Chapter 36 Plant form and Function

I. The Diversity of Plant Form

A. Plants need light, carbon dioxide, water, nitrogen, phosphorus, magnesium, and potassium to photosynthesize make macromolecules, and maintain their structure.**(Fig 36.1)**

B. Plants use two basic systems to acquire these resources.

1. The root system (a vertical taproot with lateral roots that branch horizontally) is belowground and acquires water and dissolved nutrients from soil. (**Fig. 36.2**)
2. The shoot system is aboveground and acquires the carbon dioxide and light from the atmosphere. (**Fig. 36.3**)
   a. The shoot system consists of stems with nodes where leaves are attached.
   b. Internodes are stem segments between leaves.
   c. Lateral buds grow at nodes and can develop into branches or leaves.
   d. Apical buds grow at the tip of the main stem.
3. The vascular tissue connects the root and shoot systems by transporting water and nutrients from the roots to the shoots and by transporting glucose and other nutrients from leaves to the rest of the plant.

II. The Diversity of Root Systems: North American Prairie Plants

A. Experiment: Trenches were cut exposing the roots of various plant species in Kansas prairie, and J. E. Weaver examined the extent and nature of the root systems.

B. Observations

1. Roots of different species grew to different depths. (**Fig. 36.4**)
2. Morphology of different root systems was variable; some taproots, some fibrous, some large storage roots.

C. Interpretation: Root system diversity enables many species to live together in the same environment without directly competing for the same resources. (**Fig. 36.4**)

1. Grasses have dense, fibrous root systems.
2. Prairie roses have extremely long taproots.
3. Other plants have thick roots that store starch.

D. All roots function to provide support and nutrient and water absorption.

E. Adventitious roots are lateral roots that develop out of shoots. (Example, mangrove swamps)

F. Roots show a great deal of **phenotypic plasticity** i.e., they are plastic or changeable depending on environmental conditions

III. Diversity in Shoot Systems

A. The shoot system consists of one or more stems which are vertical aboveground structures

Nodes: sites of leaf attachment
Internodes: segments between nodes
Leaf: a leaf is an appendage that projects from a stem laterally
Axillary Buds: site of node attachment to stem—may develop into a branch if conditions are appropriate.

B. Diversity in shoots analyzed on three levels:

Morphological Diversity among species
Phenotypic Plasticity within individuals
Modified Shoots with specialized functions

Example of morphological diversity:

Silverswords are a monophyletic group of plants that are variable in growth form, size, shape, and habitat.

1. Some have thick, woody stems and grow as shrubs or trees. (**Fig. 36.8a**)

2. Others forms sprawling cushions or mats. (**Fig. 36.8b**)
3. Several species grow as rosettes. (**Fig. 36.8c**)

B. The diverse silversword shoot systems are adaptations that allow the plants to obtain the resources needed for growth and reproduction in quite varied habitats.

C. Other plants have variety of modified shoots to facilitate growth in diverse habitats.
1. Cactus stems are enlarged to store water and have modified leaves called spines. (**Fig. 36.10a**)
2. Stolons are modified stems that run over the soil surface, producing roots and leaves at each node; stolons function to produce new plants via asexual reproduction. (**Fig. 36.10b**)
3. Rhizomes are stems that grow horizontally under the ground; they function to produce new plants via asexual reproduction. (**Fig. 36.10c**)
4. Tubers are rhizomes that are modified for carbohydrate storage. (**Fig. 36.10d**)
5. Thorns are modified stems that protect the plant from predators. (**Fig. 36.10e**)

