When you see a plant, do you ever think of it as being made up of separate structures, combined to make the whole plant? All living organisms consist of cells. These cells form tissues. Tissues form organs. Your heart, lungs, and stomach are examples of organs. Plant organs include their roots, stems, leaves, and reproductive structures.

Each plant organ performs a specialized task in the life of the plant. Roots, leaves, and stems are all vegetative structures. Flowers, seeds, and fruits make up reproductive structures. The roots support the plant and supply it with water and nutrients. Stems connect the roots and leaves. Leaves capture energy from sunlight and use it to make food for the plant. Reproductive structures attract pollinators* and produce seeds and fruit.

* Underlined words are defined in the Glossary of Terms.
THE PLANT CELL

Understanding the plant cell is very important. The plant cell is the basic structural and functional unit for all living organisms. Plant cell structure is very similar to that of the animal cell. The two types of cells contain many of the same organelles. These organelles carry out the same functions in both types of cells. Table 1 lists the organelles common to both plant and animal cells.

Table 1. Organelles Common to Plant and Animal Cells

<table>
<thead>
<tr>
<th>Organelle</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nucleus</td>
<td>Stores DNA, synthesizes ribosomes and RNA</td>
</tr>
<tr>
<td>Endoplasmic Reticulum (ER)</td>
<td>Rough ER prepares protein for export; Smooth ER synthesizes steroids, regulates calcium levels, breaks down toxins</td>
</tr>
<tr>
<td>Mitochondrion</td>
<td>Converts energy from organic compounds to energy for cellular activities</td>
</tr>
<tr>
<td>Ribosomes</td>
<td>Organize the production of protein</td>
</tr>
<tr>
<td>Microtubules</td>
<td>Contribute to the support and division of the cell</td>
</tr>
<tr>
<td>Golgi Complex</td>
<td>Processes and packages substances made by the cell</td>
</tr>
<tr>
<td>Cell Membrane</td>
<td>Semi-permeable membrane separating cell content from the outside</td>
</tr>
<tr>
<td>Lysosomes</td>
<td>Digest old organelles and foreign substances</td>
</tr>
</tbody>
</table>

Aside from common organelles, plant and animal cells are very different. Plant cells are very unique because of the presence of three additional structures. These structures--cell wall, vacuoles, and plastids--are important to a plant’s ability to function.
Cell Wall

The plant cell wall is a remarkable structure. The presence of the cell wall is the most significant difference between plant cells and other eukaryotic cells. The cell wall is rigid (up to many micrometers in thickness) and gives plant cells a very defined shape. While most cells have an outer membrane, none are comparable in strength to the plant cell wall. The cell wall is composed of cellulose fiber, polysaccharides, and proteins. The cellulose microtubules are comparable to the steel rods used to reinforce concrete. It has been estimated that the wood of one redwood tree, which is primarily composed of cellulose, could support the weight of 1,000 elephants.

In a new cell, the cell wall is thin and flexible. This allows the young cell to grow. At this stage in development, the cell wall is referred to as the primary cell wall. When fully grown, a plant cell may retain its primary cell wall, sometimes thickening it. The plant cell may deposit new layers of a different material, which becomes secondary cell wall. The cell wall of each cell interacts with neighboring cells to form a tightly bound plant structure. This establishes and maintains the shape of the plant. Despite the rigidity of the cell wall, chemical signals and cellular excretions are allowed to pass between cells.

Vacuoles

Vacuoles are fluid filled organelles that store metabolic waste. Although some of the stored wastes are very toxic and must be kept away from the rest of the cell, they can be used to benefit the plant. Some of these wastes can be used as a defense against plant-eating insects and animals. Vacuoles are often very large, occupying as much as 90% of the cell’s volume.

