Plant Tissues

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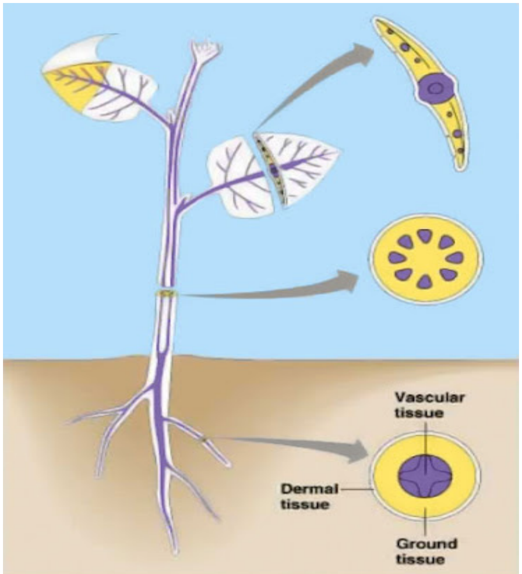
Introduction

Like animals, plant organs also contain tissues. A group of cells that perform a specialized function come together to form tissues. Several types of cells that perform a common task in plants are arranged among themselves to form tissue systems. In other words, a tissue system consists of more than one tissue. Each plant organ (root, stem, leaf) is composed of these tissue systems (ground, vascular, dermal tissue systems). Each tissue system is continuous throughout the entire body of the plant, but is arranged differently in the root, stem, and leaf.



We can generally classify plant tissues under two main headings.

1. Meristematic tissues

2. Permanent tissues

   Dermal tissue

   Ground tissue

   Vascular tissue

   Secretory tissue

Figure 1. Three Tissue System (Campbell and Reece, 2001/2006)

1. Meristematic Tissues

The growth and elongation of the plant occurs by the division and expansion of the cells at the root and shoot tips. This growth is carried out by a tissue called meristem, which consists of cells with a large nucleus, abundant cytoplasm, small and thin walls, and no intercellular spaces. Meristematic cells have the feature of continuous division, thus allowing the plant to grow in length and width. These areas where growth takes place are called growth points. Meristematic tissues are classified according to their location and origin.

A. Meristems by Location

1. Apical (at the tips) meristem: The meristem tissues located at the tips (buds) of the root, stem and their side organs are called apical meristem. It allows the plant to elogation. This elongation, called primary growth, allows the roots to spread in the soil and the shoots to have more contact with light and carbon dioxide. Herbaceous plants only show primary growth. Secondary growth is also seen in woody plants.

2. Intercalary meristem: These are the meristems that remain between the permanent tissues. Leaves, flowers and fruits reproduce their size by division of intercalary meristems. Together with the apical meristem, it ensures the longitudinal growth of the plant.

2. Lateral meristem: It is the meristem tissue that extends along the root and stem and provides the transverse growth of the plant. It is mostly found in plants with secondary growth. Secondary growth in woody plants occurs by the lateral meristem. The cambium on the stem is a good example of lateral meristems. The cambium maintains its effectiveness throughout the life of the plant, it is located between the xylem and the phloem and divides in both directions, allowing the plant to thicken.

B. Meristems by Origin

1. Primary meristem: It is the meristem that does not lose its ability to divide during the life of the plant from the embryo. The apical meristems located at the ends of the roots, stems and lateral branches, called the growth points in plants, produce primary meristem cells. These parts provide both the elongation of the plant and the origin of the tissues that make up the organs. When cross-sections are taken from the growth points, it is observed that there are three layers called dermatogen, periblem and plerome from the outside to the inside. Dermatogen gives rise to epidermal tissue, periblem gives rise to ground tissue and the plerome gives rise to vascular tissue.

2. Secondary meristem: It is formed as a result of the cells in the state of Permanent tissue gaining the ability to divide by the effect of environmental factors or hormones. For example, when a branch of the plant is cut off, some cells begin to divide to close that area and a secondary meristem is formed. Secondary meristem provides transverse thickening in the root and stem parts of the plant that grows longitudinally. Two lateral meristems called cambium and cork cambium are responsible for this transverse thickening.

