

# Garden Terms: Vegetative plant morphology — Stems, leaves, and roots

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## Stems

Stems are used to carry water and nutrients throughout the plant. They also provide the above-ground framework for the plant.

### Internal Stem Characteristics

**Vascular plant systems** contain four major internal parts: the xylem, phloem, cambium, and pith. Monocot vascular systems are arranged in paired bundles. These bundles are dispersed throughout the stem. Dicot

vascular systems are arranged in continuous rings around the inside of the stem (*Figure 1*).

**Xylem** tissues are water and nutrient conducting channels in plants. In woody plants, the xylem makes annual rings. These rings may provide information about the plant's age and the environmental conditions it has experienced. Narrow xylem rings may indicate drought conditions, while wider rings may indicate more desirable growing conditions.

**Phloem** tissues are food-conducting channels in plants. These tissues transport sugars, from photosynthesis, throughout the plant. In woody

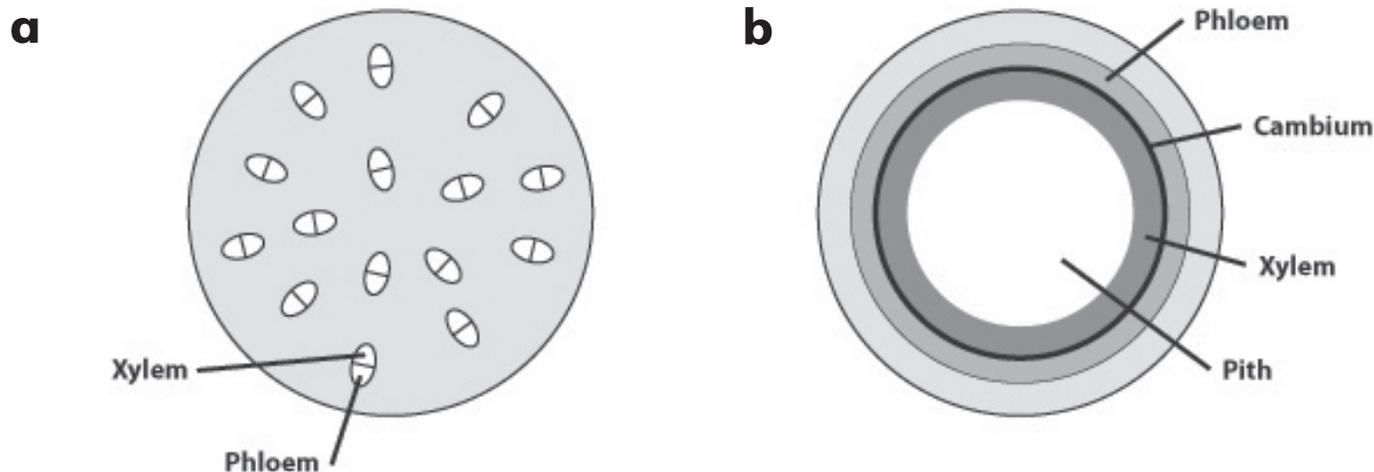


Figure 1. Flowering plants (angiosperms) are classified as either monocotyledons (monocots) or dicotyledons (dicots). Along with other morphological differences, the vascular system of each is significantly different. The vascular systems of monocots are arranged in paired bundles (a), while the vascular systems of dicots are arranged in continuous rings (b).



**Figure 2.** Leaf scars vary in size and shape and are valuable identification characteristics during the winter months. Leaf scars also may be helpful in distinguishing plants of the same genus, such as white ash (a) with a horseshoe or “C” shaped leaf scar and green ash (b) with a flat or “D” shaped leaf scar.

plants, the phloem ring is near the bark and is a component of the bark in mature stems.

**Cambium** is meristematic tissue, which is a site of cell division and active growth. It is a single celled layer located between the xylem and phloem. It produces both xylem and phloem tissue. Cell division in the cambium layer is responsible for the annual increased diameter of healthy growing woody plant stems.

**Pith** refers to the center portion of a stem. Piths may be hollow, solid, chambered or colored. These characteristics can be helpful in plant identification.

### External Stem Characteristics

**Leaf and bundle sheath scars** are marks left on the stem where a leaf was previously attached (*Figure 2*). These scars vary in size, shape and color, and are often used in plant identification when plants are dormant.