Plastids

Another distinguishing characteristic of the plant cell is the presence of plastids. Plastids are DNA containing organelles surrounded by two membranes. Plastids store starch and fats. In some cases, they contain pigments that absorb light. Chloroplasts are an example of a pigmented plastid. These green organelles convert light energy into chemical energy during photosynthesis. The green pigment gives leaves and stems their green color. Other types of plastids are responsible for the colors of fruits and flowers.

PLANT TISSUE SYSTEMS

An organized mass of similar types of cells is called tissue. Plant tissues are classified according to their origin, structure, and physiology. Plant tissues fall in to three categories: dermal, ground, and vascular.

Dermal Tissue

Dermal tissue systems form the outer layer, or epidermis, of the primary plant body (the roots, stems, leaves, flowers, fruits, and seeds). These tissues are responsible for environmental interactions such as light passage, gas exchange, pathogen recognition, and color display. The epidermis is typically one cell layer thick. The cells in this layer lack chloroplasts.
As an adaptation to a terrestrial habitat, the epidermis has developed features that regulate the loss of water, carbon dioxide, and oxygen. The walls of the epidermal cells contain mixtures of waxes and cutin. These fatty substances form a waterproof outer layer called the cuticle. The cuticle minimizes transpiration from the plant. These waxy deposits can be thin or thick, depending on the type of plant. As an example, desert plants usually have heavy wax coatings.

**Ground Tissue**

Ground tissue occupies the space between the dermal tissues and the vascular tissues. It consists of three types of specialized plant cells, which are the parenchyma (puh-REN-kuh-muh), collenchyma (koh-LEN-kuh-muh), and sclerenchyma (skluh-REN-kuh-muh). The functions of these cells include storage, metabolism, and support.

Parenchyma cells have thin, primary cell walls and a highly functional cytoplasm. These cells are alive at maturity and are responsible for a wide range of biochemical processes. Besides providing support functions, this cell type is the basis for all plant function. Some parenchyma cells are specialized for light penetration, regulating gas exchange, or anti-herbivory physiology. Others are specialized for photosynthesis or phloem loading. Parenchyma cells make up the fleshy part of fruits, roots, and tubers. Therefore, it is the most common and most abundant plant tissue.

Collenchyma cells have thick cell walls. They are typically quite elongate. In most plants, these cells consist mainly of cellulose and serve to strengthen stems and leaves. The role of this cell type is to support the plant in areas still growing in length. The primary walls of collenchyma cells lack lignin, making them somewhat brittle. However, this cell type has enough strength to provide “plastic support.” Such support can hold a young stem or petiole into the air. This is accomplished by cells that can be stretched as the cells around them elongate. Stretchable support (without elastic snap-back) is a good way to describe what collenchyma does.

Sclerenchyma cells have thick cell walls that are hard and brittle. These cells develop an extensive secondary cell wall, laid down on the inside of the primary wall. This secondary wall is invested with lignin, which makes it extremely hard. Lignin plus suberin and/or cutin make the wall waterproof as well. These cells cannot survive for long because they cannot exchange materials well enough for active metabolism. They are typically dead at functional maturity. Functions for sclerenchyma cells include support, conduction, and discouraging herbivory. Sclerenchyma cells make up the fibers used for making thread and fabric.

**Vascular Tissue**

The vascular tissue of plants is divided into two sections: xylem and phloem. Xylem tissue is found in both herbaceous and vascular plants. Its primary functions are to conduct water, transport minerals from the soil up the plant, and to support the plant.

Two fundamental cell types make up vascular tissue: tracheids and vessels. Tracheids are thick-walled, have no cytoplasm, and conduct from cell-to-cell through perforation plates in the end walls or through pits in the side walls. Vessels are dead, hollow cells that have thick walls and lack end walls. They are typically much larger in diameter and function as major pipes for water movement.
The phloem tissue also conducts material in the plant and provides plant support. Phloem tissue functions in the transport of sugars, amino acids, and other small molecules from the leaf to the rest of the plant. There are two specialized phloem cell types: sieve elements and companion cells.