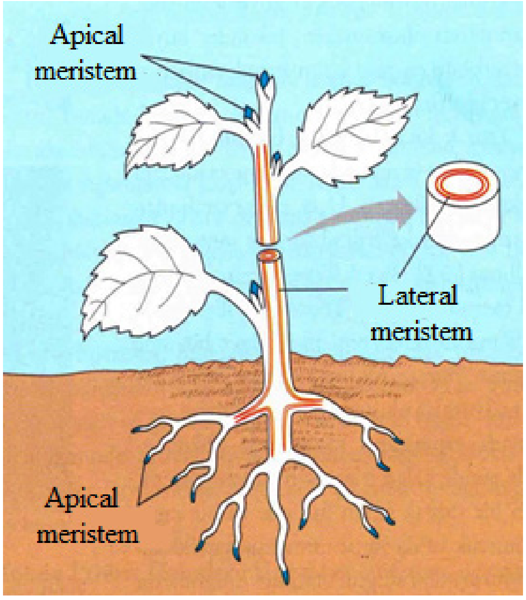


Figure 2. Meristem Regions (Campbell and Reece, 2001/2006)

2. Permanent Tissues

They are tissues that have formed as a result of the development and differentiation of primary and secondary meristem cells and have lost their ability to divide. They can be dead or alive. Their cells have little or no cytoplasm, thick cell walls and wide vacuoles. They have intercellular spaces. With these features, they can be distinguished from meristem cells.

A. Dermal Tissue

It is the tissue that covers the entire surface of the plant and protects the plant organs against water loss, various physical and chemical effects, and disease-causing organisms. Epidermis and Peridermis is dermal tissue.

1. *Epidermis*

Tissue found in young parts of herbaceous and woody plants. It covers organs such as roots, stems and leaves. Its viable, large vacuole, little cytoplasm cells are tightly packed and lack chloroplasts. It is specialized according to the function of the organ it covers. For example, extensions of epidermal cells near the root tip form root hairs, which are important for the plant's water and mineral absorption.

The epidermis of most stems and leaves secretes a waxy and transparent covering called the cuticle. The cuticle prevents excessive water loss in the above-ground parts of the plant. It also provides mechanical support to the plant and protects the plant against microorganisms. The thickness of the cuticle layer varies according to the environment in which the plant is located. It is thick in arid zone plants and thinner in humid zone plants.

Epidermis cells differentiate and form specialized structures to perform various tasks. These are structures such as.

Stoma (pore): Since the tightly arranged epidermis cells completely cover the outer surface of the plant, stomata have developed to provide gas exchange between the internal and external environment. Stomata are formed by the coming together of two bean-shaped stomatal cells (guard cells) with a stomatal opening (pore) between them. The epidermal cells around the stomatal cells. Stomatal cells are cells with abundant cytoplasm containing chloroplasts. The stoma has the ability to open and close depending on the amount of water the plant receives and the light. Thus, the amount of water vapor given by the plant by transpiration is adjusted and the CO_2 required for photosynthesis is taken from the atmosphere and the excess O_2 and water vapor are removed from the plant.

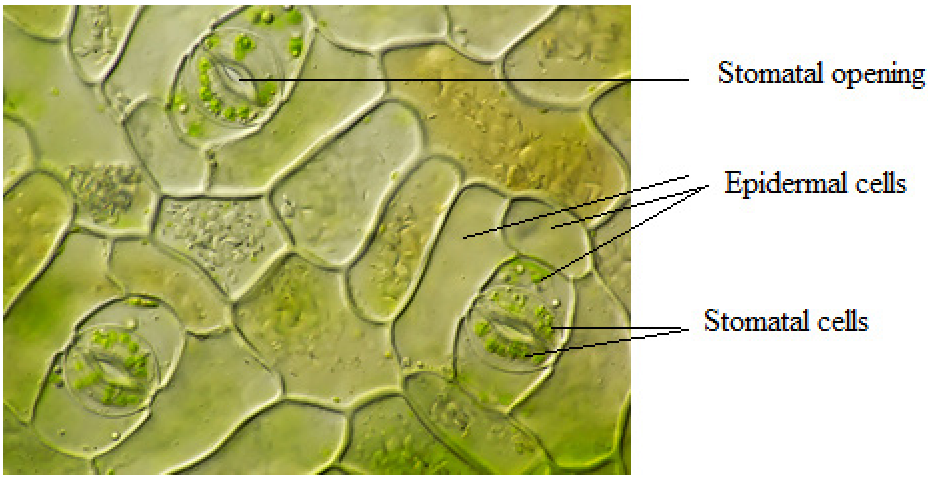


Figure 3. Stomata (https://microscopyofnature.com/stomata)

