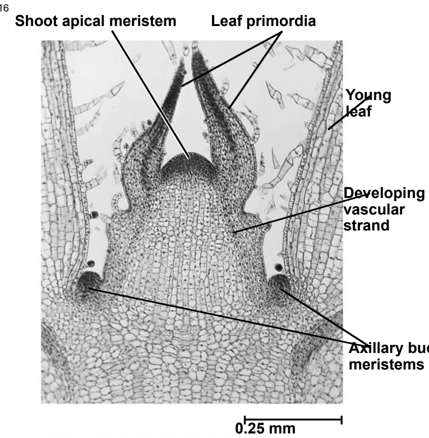



## Primary Growth of Shoots

- A shoot apical meristem is a dome-shaped mass of dividing cells at the shoot tip
- Leaves develop from **leaf primordia** along the sides of the apical meristem
- Axillary buds develop from meristematic cells left at the bases of leaf primordia



Fig. 35-16



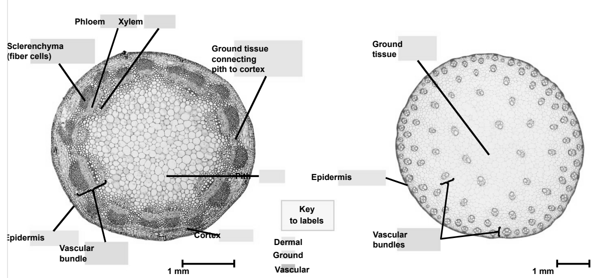



## *Tissue Organization of Stems*

- Lateral shoots develop from axillary buds on the stem's surface
- In most eudicots, the vascular tissue consists of vascular bundles that are arranged in a ring



Fig. 35-17



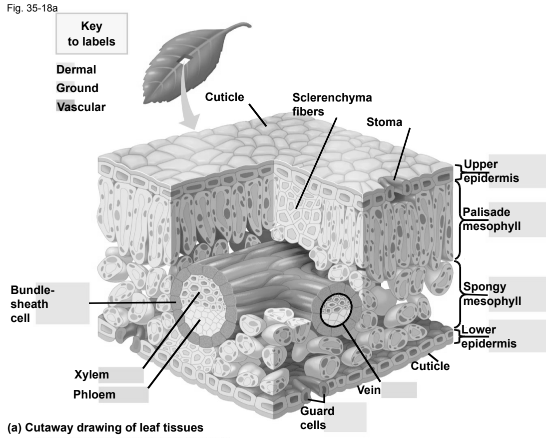

(a) Cross section of stem with vascular bundles forming a ring (typical of eudicots)

(b) Cross section of stem with scattered vascular bundles (typical of monocots)

- In most monocot stems, the vascular bundles are scattered throughout the ground tissue, rather than forming a ring



Fig. 35-18a




(a) Cutaway drawing of leaf tissues

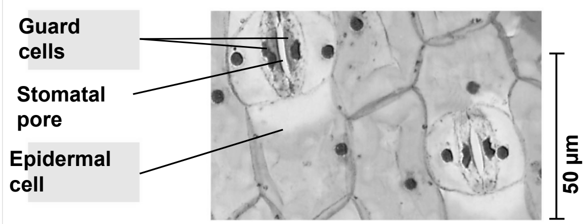


## *Tissue Organization of Leaves*

- The epidermis in leaves is interrupted by **stomata**, which allow $CO_2$ exchange between the air and the photosynthetic cells in a leaf
- Each stomatal pore is flanked by two **guard cells**, which regulate its opening and closing
- The ground tissue in a leaf, called **mesophyll**, is sandwiched between the upper and lower epidermis



Fig. 35-18b




(b) Surface view of a spiderwort (*Tradescantia*) leaf (LM)

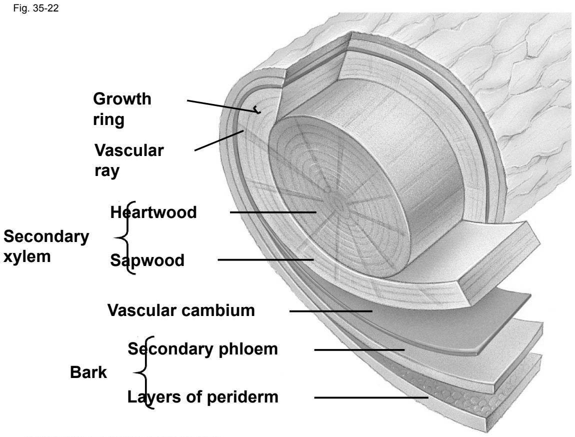


- Below the *palisade mesophyll* in the upper part of the leaf is loosely arranged *spongy mesophyll*, where gas exchange occurs
- The vascular tissue of each leaf is continuous with the vascular tissue of the stem
- Veins are the leaf's vascular bundles and function as the leaf's skeleton
- Each vein in a leaf is enclosed by a protective bundle sheath



- As a tree or woody shrub ages, the older layers of secondary xylem, the *heartwood*, no longer transport water and minerals
- The outer layers, known as *sapwood*, still transport materials through the xylem
- Older secondary phloem sloughs off and does not accumulate

Fig. 35-22






## Molecular Biology: Revolutionizing the Study of Plants

- New techniques and model systems are catalyzing explosive progress in our understanding of plants
- *Arabidopsis* is a model organism, and the first plant to have its entire genome sequenced
- Studying the genes and biochemical pathways of *Arabidopsis* will provide insights into plant development, a major goal of systems biology

