Plant Cells, Tissues, and Tissue Systems

Plants, like animals, have a division of labor between their different cells, tissues, and tissue systems. In this section we will examine the three different tissue systems (dermal, ground, and vascular) and see how they function in the physiology of a plant.

One of the best web pages I have found was done by Dr. David T. Webb,Assistant Professor of Botany, University of Hawaii at Manoa, Botany Department. He has some magnificent pictures and descriptions of specific plant cells. If you truly wish to see the inner beauty of plants, please visit Dr. Webb's page. You will notice that I have used some of Dr. Webb's pictures on this page for convenience, but I strongly recommend that you visit Dr. Webb's page for the full story on plant cells.

This section starts with a table showing all of the cells, tissues, and tissue systems. Following the table are detailed descriptions and illustrations.

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Tissue Systems, Tissues, and Cell Types in Vascular Plants

Tissue System	Tissue	Cell Types and Their Functions
Dermal	Epidermis	Parenchyma Cells: **Guard Cells of Stomata:** Regulates the size of stomata. This in turn regulates the amount of water loss, oxygen & carbon dioxide exchange in the plant leaf. **Trichomes (hairs)**: Expansion of the boundary layer, retardation of water loss, control of heat exchange, light piping, storage of secondary compounds, secretion, protection **Nectary cells**: Secretion **Epidermal cells**: Protection, support, reduction of water loss.
		Sclerenchyma cells: **Sclereids**: Protection and support
	Periderm	Cork cells (phellem) and Parenchyma cells (pheloderm): Protection

Ground	Parenchyma	Parenchyma cells: photosynthesis, storage, support Laticifers: Secretion, storage of secondary metabolites Oil Ducts: secretion Resin & Gum Duct epithelial cells: secretion
	Collenchyma	Collenchyma cells:photosynthesis, support, gravity perception in grasses
	Sclerenchyma	Fibers: support, protection Sclereids: support, protection
Vascular	Xylem	Vessel Members: Water & mineral transport, support. Mostly in advanced angiosperms Tracheids: Water & mineral transport, support. Mostly in gymnosperms and lower angiosperms Sclerenchyma Cells: Fibers & Sclereids: support, protection Xylem Parenchyma Cells: storage, short distance transport Laticifers: secretion, storage of secondary metabolites Resin & Gum Duct Epithelial Cells: secretion
	Phloem	Sieve Tube Members & Companion Cells: transport of sugars, organic nitrogen compounds, and growth regulators in angiosperms Sieve cells, Albuminous Cells: transport of sugars, organic nitrogen compounds, and growth Sclerenchyma Cell: Fibers, Sclereids: support, protection Phloem Parenchyma Cells: storage and short-distance transport Laticifers: secretion and storage of secondary metabolites Resin & Gum Duct Epithelial Cells: secretion

Dermal Tissue System:

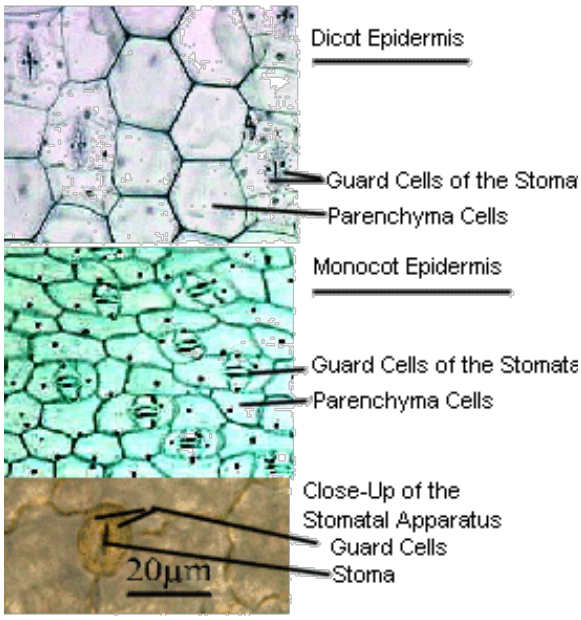
The dermal tissue system makes up the outside covering of the plant. This system consists of

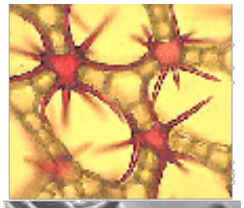
the epidermis and the periderm.