Hydathode: The openings that throw water out of the plant by dripping (gutation) are called hydathodes. It is found on the edges of the leaves of plants that grow especially in areas with high humidity. It does not have the ability to open and close like stomas. When the air is saturated with moisture, it activates and ensures that the plant takes the water from the soil.

Epidermal Hairs: Epidermis cells sometimes form outward projections to form hairs. Epidermal hairs protect the plant in hot conditions by reducing water loss; especially used as a means of defense against animals; in some climbing plants, it helps the plant to hold on to the support; secretes some substances such as tannin, resin, essential oil out of the plant; It takes part in the absorption process as in root hairs. They can consist of a single cell or multiple cells.

Figure 4. Leaf Hairs in *Solanum quadriloculatum*

(https://www.vcbio.science.ru.nl/en/virtuallessons/leaf/basicanatomy/)

Emergens: Unlike epidermal hairs, they are harder structures that do not only consist of the epidermis, but also form with the participation of the tissues under the epidermis. Emergens have duties such as protection, defense, secretion or attachment. For example, spines found on plants such as rose (Rosa) and blackberry (Rubus) are attachment emerges.

2. *Peridermis*

In plants with secondary growth (perennial), since the plant becomes thicker and the epidermis cannot perform its protective function, a fungal protective tissue formed by the accumulation of suber on its walls develops instead. This tissue is either formed by the accumulation of suberin in the epidermis and the walls of a few cells below it, or the epidermis is fragmented and replaced by the peridermis. Peridermis replaces epidermis in roots and stems and becomes a second protective tissue. It consists of three layers: Phellogen, phelloderm, and phellem.

Phellogen is a secondary meristem called the cork cambium. It occurs when the epidermis or the continuous tissue cells under it gain the ability to divide again. Phellogen cells divide outward to form phellem, and inward divide to form phelloderm.

The phelloderm is the innermost layer of the peridermis. Cell walls are cellulose and not fungal. It can contain chloroplasts, perform photosynthesis and store starch.

The cell walls of this outer layer of the phellem thicken with the accumulation of suberin and form the cork tissue. They do not have intercellular spaces, are tightly arranged, and their cells are dead because their walls are thickened. With these properties, it reduces the permeability of the plant to gases and water. Thus, instead of stomata, openings called lenticels have developed to allow the gas exchange of living cells with the outside environment.

B. Ground Tissue

It is a tissue composed of living and thin-walled cells found in all organs of the plant and responsible for most of the metabolic functions. This tissue forms the basic structure in plants, that is, it fills the parts between the covering and the vascular tissue. Organs have functions such as filling, supporting, photosynthesis and storage. It consists of three cell types as parenchyma, collenchyma, and sclerenchyma.

1. *Parenchyma*

Parenchyma cells are the most abundant cell type in most plants. They are described as a typical plant cell with a living, thin-walled, abundant cytoplasm and large central vacuole. It has several functions, including photosynthesis and storage. Parenchyma cells can divide and transform into other cell types, allowing the damaged parts of the plant to be repaired.

They are divided into four groups according to their duties:

a) Chlorenchyma parenchyma: They are found in the mesophyll layer of the leaves in the plant. They carry chloroplasts and thus synthesize organic matter by photosynthesis. Palisade parenchyma cells perform more photosynthesis in leaf blades that stand perpendicular to sunlight. Palisade parenchyma consists of long cylindrical cells near the upper surface of the leaf and contains abundant chloroplasts. Spongy parenchyma cells in the lower part of the palisade parenchyma also have more intercellular spaces and contain less chloroplasts.

