**University of Al-Mustansiriyah/ College of Science**

**Course : Botany**

**Lecture: 5**

**TISSUE PATTERNS IN STEMS**

**Steles**

Primary xylem, primary phloem, and the pith, if present, make up a central cylinder called the **stele** in most younger and a few older stems and roots. The simplest form of stele, called **a *protostele****,* consists of a solid core of conducting tissues in which the phloem usually surrounds the xylem. Protosteles were common in primitive seed plants that are now extinct

and are also found in whisk ferns, club mosses , and other relatives of ferns. ***Siphonosteles,***which are tubular with pith in the center, are common in ferns. Most present-day flowering plants and conifers have ***eusteles***in which the primary xylem and primary phloem are in discrete *vascular bundles.* Flowering plants develop from seeds that have either one or two “seed leaves,” called **cotyledons** attached to their embryonic stems . The seeds of pines and other cone-bearing trees have several (usually eight) cotyledons. The cotyledons usually store food needed by the young seedling until its first true leaves can produce food themselves.

Flowering plants that develop from seeds having two cotyledons are called **dicotyledons** (usually abbreviated to **dicots**), while those developing from seeds with a single cotyledon are called **monocotyledons** (abbreviated to **monocots**). Dicots and monocots differ from one another in several other respects, a summary of these and other differences in these two classes of flowering plants is given in Table below.

**Some Differences Between Dicots and Monocots**

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| **DICOTS** | **MONOCOTS** |
| Seed with two cotyledons (seed leaves | Seed with one cotyledon (seed leaf) |
| . Flower parts mostly in fours or fives or multiples of four or five | . Flower parts in threes or multiples of three |
| Leaf with a distinct network of primary veins | . Leaf with more or less parallel primary veins |
| Vascular cambium, and frequently cork cambium, present | Vascular cambium and cork cambium absent |
| Vascular bundles of stem in a ring | Vascular bundles of stem scattered |
| Pollen grains mostly with three apertures (thin areas in the aperture wall—see Figures 23.6 and 23.7) | Pollen grains mostly with one aperture |

**Herbaceous Dicotyledonous Stems**

In general, plants that die after going from seed to maturity within one growing season (**annuals**) have green, herbaceous (nonwoody) stems. Most monocots are annuals, but many dicots (discussed next) are also annuals. The tissues of annual dicots are largely primary, although *cambia* (plural of cambium) may develop some secondary tissues. Herbaceous dicot stems (Fig. 6.5) have discrete **vascular bundles** composed of patches of xylem and phloem. The vascular bundles are arranged in a cylinder that separates the cortex from the pith, although in a few plants (e.g., foxgloves), the xylem and the phloem are produced as continuous rings (cylinders) instead of in separate bundles.

The procambium produces only primary xylem and phloem, but later, a vascular cambium arises between these two primary tissues and adds secondary xylem and phloem to the vascular bundles. In some plants, the cambium extends between the vascular bundles, appearing as a narrow ring, producing not only the conducting tissues within the bundles but also the parenchyma cells between them. In other plants, the cambium is not in an uninterrupted cylinder but is instead confined to the bundles, each of which has its own small band of cambium between the xylem and phloem.



**Figure 6.5** *A.* A cross section of an alfalfa (*Medicago*) stem. 40. The tissue arrangement is typical of herbaceous dicot stems. *B.* An enlargement of a small portion of the outer part of the stem. 400.

**Woody Dicotyledonous Stems**

In woody plants obvious differences begin to appear as soon as the vascular cambium and the cork cambium develop. The differences involve the secondary xylem, or wood (Fig. 6.6). Some tropical trees (e.g., ebony), in which both the vascular cambium and the cork cambium are active all year, produce an uniform wood. The wood of most trees, however, is produced seasonally. In trees of temperate climates, virtually all growth takes place during the spring and summer and then ceases until the following spring. When the vascular cambium of a tree first becomes active in the spring, it usually produces relatively large vessel elements of secondary xylem; such xylemis referred to as ***spring wood****.* As the season progresses, the vascular cambium may produce vessel elements whose diameters become progressively smaller in each succeeding series of cells produced, or there may be fewer vessel elements in proportion to tracheids produced until tracheids (and sometimes fibers) predominate.