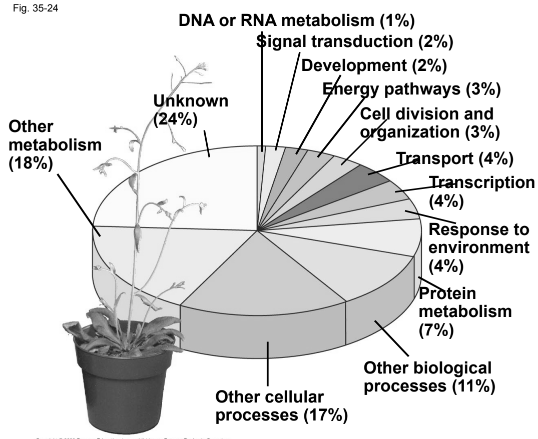


## The Cork Cambium and the Production of Periderm

- The cork cambium gives rise to the secondary plant body's protective covering, or periderm
- Periderm consists of the cork cambium plus the layers of cork cells it produces
- **Bark** consists of all the tissues external to the vascular cambium, including secondary phloem and periderm
- **Lenticels** in the periderm allow for gas exchange between living stem or root cells and the outside air



Fig. 35-24






## Concept 35.5: Growth, morphogenesis, and differentiation produce the plant body

- **Morphogenesis** is the development of body form and organization
- The three developmental processes of growth, morphogenesis, and cellular differentiation act in concert to transform the fertilized egg into a plant



## Growth: Cell Division and Cell Expansion

- By increasing cell number, cell division in meristems increases the potential for growth
- Cell expansion accounts for the actual increase in plant size

### *The Plane and Symmetry of Cell Division*

- The plane (direction) and symmetry of cell division are immensely important in determining plant form
- If the planes of division are parallel to the plane of the first division, a single file of cells is produced



### *Orientation of Cell Expansion*

- Plant cells grow rapidly and “cheaply” by intake and storage of water in vacuoles
- Plant cells expand primarily along the plant’s main axis
- Cellulose microfibrils in the cell wall restrict the direction of cell elongation



Fig. 35-25

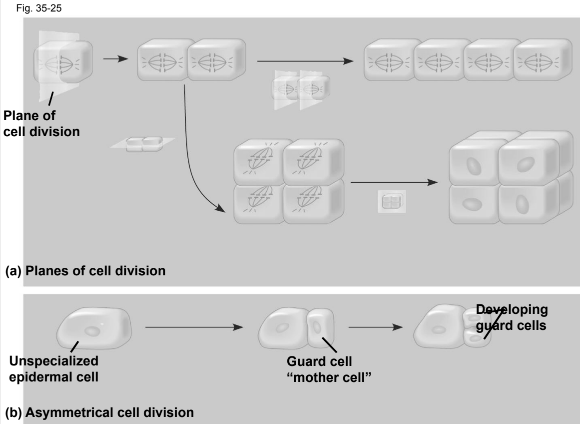
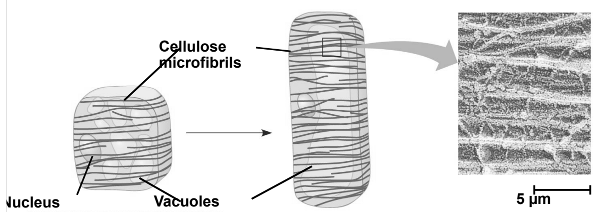



Fig. 35-27




- If the planes of division vary randomly, asymmetrical cell division occurs



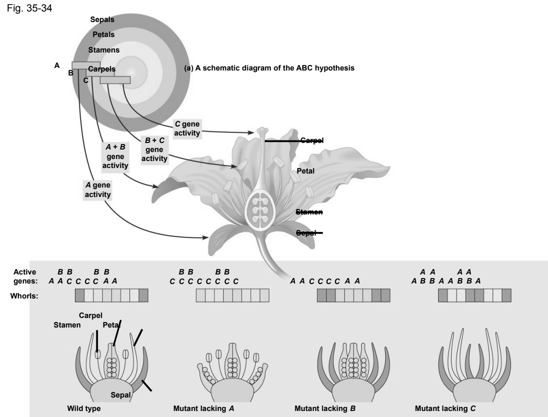
### Morphogenesis and Pattern Formation

- **Pattern formation** is the development of specific structures in specific locations
- It is determined by **positional information** in the form of signals indicating to each cell its location
- Positional information may be provided by gradients of molecules
- **Polarity**, having structural or chemical differences at opposite ends of an organism, provides one type of positional information

- Plant biologists have identified several **organ identity genes** (plant homeotic genes) that regulate the development of floral pattern
- A mutation in a plant organ identity gene can cause abnormal floral development



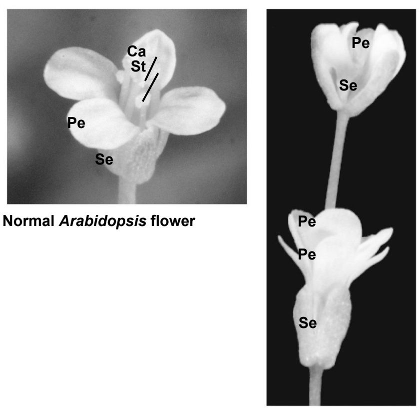
Fig. 35-34




(b) Side view of flowers with organ identity mutations



Fig. 35-33




(a) Normal *Arabidopsis* flower

(b) Abnormal *Arabidopsis* flower



- Researchers have identified three classes of floral organ identity genes
- The **ABC model** of flower formation identifies how floral organ identity genes direct the formation of the four types of floral organs
- An understanding of mutants of the organ identity genes depicts how this model accounts for floral phenotypes