Sieve elements are living cells with thin walls. The end walls of these cells are perforated and called sieve plates. The rate of flow through sieve elements is high. Their cytoplasm is very simple. It contains no developed organelles (nucleus, mitochondrion, and chloroplast). To maintain their living state, sieve element cells must directly associate with well-developed companion cells. Companion cells have a typical nucleus and cytoplasm. Enough biochemical processes occur in companion cells to keep both the sieve element and companion cells alive.

**PLANT ORGANS**

Dermal, ground, and vascular tissues all come together to build the plant organs. Each plant organ performs a specialized task in the life of the plant. Roots, leaves, and stems are all vegetative structures. Flowers, seeds, and fruits are all reproductive structures. The roots support the plant and supply it with water and nutrients. Stems connect the roots and the leaves. Leaves capture energy from sunlight and use it to make food for the plant. Reproductive structures attract pollinators and produce seeds and fruits.

**The Plant Root**

The root is the first plant structure to emerge from a seed during germination. Roots are mostly found below the soil surface. They represent about 50% of a plant’s weight. The primary functions of roots are to absorb water and nutrients from the soil and to support the plant in an upright position. Roots also distribute the food energy produced in the leaves to the rapidly growing areas found at the root tips. Some plants also use their roots as specialized food storage reserves.

The first root to emerge from a seed is the primary root, or radicle. Plant root systems are classified based on the relative sizes of their primary and secondary roots. Plants such as dandelions, carrots, turnips, and most trees have a taproot. In taproot systems, the primary root thickens and becomes the dominant root. Secondary roots are present but are much smaller in diameter.

Although most plant roots do not spread more than two to three feet into the ground, the taproots of many trees grow deeply into the soil and can often reach water far below the soil surface.
In fibrous root systems, the primary and secondary roots are of similar diameter. They remain fairly close to the soil surface. Plants with fibrous root systems are very important because their roots prevent the erosion of topsoil during heavy rainstorms. Plants such as grasses, corn, and onions have fibrous root systems.

In addition to tap and fibrous roots, some plants have adventitious roots. Adventitious roots are roots that originate from stems or leaves, rather than branching directly off the primary root. Brace, or prop, roots produced from the stems of corn plants are examples of adventitious roots. The brace roots help to support the tall plant in addition to its shallow fibrous root system.

Many climbing plants also have adventitious roots. These aerial or climbing roots originate on stems near the leaves. Plants such as ivies use climbing roots to fasten the plant to the surface on which it is growing. Spanish moss that lives attached in the branches of trees uses aerial roots to absorb moisture directly from the air. Species of *Ficus* and *Philodendron* produce aerial roots from mature stems and branches, allowing the plants to absorb additional moisture from the air.

**Parts of a Root**

A root contains three major internal parts: meristem, zone of elongation, and maturation zone. The meristem is at the tip of the root and is responsible for manufacturing new cells. This is the area where cell division and growth occur. Above this area is the zone of elongation. In this zone, cells increase in size through food and water absorption. This increase in cell size causes the root to push through the soil. The third major root part is the maturation zone. Cells in the maturation zone undergo changes in order to become specific tissues such as epidermis, cortex, or vascular tissue.

The epidermis is the outermost layer of cells surrounding the root. The cells of the epidermis are responsible for absorbing water and minerals from the soil. Cortex cells function in the movement of water and in food storage. Vascular tissues are located in the center of the root and conduct food and water up into the plant.
The root hairs and root cap are two important external features of a root. Root hairs, found along the main root, perform much of the actual work of water and nutrient absorption. These root hairs develop as an outgrowth of the epidermal cells (epidermis). Most plants produce root hairs that live only a few days or a few weeks. As the plant continues to grow, new root hairs form in the cell elongation region.

The root cap is the outermost tip of the root. It covers and protects the growing region of the root. The root cap also senses gravity and directs root growth through the soil.

The Plant Stem

Plant stems connect the roots with the leaves. Plant stems are important because they transport water and nutrients from the roots to the leaves. They also transport food energy from the leaves to the roots.