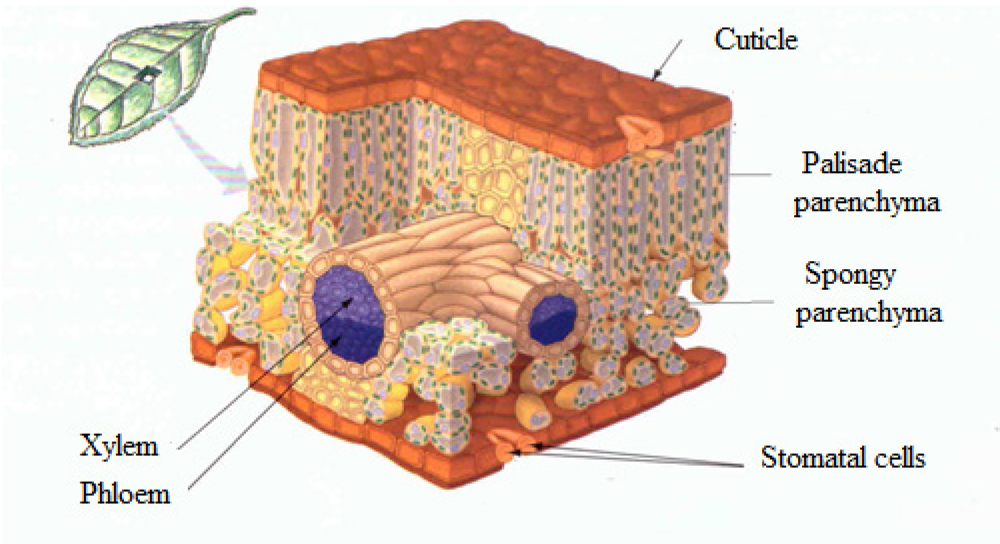


Figure 5. Palisade and Spongy Parenchyma (Modified from Simon, Dickey, Hogan and Reece, 2016/2017)

b) Aerenchyma parenchyma: It has large intercellular spaces. It is the parenchyma tissue that provides the exchange of substances between the cells and the external environment. Together with stomata, hydatodes and lenticels, it forms the ventilation system of the plant. It is mainly found in marsh and aquatic plants. For example, it is well developed in the aquatic plant Elodea.

c) Vessel parenchyma: It is the parenchyma that provides substance transmission between the vascular tissue and the chlorenchyma parenchyma. They do not have chloroplasts and are thin-walled cells. They are located around the vascular tissue.

d) Storage parenchyma: It is the parenchyma that stores substances such as carbohydrates, fats, proteins and water in plants. It is found in organs such as roots, stems, seeds and fruits of plants. Plants with water-storing parenchyma are called succulent plants (cactus, etc.). Especially in plants living in arid and salty environments, the storage parenchyma is well developed.

2. Collenchyma

It is the tissue that gives plants properties such as bending and stretching and prevents them from breaking. Young stems and petioles often have a cylinder of collenchyma just below the surface. For example, strips of celery stalk. Cells are viable, their walls are thicker than parenchyma cells. Irregular thickenings are seen with the accumulation of cellulose and pectin in their walls. Collenchyma cells are named according to these thickening regions. If the thickening occurs at the corners, it is called the corner collenchyma, and if it is on the tangential walls parallel to the periphery, it is called the plate collenchyma.