**Buds** are the stem’s primary growing points. They can be either leaf buds (vegetative) or floral (reproductive) buds. Leaf buds are often less plump and more pointed than flower buds. The buds of trees and shrubs of the temperate zone typically develop a protective outer layer of small, leathery bud scales. Annual plants and herbaceous perennials have naked buds in which the outer scales are green and somewhat succulent. Buds are commonly used in plant identification.

**Terminal buds** are located at the tip of a stem (*Figure 3*). When terminal buds are removed (called pinching when done on herbaceous plants), plants will develop a denser and typically wider growth habit.

**Lateral buds** are borne on the sides of the stem.

**Adventitious buds** arise at sites other than in the terminal or lateral position. Adventitious buds may develop from the internode of the stem, at the edge of a leaf blade, from callus tissue at the cut end of a stem or root, or laterally from the roots of plants.



**Figure 3.** Terminal buds may be single (a), as seen in many plants; double (b), commonly seen in lilac; or clustered (c), commonly seen in oak.



**Figure 4.** Some plants have distinct lenticels that are valuable for identification, such as callery pear (a), with distinct horizontal white lines; and forsythia (b), with raised bumps.

**Terminal bud scars** are marks left around the entire stem at the place where the previous year’s growth ends. Measuring the distance between terminal bud scars is an effective method in determining annual growth rates.

**Lenticels** are pores on stems and bark that allow for gas exchange. Some plants have distinct lenticels that are valuable for identification (Figure 4).

**Bark** is the protective outer layer of the stem that develops with age. Bark is a valued identification characteristic due to its year-round availability. Bark color and texture often vary with plant maturity but can be distinct for many plants (Figure 5).

**Node** is an area of the stem where leaves and lateral buds are located. Nodes are areas of great cellular activity and growth.

**Internode** is the area of stem located between two nodes. Internode lengths may depend on many factors, including fertility levels, environmental conditions, and plant competition.

## Stem Types

**Shoot** refers to the first-year growth on a woody or herbaceous plant. It has leaves present.

**Twig** is a stem that is 1 year old or less and has no leaves. It is still in the winter dormant stage.

**Branch** is a stem that is more than 1 year old and typically has lateral stems.

**Trunk** is the main stem of a woody plant. Most large shade trees have a single trunk, but many smaller ornamental trees, such as birch, serviceberry, and Japanese tree lilac, typically have a multi-trunk habit.

**Water sprouts** are adventitious shoots that arise from branches. They grow rapidly and typically have upright growth orientation and a weak structure and attachment to the branch.

**Suckers** are adventitious shoots that arise from the base of the plant. They grow rapidly and typically have



**Figure 5.** Bark color and texture often vary with plant maturity but can be distinct for many plants, including white oak (a), and scotch pine (b). White oak bark is light gray with narrow ridges. Scotch pine is orangish brown with a thin papery appearance. Both trees have bark that is distinctive from a distance.



**Figure 6.** Perennial weeds with creeping stems (either rhizomes or stolons), such as white clover, can be difficult to control because the extent of spread can be difficult to determine. When herbicide applications are used, they should be applied slightly beyond the visual edge of the weed spread.

upright growth orientation. Many plants in the *Rosaceae* family sucker. Other plants may sucker as an indication of plant stress.

**Canes** are stems that have relatively large piths and usually live only one or two years. Examples of plants with canes include roses, grapes, blackberries, and raspberries.

## Modified Stems

**Crown** is a region of compressed stem tissue from which new shoots are produced, generally found near the surface of the soil.

**Stolon (runner)** is a specialized stem that grows horizontally above the soil surface and forms a new plant at one or more of its nodes. Examples include strawberry, buffalograss, and ajuga (*Figure 6*).

**Rhizome** is a specialized stem that grows horizontally below the soil surface and acts as a storage organ and means of propagation in some plants. Some rhizomes are compressed and fleshy, such as iris; others are slender with elongated internodes such as Kentucky bluegrass.

**Tuber** is an enlarged portion of an underground stem that stores food for the plant. An example is potato.

**Tuberous stems** are short, flat, and enlarged stems found underground. Examples include tuberous begonia and cyclamen.

**Corm** is a compressed stem with reduced scaly leaves. An example is gladiolus.

**Bulb** is a compressed underground stem surrounded by fleshy scales (leaves) that attach at the base. Examples include tulip, lily, daffodil, and onion.