Stems function as supportive structures. They hold a plant’s leaves up toward the sun so they can capture energy from sunlight. Tall, strong stems give a plant a competitive advantage by holding the leaves above those of other plants, increasing their exposure to sunlight.

Young, green stems help leaves collect sunlight for photosynthesis. Stems also support flowers and reproductive structures that allow for the perpetuation of the plant species.

Stem Anatomy

The three major internal parts of a stem are the xylem, phloem, and cambium. The xylem and phloem, as mentioned before, are the major components of a plant’s vascular system. The cambium is a meristematic tissue, which means that it is a site of cell division and active cell growth. The cambium is located between the xylem and phloem. It is responsible for a stem’s increase in diameter, as it produces both the xylem and phloem tissues. The center of the stem is composed of a layer of parenchyma called the pith.
In woody plants, the phloem is referred to as the innerbark. Inside the innerbark is the cambium. Annual rings of new wood form inside the cambium layer and new bark forms outside. The sapwood (xylem) carries water and nutrients (sap) from the roots to the leaves. Inside the sapwood is the heartwood. The heartwood is inactive sapwood that provides strength for the plant. The pith of a woody tree is the dark center in the core of the heartwood. Extending in a radial direction across the grain of the wood are rays. Rays are ribbon-like strands of tissue formed by the cambium.

The external structure of stems varies among plant species. However, a number of easily recognized common features occur in both woody and herbaceous plants. Most stems have both terminal (apical) and axillary (lateral) buds. Terminal buds are those located at the stem tips. Axillary buds exist in the leaf axils at each node. Leaves attach to the stem at nodes. The space along a stem between leaves is an internode. A leaf scar remains on a stem when a leaf falls off. The vascular bundles of the leaf petiole also leave bundle scars within the leaf scar. Bud scale scars of terminal buds are also visible on woody twigs.

Several external features are present in woody plants that do not occur with herbaceous plants. The outerbark functions to protect the interior of the plant from insects and diseases, from excessive heat and cold, and from other injuries. A lenticel is an area of loosely packed cells that extends through the plant’s epidermis. Lenticels serve as “breathing pores” for gas exchange. Growth rings around a stem are bud scale scars from the last terminal bud. They physically mark periods of growth and help in determining the age of stems. Some woody plants also have a flower bud. This type of bud contains a floral meristem that develops into a flower.

**Types of Above-Ground and Below-Ground Stems**

In order to survive in their native habitats, some plants have developed modifications in the structure of their stems. These modifications have been developed for protection and for additional food and water storage capabilities. Some stem modifications exist above the surface of the soil, while other stem modifications are found below the surface.

Most people are familiar with above-ground modifications such as thorns and prickles. Thorns, which are characteristic features of the genus *Pyracantha*, are sharp-pointed, woody stems. Prickles, which are often referred to as thorns, are commonly found on the stems of roses. They develop from the superficial tissues of the stem.
Stolons, spurs, pseudobulbs, and cladophylls are additional examples of above-ground stem modifications. Stolons are runners or stems that grow horizontally along the ground. They usually have long internodes. Strawberry plants produce stolons. Spurs are found on many fruit trees. A spur is a compressed stem with short internodes. The terminal growth of spurs is generally slow and restricted. Pseudobulbs are characteristic of many orchids. A pseudobulb is a thickened bulb-like leaf base resembling a bulb. Cladophylls are modified stems, specialized for photosynthesis. Cladophylls are usually flattened, leaf-like, and green. Many cactus and succulents consist of cladophylls.

Many stem modifications exist that occur below the soil surface. Rhizomes are modified underground stems that grow horizontally. Some rhizomes may be compressed and fleshy. Others may have long internodes. Many grasses spread underground by rhizomes. Tubers are fleshy parts of underground stems. An example of a tuber is the potato. The “eyes” on a potato are buds.