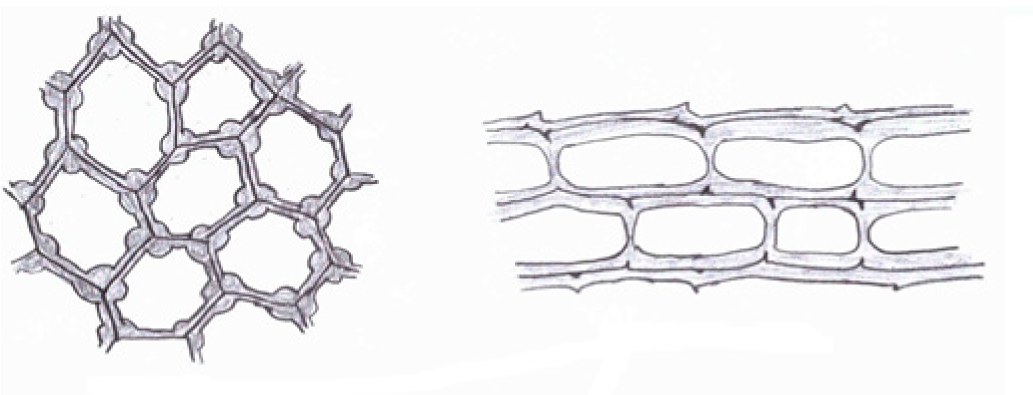


Figure 6. Corner Collenchyma and Plate Collenchyma

3. Sclerenchyma

It is a tissue that gives the plant rigidity and allows the stem to stand upright. Their cells are dead. It is thick and hard as a result of the accumulation of lignin and cellulose in its walls. This tissue consists of two types of cells, sclerenchyma fibers and stone cells.

Sclerenchyma fibers are narrow, long, dead cells with thick walls, pointed ends. Often found in groups. They are tensile resistant and durable fibers. As an example, we can give 20-40 mm long fibers of the Linum (flax) plant. These fibers are used in linen weaving.

Stone cells are spherical, polygonal, cylindrical or randomly protruding dead cells close to their length. For example, the hard particles found in the impact parts of quince and pear fruits are stone cells. It is also found in the shells of plants such as hazelnuts, walnuts, almonds.

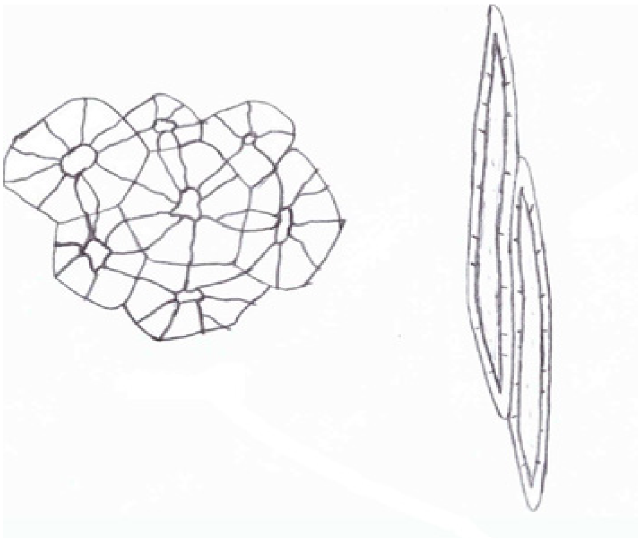


Figure 7. Stone Cells and Sclerenchyma Fibers

C) Vascular Tissue

It is the conduction tissue that provides the transport of substances between the root and the stem and is spread all over the plant body. Conduction tissue carries out the transmission of water and dissolved substances in the soil to organs far from the soil, and the organic matter formed in the assimilation organs to the organs that cannot assimilate for use or storage. For this reason, a transmission occurs from the root to the leaves and from the leaves to the root in a plant. There are two types of vascular tissue: xylem and phloem. In advanced plants, xylem and phloem usually coexist and form vascular bundles. They also provide support to the plant.

1. *Xylem*

The xylem carries water and dissolved minerals from the roots to the stem and leaves. The cell walls are thick, hollow and composed of dead cells. The water-conducting elements of this tissue, which continues uninterrupted from the roots to the leaves, are the trachea and tracheids.

Trachea and tracheids are formed in plant parts where elongation stops. When living cells lined up on top of each other reach functional maturity, they lose their vitality and form a groove in which water can flow. The walls of these end-to-end cells do not have full thickening, but there are non-thickened areas called passageways. The side walls of the cells also remain intact and take the shape of a regularly elongated wood pipe.

In general, the tracheas are wider, shorter, thinner-walled, and less pointed at the ends than the tracheids.

