Plant Organs: Stems

Chapter 7
LEARNING OBJECTIVE 1

- Describe three functions of stems
Stem Functions

• **Support**
  - leaves and reproductive structures

• **Conduct**
  - water, dissolved minerals, carbohydrates

• **Produce new living tissues**
  - at apical meristems
  - at lateral meristems (secondary growth)
Variation in Stems

(a) Morning glory (*Ipomoea purpurea*), with its trailing, twining stem, is often grown to cover a fence or trellis.

(b) The massive trunks of baobab (*Adansonia*) trees are adapted to store water and starch. The tree produces leaves only during the rainy season. Photographed in Madagascar.
LEARNING OBJECTIVE 2

• Relate the functions of each tissue in an herbaceous stem
Tissues in Herbaceous Stems 1

• **Epidermis**
  - protective outer layer
  - covered by water-conserving **cuticle**

• **Vascular tissues**
  - **Xylem** conducts water and dissolved minerals
  - **phloem** conducts dissolved carbohydrates (sucrose)
Tissues in Herbaceous Stems 2

- Storage tissues
  - Cortex and pith
  - ground tissue
LEARNING OBJECTIVE 3

• Contrast the structures of an herbaceous eudicot stem and a monocot stem
Herbaceous Eudicot Stems

- Have **vascular bundles** arranged in a circle (in cross section)

- Have a distinct cortex and pith
Monocot Stems

- Have scattered **vascular bundles**
- Have ground tissue instead of distinct cortex and pith
Monocot Stems

(a) Cross section of a corn (Zea mays) stem, showing the scattered vascular bundles.

(b) Close-up of a vascular bundle. The air space is where the first xylem elements formed. The entire bundle is enclosed in a bundle sheath of sclerenchyma for additional support.

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Epidermis

Ground tissue

Vascular bundles

(a) Cross section of a corn (Zea mays) stem, showing the scattered vascular bundles.

(b) Close-up of a vascular bundle. The air space is where the first xylem elements formed. The entire bundle is enclosed in a bundle sheath of sclerenchyma for additional support.

Fig. 7-4, p. 134
LEARNING OBJECTIVE 4

• Distinguish between the structures of stems and roots
Differences Between Stems and Roots 1

- Unlike roots, stems have **nodes** and **internodes**, **leaves**, and **buds**

- Unlike stems, roots have **root caps** and **root hairs**
KEY TERMS

• NODE
  • Area on a stem where one or more leaves is attached; stems have nodes, but roots do not

• INTERNODE
  • Stem area between two successive nodes
KEY TERMS

• **BUD**
  - An undeveloped shoot that contains an embryonic meristem
  - May be terminal (at tip of stem) or axillary (on side of stem)
A Woody Twig
Bud scale

Terminal bud

One year’s growth

Terminal bud scale scars

Axillary bud

Leaf scar

Node

Internode

Node

Lenticels

Terminal bud scale scars

Bundle scars

Fig. 7-2, p. 131
Differences Between Stems and Roots 2

• Internally
  • herbaceous roots possess an endodermis and pericycle
  • stems lack a pericycle and rarely have an endodermis
## Differences Between Stems and Roots

<table>
<thead>
<tr>
<th>TABLE 7-1</th>
<th>General Differences between Herbaceous Eudicot Roots and Stems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ROOTS</strong></td>
<td><strong>STEMS</strong></td>
</tr>
<tr>
<td>No nodes or internodes</td>
<td>Nodes and internodes</td>
</tr>
<tr>
<td>No leaves or buds</td>
<td>Leaves and buds</td>
</tr>
<tr>
<td>Nonphotosynthetic</td>
<td>Photosynthetic</td>
</tr>
<tr>
<td>No pith</td>
<td>Pith</td>
</tr>
<tr>
<td>No cuticle</td>
<td>Cuticle</td>
</tr>
<tr>
<td>Root cap</td>
<td>No cap</td>
</tr>
<tr>
<td>Root hairs</td>
<td>Trichomes</td>
</tr>
<tr>
<td>Pericycle</td>
<td>No pericycle</td>
</tr>
<tr>
<td>Endodermis</td>
<td>Endodermis rare</td>
</tr>
<tr>
<td>Branches form internally from the pericycle</td>
<td>Branches form externally from lateral buds</td>
</tr>
</tbody>
</table>