**Spur** is a short, stubby, side stem that arises from the main stem. They are common on fruit trees, such as pears and apples. Spurs typically contain the flower buds and serve as the attachment between the fruit stem and branch.

**Thorns** are modified, sharp-pointed stems that occur in the leaf axil. Examples include buckthorn and honeylocust.

## Leaves

**Leaves** are the principle location for photosynthesis, transpiration, and respiration in plants.

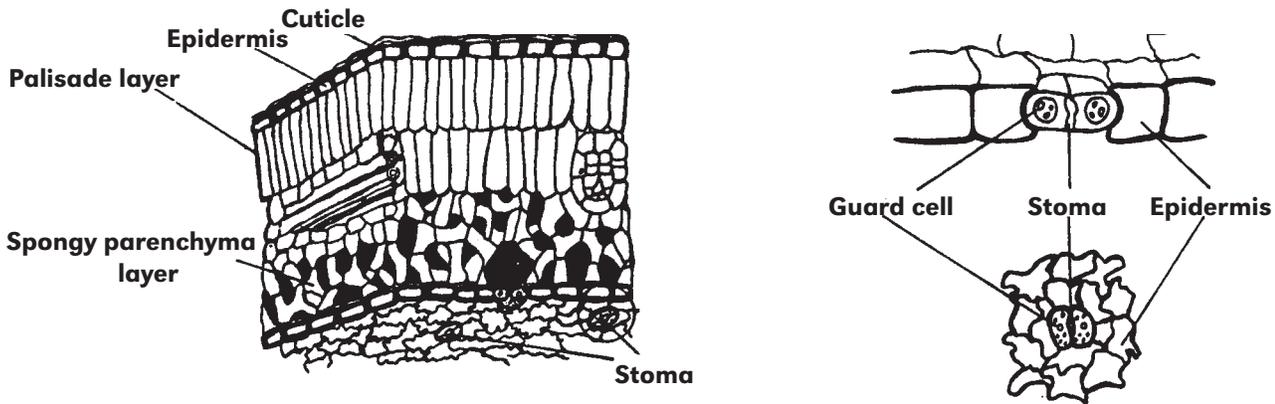


Figure 7. Stomata are microscopic natural openings in the leaf that allow for gas exchange, including water vapor, carbon dioxide, and oxygen. The opening and closing of stomata is controlled by guard cells.

### Internal Leaf Characteristics

**Epidermis** refers to the top and bottom layers of cells on a leaf. The primary function of the epidermis is to protect leaf tissue.

**Cuticle** is the outer layer of the epidermis. It produces a waxy layer called cutin. Cutin protects leaves from dehydration and prevents penetration of some diseases from penetrating. Cuticle thickness is a direct response to sunlight, increasing in proportion to light intensity. For this reason, plants grown in the shade should be moved into full sunlight gradually. This will allow the cuticle layer to thicken to protect the leaves from the shock of rapid water loss or sunscald.

**Stomata** are microscopic natural openings in the leaf that allow for gas exchange, including water vapor, carbon dioxide, and oxygen (Figure 7).

**Guard cells** protect the interior of the leaf and regulate the passage of water, oxygen, and carbon dioxide through the stomata. The opening and closing of guard cells are determined by environmental conditions.

**Mesophyll** is interior leaf tissue that may be divided into a dense upper layer of cells called the palisade and a lower layer of loosely grouped cells called the spongy parenchyma. The cells in these two layers contain chloroplasts, which is the actual site of photosynthesis.

### External Leaf Characteristics

**Blade** refers to the flattened, expanded thin structure on either side of the leaf midrib. Blades are usually the largest and most conspicuous part of the leaf. This surface is used to absorb light energy to be used in photosynthesis (Figure 8).



Figure 8. External leaf characteristics, such as those found on firehorn, *Pyracantha coccinea*, are valuable keys to plant identification.