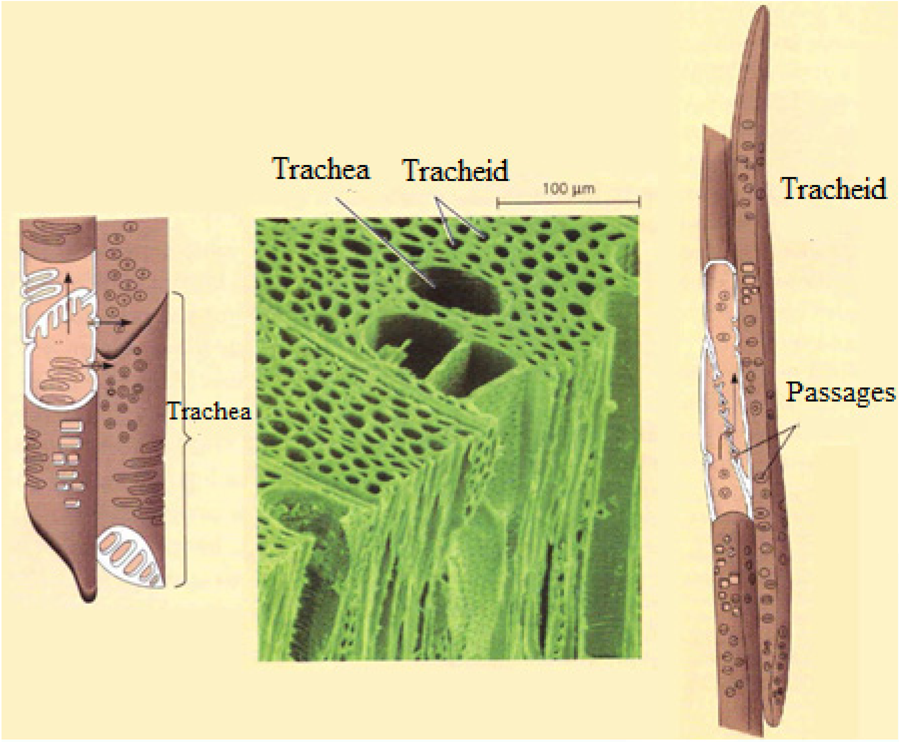


Figure 8. Trachea ve Tracheid (Campbell, Reece, 2001/2006)

2. Phloem

It is the tissue that carries organic substances produced by photosynthesis from leaves to other organs. Phloem tissue consists of two types of cells: sieve tubes and companion cells. In phloem tissue, sieve tubes do the main transport work. Sieve pipes are functionally mature and alive. Each sieve cell is attached end to end to form a column called a sieve tube. Between the sieve cells, a perforated (sieve-shaped) structure is formed by the melting of the end walls from place to place. This surface is called sieve plates. These plaques allow the assimilation products (sucrose, other organic substances, some ions) called phloem sap to pass from one cell to another. Sieve cells lack nuclei, ribosomes, and vacuoles, thus allowing phloem sap to flow easily through sieve tubes.

Next to each sieve cell is a cell called the companion cell, with abundant cytoplasm and large nucleus, which does not function as a communicator. These cells are connected to sieve tubes by channels called plasmodesms. All metabolic tasks of sieve tubes are performed by companion cells. For example, the P-protein secreted by the companion cells is delivered to the sieve cells, and this protein clogs the holes of the injured sieve cells, preventing the phloem sap from flowing out. Primitive plants (ferns and gymnosperms) do not have companion cells, they are found in angiosperms (angiosperms).

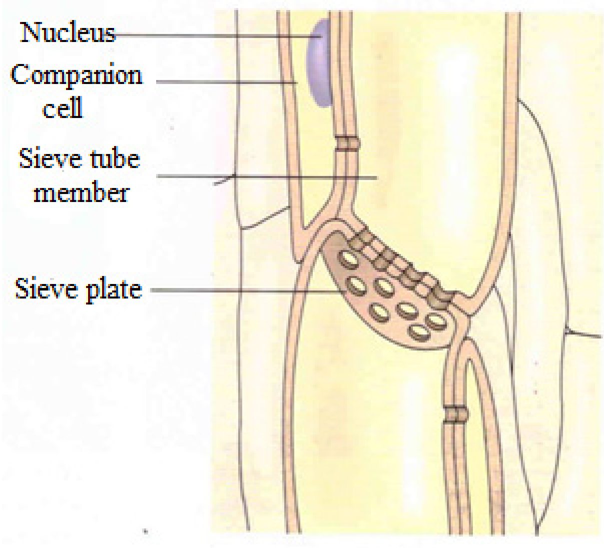


Figure 9. Floem (Campbell, Reece, 2001/2006)

Vascular Bundle: Phloem and xylem are usually found side by side. The entire tissue formed by the phloem and xylem is called the vascular bundle. The vascular bundle consisting of only phloem or only xylem is rarely encountered.