*Note: Some exceptions to these general differences exist.*
LEARNING OBJECTIVE 5

- Outline the transition from primary growth to secondary growth in a woody stem

- List the two lateral meristems, and describe the tissues that arise from each
Primary Growth: Eudicot

(a) Cross section of a sunflower (**Helianthus annuus**) stem, showing the organization of tissues. The vascular bundles are arranged in a circle.

(b) Close-up of a vascular bundle. The xylem is toward the stem’s interior, and the phloem toward the outside. Each vascular bundle is “capped” by a batch of fibers for additional support.
(a) Cross section of a sunflower (Helianthus annuus) stem, showing the organization of tissues. The vascular bundles are arranged in a circle.

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Fig. 7-3, p. 132
KEY TERMS

- VASCULAR CAMBIUM
  - A lateral meristem that produces secondary xylem (wood) to the inside and secondary phloem (inner bark) to the outside
Secondary Growth

- Occurs in woody eudicots and conifers
- Produced by **vascular cambium**
  - between primary xylem and primary phloem
Vascular Cambium 1

- Is not initially a solid cylinder of cells
  - becomes continuous when production of secondary tissues begins
Vascular Cambium 2

- Certain parenchyma cells between vascular bundles
  - retain ability to divide
  - connect to vascular cambium cells in each vascular bundle
  - form a complete ring of vascular cambium
Dividing Vascular Cambium

Second division of vascular cambium forms a phloem cell.

Division of vascular cambium forms two cells, one xylem cell and one vascular cambium cell.

Vascular cambium cell when secondary growth begins.
Time

Secondary xylem
Secondary phloem
Second division of vascular cambium forms a phloem cell.
Division of vascular cambium forms two cells, one xylem cell and one vascular cambium cell.
Vascular cambium cell when secondary growth begins.

Fig. 7-6, p. 136
KEY TERMS

• CORK CAMBIUM
  • A lateral meristem that produces cork parenchyma to the inside and cork cells to the outside
  • Cork cambium and the tissues it produces make up the outer bark of a woody plant
Cork Cambium

- Arises near the stem’s surface

- Is either a continuous cylinder of dividing cells or a series of overlapping arcs of meristematic cells that form from parenchyma cells in successively deeper layers of the cortex and, eventually, secondary phloem
Development: Woody Eudicot

(a) At the onset of secondary growth, vascular cambium arises in the parenchyma between the vascular bundles (that is, in the pith rays), forming a cylinder of meristematic tissue (*blue circle in cross section*).

(b) Vascular cambium begins to divide, forming secondary xylem on the inside and secondary phloem on the outside.

(c) A young woody stem. Vascular cambium produces more secondary xylem than secondary phloem.
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(c) A young woody stem. Vascular cambium produces more secondary xylem than secondary phloem.
3-Year-Old Stem

(a) LM of cross section of basswood (*Tilia americana*) stem. Note the location of the vascular cambium between the secondary xylem (wood) and secondary phloem (inner bark).

(b) Sketch of a pie-shaped segment of the cross section. The primary phloem is not labeled because it is crushed beyond recognition.
(a) LM of cross section of basswood (Tilia americana) stem. Note the location of the vascular cambium between the secondary xylem (wood) and secondary phloem (inner bark).

(b) Sketch of a pie-shaped segment of the cross section. The primary phloem is not labeled because it is crushed beyond recognition.
Cross section of twig

Vascular cambium

Cortex
Phloem fiber cap
Primary phloem
Secondary phloem
Vascular cambium
Secondary xylem
Primary xylem
Pith

Fig. 7-8, p. 138
Variation in Bark

(a) Bur oak (*Quercus macrocarpa*) bark is deeply fissured.