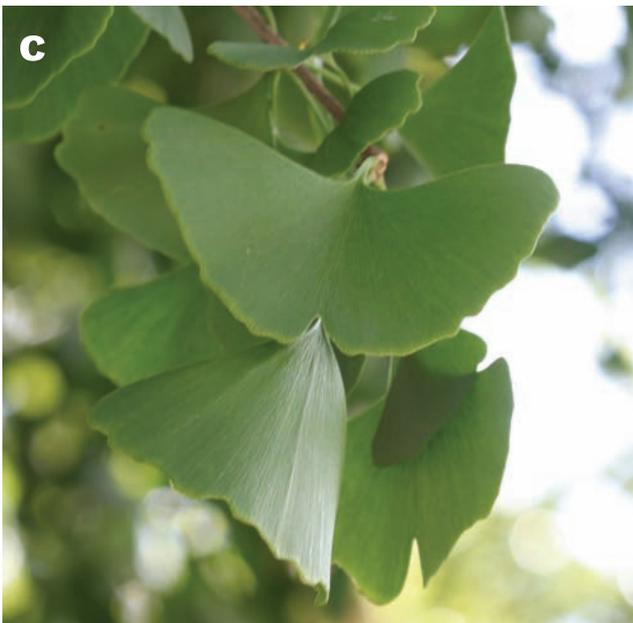


Figure 9. Plants exhibit different types of venation, including pinnate (a), palmate (b), dichotomous (c), and parallel (d).

**Petiole** is the stem-like appendage that supports the leaf away from the stem. It may vary in length or may be lacking entirely in some cases. Cottonwood tree leaves have very long petioles that allow the leaves to characteristically flutter in a gentle breeze; elm leaf petioles are typically measured in fractions of an inch.

**Stipules** are leaf-like appendages at the base of the leaf.

**Shape** refers to the overall form of the leaf. Other leaf characteristics, such as the shape of the leaf apex, base, and margin, are useful in plant identification.

**Veins** are vascular bundles (which contain xylem and phloem) that extend from the stem through the petiole and spread out in the blade. Venation refers to the patterns in which the veins are distributed in the blade (Figure 9).

**Net-veined (reticulate-veined)** leaves have veins which branch from the main rib or ribs and then subdivide into finer veinlets that unite in a complicated network. This system of enmeshed veins gives the leaf more resistance to tearing than parallel-veined leaves. Net-veined leaves occur on plants that are part of the dicotyledon group.

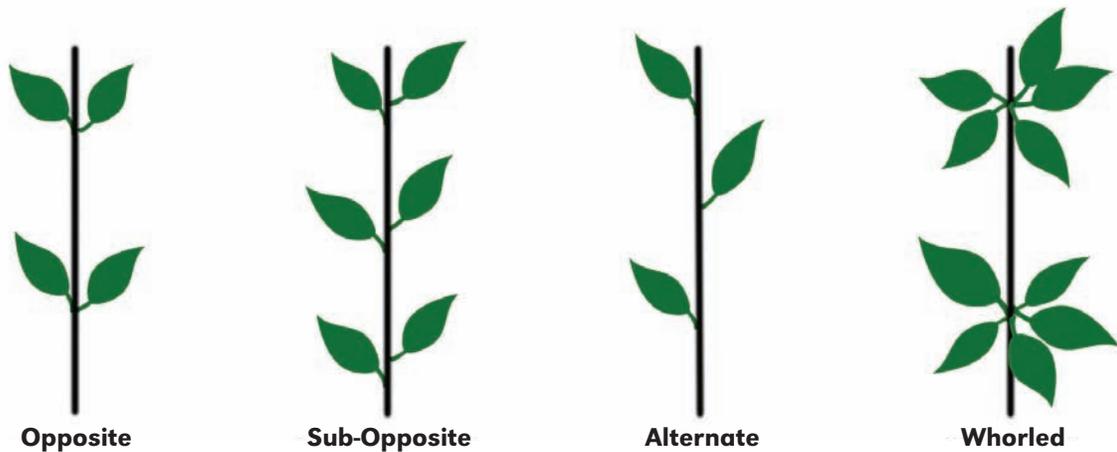


Figure 10. Leaf arrangement is one of the primary characteristics used to help separate plants in vegetative plant keys. Most plants have alternate or opposite leaf arrangement, but sub-opposite, whorled and rosette arrangements are also observed on plants.

**Palmate veined** leaves have principle veins extending outward from one point, usually from near the base of the leaf blade. This type of venation occurs in grape and maple leaves.

**Pinnate veined** leaves have veins extending laterally from the midrib to the edge. This is the most common type of venation among net-veined plants. Pinnate venation is found in common plants such as apple, oak and elm.

**Dichotomous veined** leaves have veins arranged in a unique “Y” shaped formation. This type of venation is only found in ginkgo.