The xylem that is produced after the spring wood, and which has smaller or fewer vessel elements and larger numbers of tracheids, is referred to as ***summer wood****.* Over a period of years, the result of this type of switch between the early spring and the summer growth is a series of alternating concentric rings of light and dark cells. One year’s growth of xylem is called an **annual ring.** In conifers, the wood consists mostly of tracheids, with vessels and fibers being absent. Annual rings are still visible, however, since the first tracheids produced in the spring are considerably larger and lighter in color than those produced later in the growing season.

The annual rings not only indicate the age of the tree (since normally only one is produced each year), but they can also tell something of the climate and other conditions that occurred during the tree’s lifetime (Fig. 6.7). For example, if the rainfall during a particular year is higher than normal, the annual ring for that year will be wider than usual because of increased growth.

When a tree trunk is examined in transverse, or cross section, fairly obvious lighter streaks or lines can be seen radiating out from the center across the annual rings (see Figs. 6.6 and 6.8). These lines, called vascular rays, consist of parenchyma cells that may remain alive for 10 or more years. Their primary function is the lateral conduction of nutrients and water from the stele, through the xylem and phloem, to the cortex, with some cells also storing food. Any part of a ray within the xylem is called a xylem ray, but its extension through the phloem is called a phloem ray.

The term bark is usually applied to all the tissues outside the cambium, including the phloem.

Despite the presence of fibers, the thin-walled conducting cells of the phloem are not usually able to withstand for many seasons the pressure of thousands of new cells added to their interior, and the older layers become crushed and functionless. The parenchyma cells of the cortex to the outside of the phloem also function only briefly because they too become crushed or sloughed off. Before they disappear, however, the cork cambium begins its production of cork, and since new xylem and phloem tissues produced by the vascular cambium arise to the inside of the older phloem, the mature bark may consist of alternating layers of crushed phloem and cork.

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**Figure 6.6** A cross section of a portion of a young linden (*Tilia*) stem. ca. 300.

**Monocotyledonous Stems**

Most monocots (e.g., grasses, lilies) are herbaceous plants that do not attain great size. The stems have neither a vascular cambium nor a cork cambium and thus produce no secondary vascular tissues or cork. As in herbaceous dicots, the surfaces of the stems are covered by an epidermis, but the xylem and phloem tissues produced by the procambium appear in cross section as discrete vascular bundles scattered throughout the stem instead of being arranged in a ring (Fig. 6.12). Each bundle, regardless of its specific location, is oriented so that its xylem is closer to the center of the stem and its phloem is closer to the surface. In a typical monocot such as corn, a bundle’s xylem usually contains two large vessels with several small vessels between them (Fig. 6.13). The first-formed xylem cells usually stretch and collapse under the stresses of early growth and leave an irregularly shaped air space toward the base of the bundle; the remnants of a vessel are often present in this air space. The phloem consists entirely of sieve tubes and companion cells, and the entire bundle is surrounded by a sheath of thicker-walled sclerenchyma cells. The parenchyma tissue between the vascular bundles is not separated into cortex and pith in monocots, although its function and appearance are the same as those of the parenchyma cells in cortex and pith. In a corn stem, there are more bundles just beneath the surface than there are toward the center. Also, a band of sclerenchyma cells, usually two or three cells thick, develops immediately beneath the epidermis, and parenchyma cells in the area develop thicker walls as the stem matures. The concentration of bundles, combined with the band of sclerenchyma cells beneath the epidermis and the thicker walled parenchyma cells, all contribute to giving the stem the capacity to withstand stresses resulting from summer storms and the weight of the leaves and the ears of corn as they mature.



**SPECIALIZED STEMS**

Although most higher plants have an erect shoot system, many species have specialized stems that are modified for various functions (Fig. 6.14). The overall appearance of specialized stems may differ markedly from that of the stems discussed so far, but all stems have *nodes, internodes,* and *axillary buds*; these features distinguish them from roots and leaves, which do not have them. The leaves at the nodes of these specialized stems are often small and scalelike. They are seldom green, but full-sized functioning leaves may also be produced. Descriptions of some of the specialized stems follow.