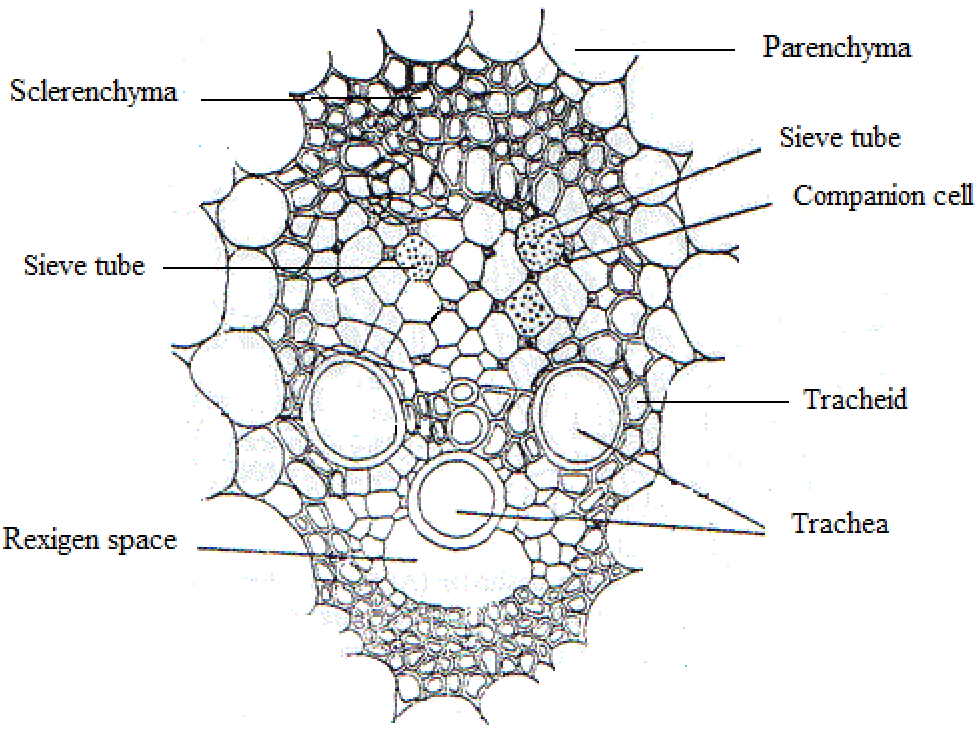


Figure 10. Vascular Bundle (Modified from Kadıoğlu and Kaya, 2001)

D) Secretory Tissue

Cell groups that secrete solid or liquid substances such as water, alkaloid, glycoside, nectar, mucilage, latex, resin, ethereal oil and tannin, which are formed as a result of metabolism in plants, are called secretory tissue. It consists of living cells with abundant cytoplasm and large nuclei. Cells are scattered among other tissues individually or in groups. The secretions they produce play an important role in plant life. For example, antiseptic substances such as tannin and resin protect the plant against rotting, while substances such as alkaloids and glycosides protect the plant against enemies. Substances such as lignin, suberin and cutin also increase the resistance of the cell wall.

Secretory cells are structures that either accumulate their secretions inside the cell or send them out of the cell. Secretory cells that accumulate the secretory substance inside the cell lose their cytoplasm and become dead. For example, etheric fat cells in honeydews are of this type. The secretions in this type of cells are thrown out if the cell is damaged. For example, we see that a yellow or white substance called latex (milk) is flowing from the spurge branch that we take and break.

In cells that release the secretory substance out of the cell, the secretion is either stored in the secretory pockets (intercellular spaces) within the plant or excreted from the plant. The resin secreted by the pine (Pinus) plant or the enzymes secreted by the insect trapping plants (Drosera, Nepenthes and Sarracenia) out of the cell can be given as examples of this type of secretion.

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