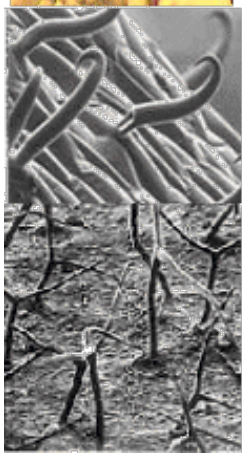
Epidermis:

The epidermis consists of a single layer of cells that covers the majority of young plants. The epidermis is present throughout the life of plants that exhibit only primary growth. Primary growth refers to cells and tissues that originate from the apical meristems. Apical meristems are regions of dividing cells located at the tips of stems and roots.

Parenchyma Cells: Living, thin walled cells. Variable in shape. Lack chloroplasts. These cells cover the outside surface of herbaceous plants. Little gas exchange occurs through these cells, due to a thick covering of a lipid compound call cutin.
Sclerechyma Cells: Parenchyma cells that have developed secondary cell walls. There are two main types: **fibers** and **sclereids**. Fibers are long and narrow. They protect and support other tissues due to their thick lignified cell walls.
Stomata (pl.), **Stoma** (sing.): Small openings scattered throughout the epidermis. Stomata are important for gas exchange and transpiration. Each stoma is surrounded by two guard cells which contain chloroplasts. The guard cells control the size of the stomatal opening, and thus control the amount of gas exchange and transpiration.
Trichomes: These are small hairs on the plant surface. They are epidermal extensions that can alter the boundary layer over a leaf surface.. Trichomes function in light piping (concentrating light on the underlying tissues). They aid in reducing water loss through transpiration. They can also alter heat loss from a plant, and act in storage and secretion of secondary metabolites. Root hairs are also trichomes that aid in water and mineral absorption.




Examples of Trichomes



Periderm:

When plants increase in girth due to secondary growth, they slough off their epidermal tissues and replace them with periderm. The periderm is composed of cork cells (phellem) that have thick walls impregnated with suberin (a waxy substance which protects and waterproofs the surface of the cells). Cork cells are not very strong, and therefor are

continually added to the plant as it grows. Periderm may also contain unsuberized,thin-walled parenchyma cells call phelloderm. Water and gas exchange occurs through openings called lenticles. Although the function of lenticles is the same as the stomata, lenticles cannot control the size of their openings. The corks found in wine bottles are cut from the bark of *Quercus suber*. In order to prevent wine bottle corks from leaking, they are cut at right angles to the lenticles

Ground Tissue System:

Ground tissue consists of all tissues not included in the Dermal and Vascular Tissue Systems. Ground tissue has a wide variety of functions, even though it is composed of fairly simple tissue types.

Parenchyma Tissue:

The most abundant, diverse, and versatile cells in a plant are found in the parenchyma tissue. Parenchyma cells have thin cell walls, and their structure is somewhat non-descript, but tend to be more or less isodiametric (equal diameters in all directions). What distinguishes these cells are their many and varied functions. Some examples are:

Starch storage tissues of tubers: contain a large amount of amyloplasts (organelles where starch is stored).
Transfer Cells: rapid transport of food metabolites associated with veins of leaves and nectaries of flowers.
Stellate Parenchyma Cells: found in ground tissue in aquatic plants that are composed of star-shaped cells with large intercellular spaces between the arms used as air canals.
Water storage cells: the stems of cacti have cells within the cortex that store large amounts of water.
Chlorenchma Cells: found in the mesophyll of leaves contain large amounts of chloroplasts.

Collenchyma:

Collenchyma cells differentiate from parenchyma cells and are alive at maturity. Collenchyma cells have uneven thickenings in their primary cell walls. Collenchyma cells are important for support of the growing regions of shoots, roots, and leaves. They are found in expanded leaves, petioles, and near the apex of stems. Adaptations of collenchyma cells that aid in their support function are: (1) ability to stretch due to their nonlignified cell walls, (2) elongated or cylindrical structure which maximizes support.

Sclerenchyma:

Sclerenchyma have thick, nonelastic secondary cell walls and are dead at maturity. Sclerenchyma cells support and

strengthen nonexpanding tissues of the plant such as mature roots, stems, and leaves. There are two types of sclerenchyma cells, sclereids and fibers, which are distinguished by their shape and grouping. Sclereids are variable in shape, are short, and exist singularly or in small groups. Fibers are elongated and slender and exist either singularly or in bundles.

Sclereids: occur throughout a plant. They are responsible for hard seed coats, and hulls of pea pods. Sclereids are found in the flesh of pears where they give the gritty texture.