1. **Rhizomes**

**Rhizomes** (Fig. 6.14) are horizontal stems that grow below ground, often near the surface of the soil. They superficially resemble roots, but close examination will reveal scalelike leaves and axillary buds at each node, at least during some stage of development, with short to long internodes in between. Adventitious roots are produced all along the rhizome, mainly on the lower surface. The word *adventitious* refers to structures arising at unusual places, such as roots growing from stems, or leaves or buds appearing at places other than leaf axils and tips of stems. A rhizome may be a relatively thick, fleshy, food-storage organ, as in irises, or it may be quite slender, as in many perennial grasses or some ferns.

1. **Runners and Stolons**

**Runners** are horizontal stems that differ from rhizomes in that they grow above ground, generally along the surface; they also have long internodes (Fig. 6.14). In strawberries, runners are usually produced after the first flowers ofthe season have appeared. Several runners may radiate out from the parent plant, and within a few weeks may grow up to 1 meter (3 feet) or more long. Adventitious buds appear at alternate nodes along the runners and develop into new strawberry plants, which can be separated and grown independently. In saxifrages and some other house plants, runners may produce new plants at intervals as they grow out and hang over the edge of the pot.

**Stolons** are similar to runners but are produced beneath the surface of the ground and tend to grow in different directions but usually not horizontally. In Irish potato plants, tubers are produced at the tips of stolons. Some botanists consider stolons and runners to be variations of each other and prefer not to make a distinction between them.

1. **Tubers**

In Irish or white potato plants, several internodes at the tips of stolons become **tubers** as they swell from the accumulation of food (Fig. 6.14). The mature tuber becomes isolated after the stolon to which it was attached dies. The “eyes” of the potato are actually nodes formed in a spiral around the thickened stem. Each eye consists of an axillary bud in the axil of a scalelike leaf, although this leaf is visible only in very young tubers; the small ridges seen on mature tubers are leaf scars.

1. **Bulbs**

**Bulbs** (Fig. 6.14) are actually large buds surrounded by numerous fleshy leaves, with a small stem at the lower end. Adventitious roots grow from the bottom of the stem, but the fleshy leaves comprise the bulk of the bulb tissue, which stores food. In onions, the fleshy leaves usually are surrounded by the scalelike leaf bases of long, green, aboveground leaves. Other plants producing bulbs include lilies, hyacinths, and tulips.

1. **Corms**

**Corms** resemble bulbs but differ from them in being composed almost entirely of stem tissue, except for the few papery, scalelike leaves sparsely covering the outside (Fig. 6.14). Adventitious roots are produced at the base, and corms, like bulbs, store food. The crocus and the gladiolus are examples of plants that produce corms.

1. **Cladophylls**

The stems of butcher’s broom plants are flattened and appear leaflike. Such flattened stems are called **cladophylls** (or *cladodes* or *phylloclades*) (Fig. 6.14). There is a node bearing very small, scalelike leaves with axillary buds in the center of each butcher’s broom cladophyll. The feathery appearance of asparagus is due to numerous small cladophylls. Cladophylls also occur in greenbriers, certain orchids, prickly pear cacti (Fig. 6.15), and several other lesser-known plants.

1. **Other Specialized Stems**

The stems of many cacti and some spurges are stout and fleshy. Such stems are adapted for storage of water and food. Other stems may be modified in the form of ***thorns****,* as in the honey locust, whose branched thorns may be more than 3 decimeters (1 foot) long, but all thornlike objects are not necessarily modified stems. For example, at the base of the petiole of most leaves of the black locust is a pair of ***spines***(modifed *stipules;* stipules were mentioned in the discussion of twigs). The ***prickles***of raspberries and roses, both of which originate from the epidermis, are neither thorns nor spines. Tiger lilies produce small, aerial ***bulblets***in the axils of their leaves. Climbing plants have stems modified in various ways that adapt them for their manner of growth. Some stems, called ***ramblers****,* simply rest on the tops of other plants, but many produce **tendrils** (see Fig. 6.14). These are specialized stems in the grape and Boston ivy but are modified leaves or leaf parts in plants like peas and cucumbers. In Boston ivy, the tendrils have adhesive disks. In English ivy, the stems climb with the aid of adventitious roots that arise along the sides of the stem and become embedded in the bark or other support material over which the plant is growing.

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**Figure 6.15** The flattened stems of prickly pear cacti (*Opuntia*) are cladophylls on which the leaves have been reduced to spines.