**Parallel veined** leaves have numerous veins that run essentially parallel to each other and are connected laterally by minute straight veinlets. One of the most common types of parallel-veining is found in plants of the grass family (*Poaceae*), where the veins run from the base to the apex of the leaf. Another type of parallel venation is found in as banana, where the parallel veins run laterally from the midrib. Parallel-veined leaves occur on plants that are part of the monocotyledon group.

## Leaf Arrangement

**Opposite** arranged leaves are positioned across the stem from one another, two leaves at each node. Examples of plants with this type of arrangement include maple, ash, dogwood, viburnum, and buckeye (*Figure 10*).

**Sub-opposite** leaves reflect an opposite pattern with a slight offset. An example of a plant with this type of arrangement is European buckthorn.

**Alternate** arranged leaves are positioned in alternate steps along the stem with only one leaf at each node. Examples of plants with this type of arrangement include oak, elm, linden, and cottonwood.

**Whorled** leaves are arranged in a cluster pattern of three or more leaves at a single node. An example of a plant with this type of arrangement is catalpa.

**Rosette** leaves are arranged in a cluster at the base of the stem. Examples of plants with this type of leaf arrangement include dandelion and many biennial plants during the first year of growth.

## Broadleaf Leaf Types

**Simple** leaves are those in which the leaf blade is a single continuous unit (*Figure 11*).

**Compound** leaves are divided and are composed of several separate leaflets. In determining whether a leaf is simple or compound, locate where the petiole attaches to the stem (adjacent to a bud). Leaflets do not have buds associated with them, so all leaf parts, including and beyond the attached petiole, comprise a single leaf.

**Pinnately compound** leaves have leaflets arranged on both sides of the rachis (central leaf stem). An example is white ash.

**Bipinnately compound** leaves have a double set of leaflets. An example is Kentucky coffeetree.

**Palmately compound** leaves have leaflets radiating from a central point. An example is Ohio buckeye.

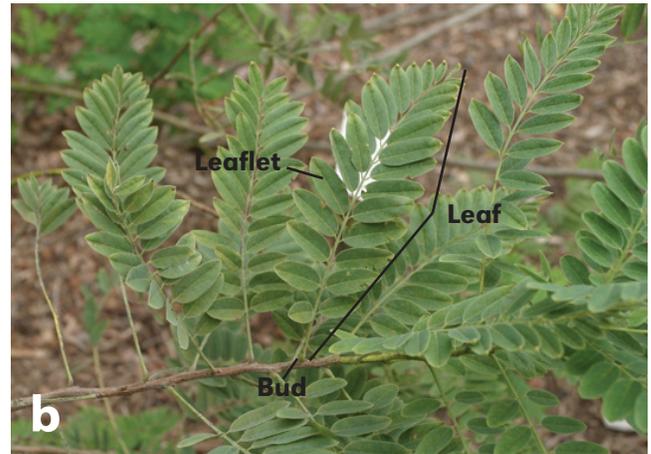
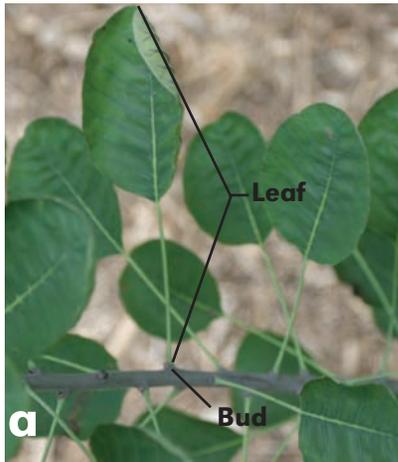


Figure 11. Simple (a) and compound (b) leaves can be differentiated by bud location. Leaflets of a compound leaf do not possess buds.

## Needle-like Leaf Types

**Awl-shaped** leaves are sharp to the touch. Many junipers have awl-shaped leaves.

**Needle-like** leaves can be borne singly (firs, spruces) or in clusters/fascicles (pines).

**Scale-like** leaves have overlapping leaves that are soft to the touch. Examples include arborvitae and many junipers.

## Modified Leaves

**Adhesive discs** are modified leaves used for attaching to surfaces. Boston ivy clings to walls with adhesive discs.

**Bracts** are specialized leaves which are often brightly colored. The showy structures on flowering dogwood and poinsettias are bracts, not petals.

**Spines** are sharp-pointed modified leaves. They are usually located at the base of a leaf. Examples include cactus and barberry.