Corms are short, thickened, underground stems with few nodes and short internodes. Dry, scale-like leaves usually enclose a corm. Gladioli and crocuses are examples of plants with corms. A bulb is a specialized underground storage organ. It is composed of a compressed, plate-like stem enclosed by fleshy or papery leaves or leaf bases. A concentric bulb, such as an onion, consists of a stem enclosed by sheathing leaves or leaf bases. A scaly bulb, such as a lily bulb, consists of a stem enclosed by separate, thick, scale-like leaf bases.

The Plant Leaf

The primary function of leaves is to capture sunlight for manufacturing food reserves. This process is called photosynthesis. Photosynthesis occurs within specialized cells found in leaves or modified stems such as cladophylls. During photosynthesis, water and carbon dioxide chemically combine in the presence of sunlight to make plant sugars, oxygen, and water. Many of the external structures of leaves are designed to help the plant photosynthesize so it can manufacture sugar food reserves.

In addition to capturing sunlight for photosynthesis, leaves are also important in the process of gas exchange. Photosynthesis requires carbon dioxide and produces oxygen. To maintain a supply of carbon dioxide, the plant opens tiny pores called stomata located on the undersides of leaves. The open stomata allow carbon dioxide to enter a leaf. Oxygen produced by photosynthesis also escapes through the open stomata. At the same time, tiny droplets of water vapor escape from the humid environment inside the leaf into the dry air around the plant. This process of water evaporation from the surface of the plant is called transpiration.

During a 12-hour day, a large tree may transpire as much as 180 gallons of water. Transpiration is important because it continually draws more water up from the roots, through the stems, and to the leaves. Water drawn in from the soil by the roots contains nutrients that help the plant grow. Many plants have modified leaves that function as storage organs. Modified leaves also protect buds and flowers and help a plant species adapt itself to a harsh environment.

Most plants have flat leaves with large areas arranged in such a way as to efficiently take in solar energy for manufacturing food. However, needle-like leaves (as found on conifers) and stem-like fleshy leaves (as found on cacti) also have sufficient surface areas for producing abundant plant food. Dicot plant leaf blades attach to the stem by a petiole. Leaves of deciduous plants separate and fall from the stem seasonally. Leaves of evergreen plants do not shed seasonally. Instead, evergreen plants shed their leaves over a period of three or four years.
**Anatomical Structures of a Leaf**

The flat portion of a leaf is the leaf blade, or lamina. The petiole attaches the lamina to the plant stem. On some plants, small leaf-like appendages exist at the base of the petiole. These stipules serve as food manufacturing structures. An axillary bud exists on the stem just above the point where the leaf petiole attaches to the stem.

**Structure of a Deciduous Plant**

[Diagram showing leaf anatomy with labels: Vein, Midrib, Expanded Portion of Blade (Lamina), Axillary Bud, Node, Bladestalk (Petiole), Base of Leaf.]

Leaves are classified as either simple or compound. Simple leaves consist of a single leaf blade. Compound leaves have several secondary leaves, or leaflets. These leaflets have a small leaf stalk (petiolule) that attaches to the rachis. The rachis is an extension of the petiole in a compound leaf.

A leaf blade contains veins and soft tissue. The midrib is the most prominent, central vein in a leaf. Lateral veins are secondary veins that branch from the midrib. Both the midrib and the lateral veins contain vascular tissue. The arrangement of veins in a leaf varies among plants. In dicotyledonous plants, the veins branch several times and are referred to as being netted. The leaf veins in monocotyledonous plants are usually parallel to each other.

A leaf consists of several layers of cells. The cuticle is a thin film that covers the epidermis. The cuticle protects the leaf from excessive temperatures and water loss that could damage the leaf. The upper epidermis and lower epidermis are the surface layers of cells in a leaf. These layers of cells also protect the inner cell layers of the leaf. The epidermal layers of a leaf contain guard cells that regulate the opening and closing of the stomata. Stomata are small pores, or openings, in the leaf surfaces through which water, oxygen, and carbon dioxide exchange.