(b) Shagbark hickory (*Carya ovata*) has a rough, “shaggy” bark.

(c) Bark from Norway pine (*Pinus resinosa*) is scaly.

(d) Paper birch (*Betula papyrifera*) has a peeling bark.
Lenticels
Lenticel

Cork cells
Cork cambium and cork parenchyma (phelloderm)

Calico flower

Fig. 7-10, p. 141
Heartwood and Sapwood
Tree-Ring Dating

- **Tilia** (basswood)
  - Long, slender core of wood extracted by a boring tool

- **Annual rings**
- **Pith**
- **Bark**
- **Vascular cambium**

- **Sample from a living tree**
- **1950**: Outermost ring is the year when the tree was cut.
- **1940**, **1932**: Sample from a dead tree in the same forest.

- **Matching and overlapping older and older wood sections extends dates back in time**
  - **1931**, **1926**: Sample from an old building in the same area as the forest.
Tilia (basswood)

Long, slender core of wood extracted by a boring tool

Outer bark

Vascular cambium

Annual rings

Pith

Sample from a living tree

1950

1940 1932

Outermost ring is the year when the tree was cut.

Sample from a dead tree in the same forest

1940 1932

1931 1926

Matching and overlapping older and older wood sections extends dates back in time

Sample from an old building in the same area as the forest

1931 1926

1920 1918

1926 1920 1918

1932 1940

1950

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Annual Rings

Cross section of 3-year-old *Tilia* stem

Secondary phloem
Vascular cambium
Late summerwood
Annual ring of xylem
Springwood
Late summerwood of preceding year
Cross section of a 3-year-old *Tilia* stem:

- Secondary phloem
- Vascular cambium
- Late summerwood
- Annual ring of xylem
- Springwood
- Late summerwood of preceding year

Fig. 7-12, p. 144
Sections

(a) Cross section

(b) Tangential section

(c) Radial section

Annual rings
Rays

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(a) Cross section

(b) Tangential section

(c) Radial section

Fig. 7-13, p. 144
KEY TERMS

• DEFORESTATION
  - The temporary or permanent clearance of large expanses of forests for agriculture or other uses
KEY TERMS

• VINE
  • A plant with a long, thin, often climbing stem
LEARNING OBJECTIVE 6

• Contrast the various stems that are specialized for asexual reproduction
KEY TERMS

• RHIZOME
  - A horizontal underground stem that often serves as a storage organ and a means of sexual reproduction
  - Example: iris
A Rhizome

Rhizome

Adventitious roots
Adventitious roots
Rhizome
Adventitious roots
KEY TERMS

• TUBER
  • The thickened end of a rhizome that is fleshy and enlarged for food storage
  • Example: white potato
A Tuber

Diagram of a plant showing a rhizome, tubers, and roots.
KEY TERMS

• BULB
  • A rounded, fleshy underground bud that consists of a short stem with fleshy leaves
  • *Example*: onion
A Bulb

- Bulb
- Fleshy leaves
- Stem
- Adventitious roots

(c)
**KEY TERMS**

- **CORM**
  - A short, thickened underground stem specialized for food storage and asexual reproduction
  - *Example: crocus*
(d) Corm

- Axillary bud
- Leaf Scars
- Corm (modified stem)
- Old corm (last year's)
- Adventitious roots
Adventitious roots

Old corm (last year’s)

Corm (modified stem)

Old corm (last year’s)

Axillary bud

Leaf scars

Adventitious roots

Fig. 7-14d, p. 147
KEY TERMS

• STOLON
  - An aerial horizontal stem with long internodes; often forms buds that develop into separate plants
  - *Example:* strawberry
Stolons

New shoot

Scale leaf (at node)

Adventitious roots

Stolon (runner)

(e)
New shoot

Scale leaf (at node)

Adventitious roots

Stolon (runner)