D. Leaves are the photosynthetic structures of the shoot system.
1. Leaves consist of an expanded blade and a petiole that arises from the lateral bud. (**Fig. 36.11a**)
2. Many plants have modified leaves.
   a. Grass lacks petioles.
   b. Compound leaves are divided into leaflets (**Fig. 36.11b**); double compound leaves have leaflets that are again divided into leaflets. (**Fig. 36.11c**)
   c. Cacti and evergreens have needlelike leaves to minimize water loss via transpiration. (**Fig. 36.11d**)
3. Not all leaves are photosynthetic.
   a. Onion bulbs consist of thickened leaves that store nutrients. (**Fig. 36.14a**)
   b. Thick leaves of succulents store water. (**Fig. 36.14b**)
   c. Tendrils of vines help the plant climb. (**Fig. 36.14c**)
   d. Brightly colored leaves of poinsettias attract pollinators. (**Fig. 36.14d**)
   e. Leaves of carnivorous plants help to trap insect prey. (**Fig. 36.14e**)
   f. Flowerpot plant leaves are host to ant colonies; the plant develops adventitious roots within those balloon-like leaves to absorb nutrients from the ant feces. (**Fig. 36.14f**)

IV. Plant Cells, Tissues, and Organization

Meristematic cells are responsible for plant growth. Meristematic cells are undifferentiated and divide rapidly when conditions are good for growth. (**Fig 36.15)**

Basic Plant Cell Anatomy (**Fig. 36.19a**)
1. Plant cells are surrounded by a stiff cell wall made of strong cellulose fibers.
2. Plant cells have one or more storage vacuoles that contain cell sap and help the cell maintain its proper volume.
3. Photosynthetic plant cells have chloroplasts for photosynthesis.
4. Plant cells are connected by gaps in the cell wall and cell membrane called plasmodesmata. (**Fig. 36.19b**)

A.) Three tissues comprise the plant body: **Dermal, Ground and Vascular**
1. **Epidermis** (dermal tissue) is the outermost single layer of cells covering the entire plant that provides protection and reduces water loss.
   a. Epidermal cells secrete the cuticle, a waxy compound that coats the outer surface of the plant and minimizes water loss.
   b. The cuticle also reduces gas exchange, and CO_2 needs to be able to enter leaves to be used in photosynthesis.
      (1) Thus, there are structures in the epidermis of leaves called stomata.
      (2) Stomata are made up of specialized epidermal cells guard cells that regulate the opening and closing of a pore. (**Fig. 36.20**)
      (3) Stomata can open to allow CO_2 in and O_2 out, and close to minimize water loss.

c. Epidermal cells have appendages called trichomes to cool the leaf surface by reflecting sunlight, or to help protect plant from predators. (**Fig. 36.21**)

2.) **Ground Tissue**---most photosynthesis and carbohydrate storage takes place in ground tissue Ground tissue is comprised of **parenchyma, collenchyma, and sclerenchyma** and makes up the bulk of the plant.

a. Most photosynthesis and carbohydrate storage occurs in ground tissue.

b. Cells in the ground tissue also make and release hormones, pigments, and defense toxins.

Parenchyma cells are the most abundant and versatile cells in plants. (**Fig 36.22)**

a. They are living cells with thin walls.
b. They are totipotent and can divide and develop into a complete plant.
   (1) This is important in plant wound healing and asexual reproduction.
   (2) If you remove part of a geranium stem, the parenchyma cells divide to form a callus, which is the beginning of a new plant.)
   (3) Researchers have grown entire plants from single parenchyma cells.
c. Parenchyma cells in leaves are the site of photosynthesis.
d. Parenchyma cells in roots are specialized for carbohydrate storage.
e. Parenchyma cells also make up the phloem, part of the vascular system.

Collenchyma and sclerenchyma cells function to support the plant.

a. Collenchyma cells are living cells with unevenly thickened primary cell walls that support young stems and leaves. (**Fig. 36.24**)
b. Sclerenchyma cells are dead, hollow cells with thick secondary walls found throughout a mature plant.
   (1) The secondary cells walls of sclerenchyma cells contain lignin, a tough, rigid compound.
   (2) Sclerenchyma cells provide support to mature stems.
      (*a*) Fibers are extremely elongated sclerenchyma cells that are often used to manufacture paper, fabrics, and ropes. (**Fig. 36.25**)
      (*b*) Sclerids are short sclerenchyma cells that are often found in the protective coats of seeds and nuts. (**Fig. 36.25**)
   (3) Cells of the xylem, tracheids, and vessel elements are types of sclerenchyma cells.