The innermost layers in a leaf make up the mesophyll. The mesophyll consists of palisade parenchyma cells and spongy parenchyma cells. Palisade parenchyma cells are elongated cells rich in chlorophyll and other colored plastids. Their arrangement is in upright layers. The palisade parenchyma cells are specialized for photosynthesis.
Spongy parenchyma cells make up the layer between the palisade cells and the lower epidermis. This layer is specialized for gas exchange. The spongy parenchyma layer contains chloroplasts, air spaces (sub-stomatal chambers), and vascular bundles. Vascular bundles are the veins that conduct water and food reserves through the leaf.

Not all plants have thin, flattened, and green leaves. Some plants have modified leaf forms that are beneficial for survival in their native habitats. Junipers have scale-like leaves. Pines have long, slender needle-like leaves. Many plants such as poinsettias, spathiphyllums, and dogwood trees produce colored bracts that subtend their flower or flower clusters. Cataphylls are reduced leaf forms modified into bud scales. These bud scales function to protect the bud.

Some leaf forms are modified for water storage. Bulbs such as onions and lilies have modified underground leaves for storage. Plants such as aloes and sedums have thick, succulent leaves. Succulent leaves are thick, fleshy, and modified for water storage.

Climbing vines such as grapes and cucumbers have tendrils. Tendrils are slender, twining, modified leaves for clinging to objects for support. The sharp-pointed spines on cactus are modified leaves. The leaves of many hollies have spines along their margins.

**The Plant Flower**

Flowers are the reproductive structures of angiosperms (flowering plants). Reproductive structures play an important part in the life cycle of plants because they promote sexual reproduction and produce seeds and fruits that aid the dispersal of the plant species. Flowers, like any other part of the plant, vary in structure, size, and composition. Some flowers resemble stems, whereas others resemble leaves. Flowers develop from buds, as do shoots. Therefore, they are considered to be specialized branches of a plant.
Parts of a Complete Flower

While flowers differ between plant species in characteristics such as color, size, shape, and scent, most flowers have a similar structure. Complete flowers have four basic parts: petals, pistil, sepals, and stamens. The flower is supported and connected to the stem by an elongated and specialized stem called the pedicel. The enlarged part of the pedicel where it joins the flower is the receptacle. All four of the basic flower parts attach to the receptacle.

![Parts of a Flower Diagram](image)

The first of the four major flower structures is the sepals. Sepals are leaf-like structures that form an outer ring around the base of the flower. Sepals enclose and protect the flower bud before it opens. Sepals are often small, green structures. However, in some flowers they are large and colorful. The complete ring of sepals is called the calyx.

The next ring of structures is the corolla. The corolla consists of individual petals. Petals are the bright and colorful part of the flower. Petal colors and scents attract specific pollinators. Flowers that rely on birds such as hummingbirds for pollination usually have red or orange petals. This is because hummingbirds can see these colors best and are attracted preferentially to these flowers. Bees are most attracted to blue, yellow, and white flowers. So, flowers that are mainly pollinated by bees use these colors to attract their pollinators. Other flowers, such as jasmine, do not have colored petals. They have powerful scents to attract pollinators such as night-flying moths.

The reproductive organs are at the center of the flower. The stamens are the male reproductive organs. The pistil is the female reproductive organ. A stamen is comprised of two parts: an anther and a filament. The filament is a stalk-like structure that holds the anther. The length of the filament is determined by the mode of pollination. Flowers pollinated by birds such as hummingbirds often have very long filaments so that the anthers hang above the bird’s head as it hovers to collect nectar from the flower. Flowers that do not want the pollen from its anthers to reach its own female organs usually have short filaments to prevent self-pollination. These flowers must cross-pollinate by insects that land on the flower and carry pollen from another plant.
The anthers are located at the tip of the filament. They are sac-like structures that contain pollen grains. Pollen grains contain the male sex cell and are modified to be sticky or easily carried by the wind, depending on the mode of pollination for the particular plant. A single flower usually has several stamens.