Fibers: originally differentiate from parenchyma cells after their extension. Fibers are classified in several ways. Commonly, fibers are classified according to their location within the plant. For example, xylem fibers or phloem fibers. Commercially, fibers are classified according to their strength. For example, hard fibers (ones that contain large amounts of lignin - usually from associated xylem cells), and soft fibers (ones that do not contain lignin). Hard fibers such as jute (from *Corchorus capsularis*), hemp (from *Musa textilis, Furcraea gigantea, Cannabis sative*), and sisal (from *Agave sisalana*) are used for making ropes, cords, and twines. Soft fibers such as flax (form *Linum usitatissimum*) are used for making linen, and also ramie (form *Boehmeria nivea*) which is also used for making textiles. Cotton, however, is not a sclerenchyma fiber. Cotton is formed from elongated epidermal cells that form from trichomes on the surfaces of seed coats.

Vascular Tissue System:

The vascular tissue system is important in transport. The vascular tissue system is composed of the xylem (transport of water and dissolved minerals) and phloem (transport of food - usually sucrose and other sugars-, nitrogen containing compounds, and hormones). The xylem and phloem in the primary plant body are usually closely associated in the form of vascular bundles. In woody plants the xylem forms the wood of trunks and branches as well as the central core of the roots. The bark of a tree is a mixture of old, nonfunctional phloem and the young functional phloem (periderm).

Xylem: There are two types of conducting cells in xylem, tracheids and vessel elements. Both have thick lignified secondary walls and are dead at maturity. These cells create hollow cylinders that have high tensile strength. Materials moving within the xylem are under tension. Therefor the high tensile strength of the xylem cells keeps them from collapsing. Transport in the xylem occurs in one direction = roots->stems->leaves.

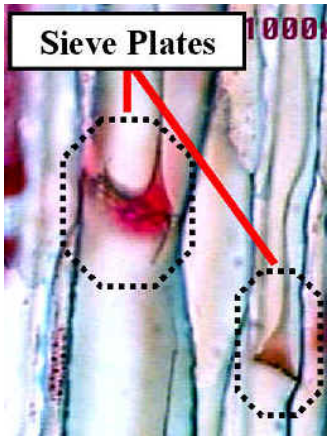
Tracheids: long, slender cells with overlapping, tapered ends. Water moves between tracheid cells via the bordered pits. Bordered pits are thin areas in the cell walls where only primary cell wall material has been deposited. Tracheids are the more primitive (less specialized) of the two xylem cells. They are found in most woody, nonflowering plants.

Vessel Elements: short, wide cells arranged end to end. Their end walls are partially or wholly dissolved allowing them to form long, hollow tubes up to 3 meters long. The larger diameter and lack of end walls allows vessel elements to transport water more rapidly. Vessel element are evolutionarily more advanced than tracheids. They are found in angiosperms and are one of the major reasons why angiosperms the dominant land plant.

Xylem Fibers and Xylem Parenchyma: Fibers lend support to the woody tissues (especially in plants with tracheids) while the parenchyma cells function to store metabolites, or function in secretion (resin ducts and laticifers).

Phloem: Phloem transports dissolved organic material throughout the plant. Transport within the phloem is from source to sink. This means that the direction of movement of materials within the phloem may change over time. This movement depends on the time of year and age of the plant. Phloem cells are alive at maturity, mainly because movement of materials within the phloem requires energy. Also, the materials moving within the phloem are under pressure, which means that the cell walls of the phloem cells do not have to have as great a tensile strength.

Sieve Cells: more primitive phloem conducting cells of ferns and conifers. Sieve cells are long and tapered with overlapping ends. They have sieve areas, fields of pores scattered over their cell wall surface. These areas allow direct contact between the protoplasts of adjacent cells. The pores are surrounded by callose, a complex carbohydrate that can block the pore opening after injury. Associated with the sieve cells are **Albuminous Cells** that play a role in aiding the movement of materials within the phloem.



Sieve Tube Members: more advance phloem conducting cells of angiosperms. Sieve tube members are short and wide, and arranged end to end into sieve tubes. The sieve pores are large and are concentrated along the end walls of adjacent sieve tube members. These specializations allow solutes to move more rapidly in sieve tube members and sieve cells. At maturity the nuclei in the sieve tube members disintegrates, the ribosomes disappear, and the tonoplast (vacuole membrane) breaks down. Mitochondria and plastids are still present. Sieve Tube Members are always associated with **Companion Cells** which control the metabolism of the cells. These two cells are connected by numerous plasmodesmata. The companion cells aid in the movement of materials into and out of the sieve tube members. Sieve tube members also contain P-protein, which stands for Phloem-

protein. This protein is located along the longitudinal walls of the cells. Some sieve tube members also contain a glucose polymer called callose. Both P-protein and callose are responsible for sealing wounds in the sieve tubes.

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