3.) **Vascular tissue**, which conducts materials throughout the plant, consists of xylem and phloem.

a. Xylem tissue transports water and nutrients and is composed of specialized sclerenchyma cells called vessel elements and tracheids.
   (1) All vascular plants have tracheids; only angiosperms have vessel elements.
   (2) Tracheids are long, slender cells with tapered ends that contain pits where one tracheid contacts another. (**Fig. 36.26**)
      (*a*) Pits are breaks in secondary cell wall, not the primary cell wall.
      (*b*) Water moves from one tracheid to another through the pits.
   (3) Vessel elements are shorter and wider than tracheids; have perforations where one vessel elements meets another. (**Fig. 36.26**)
      (*a*) Perforations are breaks in both the primary and secondary cell walls; sometimes these cells will lack cell walls at these junctions.
      (*b*) Since vessel elements offer little resistance to water flow, they conduct water more efficiently than tracheids do.
b. Phloem tissue transports sugars, amino acids, hormones, and toxins through specialized parenchyma cells called sieve-tube members.
   (1) Sieve-tube members are long, thin cells that are alive at maturity.

(2) They have perforated ends called sieve plates and lack nuclei, chloroplasts, and other organelles.

(3) Sieve-tube members are connected to companion cells via plasmodesmata. (**Fig 36.27**)

(*a*) Companion cells provide the sieve-tube members with the molecules that keep them alive.

(*b*) Companion cells help to load and unload carbohydrates from the sieve-tube members.

B.)Primary Root System organized into three zones: (**Fig 36.17)**

Zone of Cellular Division
Zone of Cellular Elongation
Zone of Cellular Maturation

C.0 Primary Shoot System

Vascular Bundles
Pith—ground tissue inside vascular bundles
Cortex—ground tissue outside the vascular bundles

V. The Anatomy of Plant Growth

A. Plants exhibit indeterminate growth because they never stop growing.

B. Plant growth is the result of two processes.
1. Repeated mitotic divisions in meristems
2. Expansion of the volume of those cells; cell enlargement

C. The direction of growth and the shape of the plant are determined by two things:
1. The orientation of the cell plate or the axis of division
2. The direction and extent of cell enlargement

D. Meristematic tissue is found in distinct regions and mediates different types of growth.
1. Apical meristems are found at the tips of roots and shoots and are the site of primary growth.
   a. Primary growth makes the plant taller and the roots longer.
   b. Primary growth leads to nonwoody, herbaceous stems.
2. Lateral meristems are found in rings along the length of roots and shoots and are the site of secondary growth.
   a. Secondary growth makes the stem and roots increase in width.
   b. Secondary growth results in the formation of wood.
3. Some plants lack apical or lateral meristems and grow taller and wider as a result of other types of meristems.

E. Primary Growth: The Root System
1. To access more water and nutrients, roots must continually be growing into new regions of soil.
   a. How do roots push their way through tough soil?
      (1) The growing edge of the root is protected by the root cap. (**Fig. 36.17**)
      (2) Apical meristems in the root continually replenish damaged cells in the root cap.
      (3) Root cap cells sense gravity and determine the direction of growth.
      (4) Root cap cells also make and secrete mucigel, a slimy lubricant that aids in movement through the soil.
   b. Three distinct populations of cells exist behind the root cap to facilitate root growth. (**Fig. 36.17**)
      (1) The zone of cellular division contains the apical meristem, where cells are actively dividing.