The pistil is located at the center of the flower. A flower may have many pistils. However, many flowers only have one. The pistil has three parts: stigma, style, and ovary. The stigma is a sticky, flattened surface that projects upwards towards the pollinator. As an insect or bird pollinator collects nectar, the pollen from previous plants it visited is brushed against the sticky surface of the stigma. The pollen sticks on the stigma and is triggered to germinate like a seed. The pollen produces a root-like structure called a pollen tube that grows down into the stigma, through the style and into the ovary. The style is a supportive structure equivalent to the filament in the stamen. The style holds the stigma in a position to maximize the chances of pollination. At the base of the style is the ovary.

The ovary is an enlarged structure that contains the female sex cells, or ovules. The pollen tube grows through the ovary and into an ovule. When the male and female sex cells merge, fertilization occurs. At this point, the ovary begins to develop and change into a fruit.

Not all flowers have a corolla, calyx, pistil, and stamen. Flowers with all four basic parts are perfect complete flowers. Those missing at least one of these components are incomplete. Perfect incomplete flowers lack petals or sepals. Pistillate flowers have a pistil but no stamens. Staminate flowers have stamens but no pistils. Both pistillate and staminate flowers are imperfect incomplete flowers because they are missing reproductive organs. Sterile flowers are missing both pistils and stamens.

A monoecious plant is one that has both staminate and pistillate flowers on the same plant. Corn is a monoecious plant with staminate flowers occurring at the top of the plant where the wind can catch most of the pollen. Pistillate flowers occur further down the stem. The pistillate flowers of the corn plant have long “silks” that are extended sticky stigmas and styles to catch the wind-borne pollen. Dioecious plants have male and female flowers on completely separate plants. Staminate flowers occur only on male plants while pistillate flowers occur only on female plants. Kiwi, asparagus, holly, and Ginkgo are examples of dioecious plants.

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GLOSSARY OF TERMS

Adventitious - Arising or occurring sporadically or in other than the usual location.

Dispersal - Scattering; spreading out.

Elongate - Stretched out.

Eukaryotic - An organism composed of one or more cells containing visibly evident nuclei and organelles.

Germination - To begin to sprout or develop.

Herbaceous - Having little or no woody tissue and persisting usually for a single growing season.

Herbivory - Feeding on plants.

Meristem - A formative plant tissue usually made up of small cells capable of dividing indefinitely and giving rise to similar cells or to cells that differentiate to produce the definitive tissues and organs.

Metabolic - Of, relating to the chemical changes in living cells by which energy is provided for vital processes and activities and new material is assimilated.

Organelles - A specialized cellular part, such as a mitochondrion, lysosome, or ribosome, that is analogous to an organ.

Perpetuation - Continued existence.

Photosynthesis - Synthesis of chemical compounds with the aid of radiant energy and especially light; formation of carbohydrates from carbon dioxide and a source of hydrogen (as water) in the chlorophyll-containing tissues of plants exposed to light.

Pollination - The transfer of pollen from an anther to the stigma in angiosperms or from the microsporangium to the micropyle in gymnosperms.

Pollinator - An insect that carries pollen from flower to flower and thereby brings about the fertilization necessary for the production of the fruit or seed of the plant.

Subtend - To be opposite to and extend from one side to the other.

Transpiration - The act or process or an instance of transpiring. The passage of watery vapor from a living body through a membrane or pores.
SELECTED STUDENT ACTIVITIES

SHORT ANSWER/LISTING: Answer the following questions or statements in the space provided or on additional paper if necessary.