**Tendrils** are modified leaves that assist in supporting the stem by wrapping around small diameter objects and structures. Woodbine and porcelain vine both produce tendrils for attaching to vertical structures.

## Roots

**Roots** are used to provide support for the stem, to absorb water and nutrients for plant growth, and to store food (Figure 12).

## Internal Root Characteristics

**Meristematic zone** is an area of cell division and growth.

**Root cap** is the outermost tip of the root and consists of cells that are sloughed off as the root grows through the soil. The root cap protects the root meristem, located directly behind the root cap. The root meristem is an area of cell division.

**Zone of elongation** is located behind the meristematic zone. In this area, cells increase in size through food and water absorption. These cells, by increasing in size, push the root through the soil.

**Zone of maturation** is the location where cells undergo changes to become specific tissues.

**Epidermis** cells compose the outer layer of the root. Root hairs are an extension of epidermal cells in the root. These tiny, hair-like structures are responsible for the majority of the nutrient and water absorption from the soil. Root hairs are delicate and can be easily damaged.

**Vascular tissue** is located in the center of the root. These tissues conduct food and water throughout the plant.

## Root Types

**Tap roots** are primary roots that elongate mainly downward into the soil and become the central and most important feature of the root system. Examples include walnut, oak, and carrot. Plants that produce tap roots will also typically develop some fibrous roots to allow oxygen, water, and nutrient uptake near the soil surface.

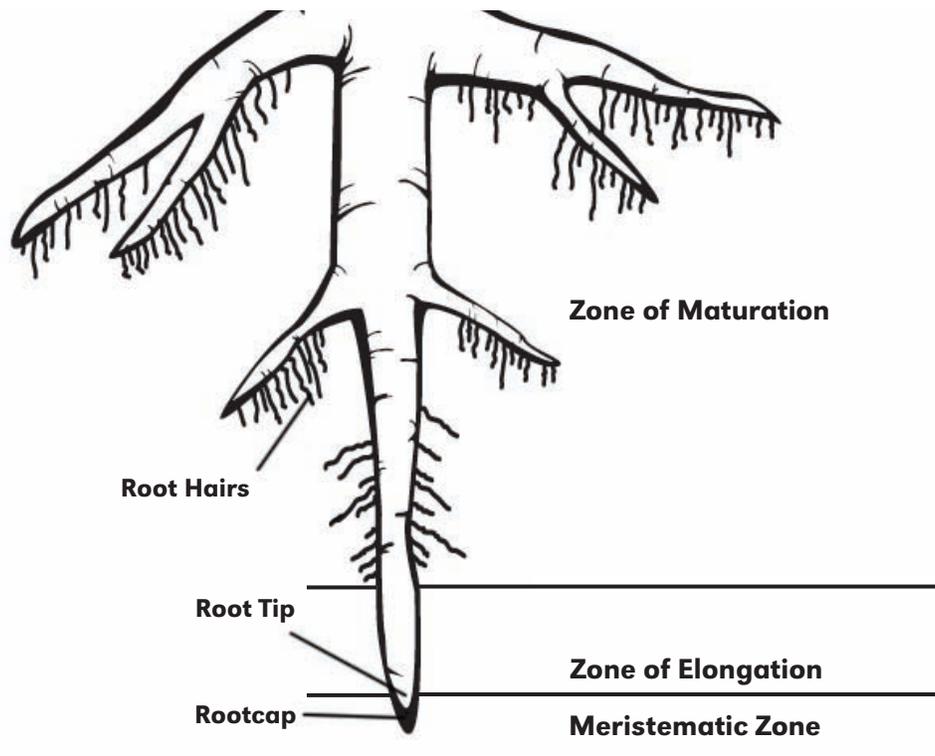


Figure 12. Roots are important for the absorption of water and nutrients for plant growth. Damage to roots, especially the root hairs, during planting or transplanting can hinder plant growth and development.

**Fibrous root** systems have numerous branched roots. The greatest concentration of fibrous roots occurs in the top 18 inches of soil, but significant numbers of lateral roots may grow downward from these roots to provide an effective absorption system in deeper locations. Examples include turfgrasses, most perennial and annual flowers, and many trees and shrubs.

**Adventitious roots** arise from locations where root growth normally does not occur.

**Aerial roots** arise from above-ground stem tissue.

**Tuberous roots** are underground storage organs. They are often confused with tubers, but do not contain stems, so they are classified as roots. Examples include dahlia and sweet potato.

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