(2) The zone of cellular elongation contains new cells that are growing in length.
(3) The zone of cellular maturation contains cells that are differentiating into dermal, vascular, or ground tissue cells.
(*a*) Dermal cells in this zone form root hairs.
(*b*) Root hairs increase the absorptive area of the root and are the primary site of absorption in the root.

F. Primary Growth: The Shoot System
1. The top of the stem is a rounded dome of cells that make up the shoot apical meristem.
a. On both sides of this meristem, new leaves arise as leaf primordial.
b. As in the root, the cells behind the apical meristem are enlarging and differentiating.
2. The anatomy of a stem—the alfalfa plant (**Fig. 36.18**)
a. The center of the stem, the pith, is made up of ground tissue that stores carbohydrate.
b. Xylem and phloem are found in vascular bundles around the pith that run the length of the stem.
c. The cortex lies between the vascular bundles and the epidermis.
d. Alfalfa is a eudicot, so the vascular bundles form a ring around the pith (**Fig. 36.18**); but in monocots, the vascular bundles are scattered throughout the pith. (**Fig. 36.18b**)

G. Secondary Growth (**Table 36.2)**
1. This growth results from a ring of secondary meristem or cambium that leads to an increase in girth and gives structural support to the growing plant.
2. Lateral meristems divide in a plane parallel to the long axis of the root or shoot, thus increasing the width of the structure.
3. The two types of stem secondary meristems make wood and bark.
a. The cork cambium is a secondary meristem located near the perimeter of the stem that replaces the epidermis and forms the bark. (**Fig. 36.28**)
(1) The cork cambium produces cork cells that replace the original epidermal cells.
(2) The cells in the cork layer die, forming a protective outer layer.
(3) These cells are an important element of bark that also includes all cells outside of the vascular cambium.
b. The vascular cambium is a secondary meristem located between the primary xylem and primary phloem.
(1) Vascular cambium (secondary meristem) produces secondary xylem and phloem; primary meristem produces primary xylem and phloem.
(2) Primary and secondary xylem and phloem are important for conducting water and nutrients along the plant's length, but vascular cambium also produces conducting parenchyma cells in rays to transport water and nutrients laterally via large stems. (**Fig. 36.28**)
(3) Two daughter cells are produced when a cell in the vascular cambium divides; one differentiates, and one continues to divide.
(4) Cells produced by the vascular cambium to the exterior of the meristem form secondary phloem, which contributes to bark.
(5) Cells produced to the interior form secondary xylem, or wood.
(*a*) Plants that form secondary xylem are woody plants; those that do not are known as herbaceous plants.
(*b*) Wood provides the structural support for plants, permitting them to withstand wind and enabling them to grow taller.
4. The structure of a tree trunk and the formation of growth rings
a. Trees are perennial plants that live for many years.
b. In many places, the vascular cambium of trees stops growing for a certain amount of time each year; this condition is called dormancy.
c. Growth rings form due to differences in the size and cell-wall thickness of secondary xylem cells when the vascular cambium is activated after dormancy.

(1) The first cells formed after dormancy are large and have thin cell walls because water and nutrients are abundant.

(2) As the growing season ends and water and nutrients are less abundant, the cells arising from vascular cambium are smaller and have thick cell walls.

(3) Therefore, in trees experiencing this type of seasonal growth, regions of large, thin-walled cells alternate with regions of small, compact, thick-walled cells.

(4) This alternating pattern forms growth rings that can be seen in cross sections of tree trunks. (**Fig. 36.29**)

(5) Growth-ring size reflects the availability of water and nutrients in a given year and can be used as an indicator of past climatic changes. (**Fig. 36.29**)

d. As the tree trunk grows wider, the innermost xylem layers stop conducting and are infiltrated with waste products forming gums, resins, and so on. (**Fig 36.29)**

(1) Heartwood is older secondary xylem that is no longer conducting water.

(2) Sapwood is secondary xylem toward the exterior of a stem that is transporting water.