1. What three structures are unique to the plant cell? [Visit the virtual cells at www.life.uiuc.edu/plantbio/cell or www.cellsalive.com/cells/plntcell.htm. to get a closer look at these structures.]
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2. List the three types of plant tissues and give a brief description of each tissue.
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3. Would you expect to find sclerenchyma and collenchyma cells in the root? Explain your answer.
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4. What are the major functions of the root system?
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5. Describe the differences between a fibrous root system and a taproot system. Why might a taproot system be an advantage to some plants while a fibrous root system is an advantage to others?

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6. Name the three major internal parts of the stem and identify their functions.

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7. What is the primary function of the plant leaf?

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8. What is the cuticle? Describe its function and how it helps protect the plant.

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9. What is the difference between a complete and incomplete flower?

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10. Which part of the flower is considered to be male and which part is considered to be female?
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11. What role do petals play in pollination?
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FILL IN THE BLANK: Complete the following statements.

12. The three major parts of a root are the ____________, ____________, and ____________.

13. The stamen is comprised of the _________________________ and _________________________.

14. Only ________________ flowers occur on male plants and ________________ flowers occur on female plants.

TRUE/FALSE: Circle the “T” if the statement is true or the “F” if it is false.

T  F  15. Stolons are runners or stems that grow horizontally below the ground surface.

T  F  16. Xylem conducts plant food materials through sieve tubes.

T  F  17. Corms are underground stems that are fleshy and short with a few nodes.

T  F  18. A petiole is part of a leaf.

T  F  19. Plant growth is the result of cell division and changes among tissues.

T  F  20. Both plants and animals use protein, fats, and carbohydrates for energy and growth.
ADVANCED ACTIVITIES

1. Scientists frequently use insects as research tools in scientific experiments. Prepare a report on the use of aphids in determining how sugars are transported throughout a plant.

2. Have you ever wondered what makes the leaves change colors in the fall? As you may already know, chlorophyll gives leaves their green color. Find out what causes leaves to turn orange, red, yellow, or purple in the fall. The Internet is a good place to begin your research. After you have discovered the process that causes this change in color, replicate this process using the following lab exercise.

Separate Colors in a Green Leaf Using Chromatography

Materials:

- A variety of leaves
- Small jars (baby food jars)
- Covers for jars, aluminum foil, or plastic wrap
- Rubbing alcohol
- Paper coffee filters
- Shallow pan
- Hot tap water
- Tape
- Pen
- Plastic knife or spoon
- Clock or timer

Procedure:

1. Collect 2 to 3 large leaves from several different trees. Tear the leaves into very small pieces and put them into small jars labeled with the name or location of the tree.

2. Add enough rubbing alcohol to each jar to cover the leaves. Using a plastic knife or spoon, carefully chop and grind the leaves in the alcohol. SAFETY NOTE: Isopropyl rubbing alcohol can be harmful if mishandled or misused. Read and carefully follow all warnings on the alcohol bottle.

3. Cover the jars very loosely with lids, plastic wrap, or aluminum foil. Place the jars carefully into a shallow tray containing 1 inch of hot tap water. SAFETY NOTE: Hot water above 150°F can quickly cause severe burns. Experts recommend setting your water heater thermostat no higher than 125°F.

4. Keep the jars in the water for at least a half-hour, longer if needed, until the alcohol has become colored (the darker the better). Twirl each jar gently about every five minutes. Replace the hot water if it cools off.
5. Cut a long thin strip of coffee filter paper for each of the jars and label it.

6. Remove jars from the water and uncover. Place a strip of filter paper into each jar so that one end is in the alcohol. Bend the other end over the top of the jar and secure it with tape.

7. The alcohol will travel up the paper, bringing the colors with it. After 30 to 90 minutes or longer, the colors will travel different distances up the paper as the alcohol evaporates. You should be able to see different shades of green, and possibly some yellow, orange, or red, depending on the type of leaf.

8. Remove the strips of paper, let them dry, and then tape them to a piece of plain paper. Discuss the color change in the different types of leaves.

NOTE: ADULT SUPERVISION IS REQUIRED. Please read all instructions completely before starting. Observe all safety precautions.
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