Chapitre 3 : anatomy of higher plants

INTRODUCTION

Anatomy (ana- = through; -tomie = section) is the study of the internal structure of a plant, i.e. the arrangement of tissues within an organ (root, stem, leaf). Plants have two structures: a primary structure (primary meristem) that allows them to grow in length. This first structure is common to all plants (pteridophytes and spermatophytes). In a second phase, a secondary structure is established within the primary structure, allowing the plant to grow in thickness. The secondary meristems, cambium and phellogen, are absent in monocotyledons.

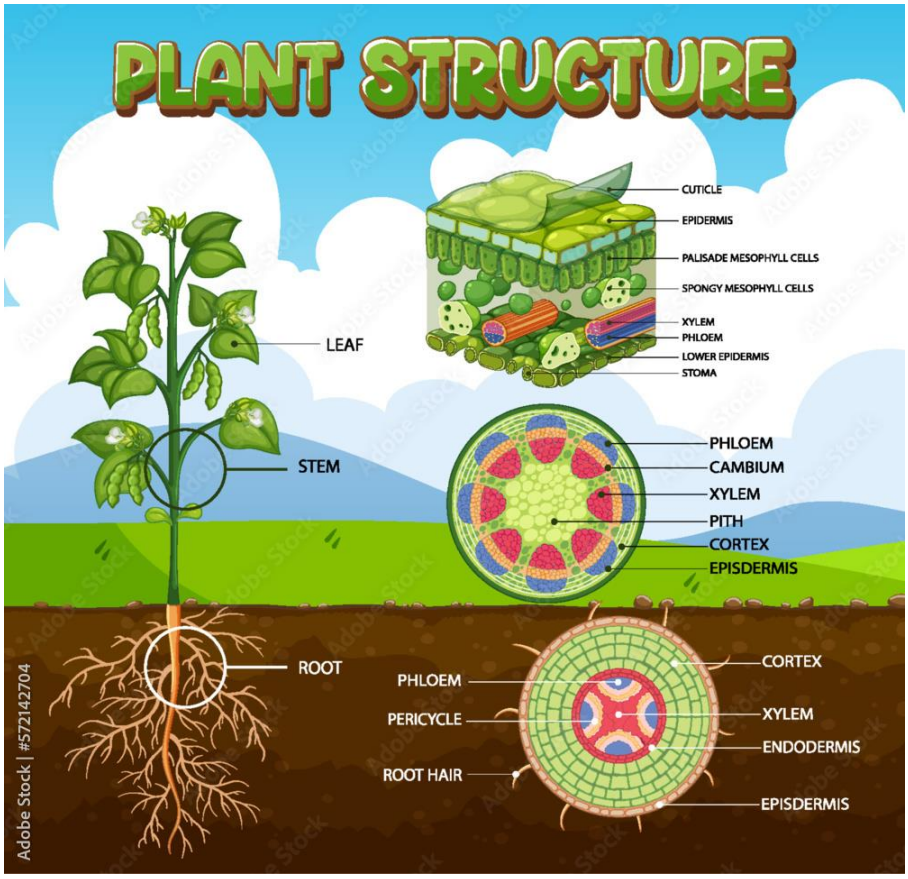

Figure 1: Internal plant structure.

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3.1 Root study

3.1.1 The Anatomical Structure of a Root

3.1. 1.1 General characteristics of a root:

The root is the subterranean organ of a plant that connects it to the soil and draws from it the water and nutrients necessary for its development. The root can also play the role of a reserve organ resulting from the development of the radicle of the embryo contained in the seed. It can have two successive types of structure:

- Primary structure in young seedlings,
- Secondary structure in older plants, but only in dicots and gymnosperms.

A cross section of a young root at the level of the absorbing hairs shows axial symmetry and allows us to distinguish several structures from the outside to the inside:

① **Cortex** (composed of rhizodermis and cortical parenchyma)

a- The absorbing hairs on the rhizoderm are extensions of the rhizoderm cells. The rhizoderm evolves with the age of the root, which grows at its apex and may be doubled or replaced by an exoderm consisting of one or more layers of cells whose wall may be suberized and lignified. This exoderm helps to limit the loss of water from the root to the soil.

b- The cortical parenchyma is made up of contiguous cells in the shape of a parallelepiped, elongated in the direction of the root axis, leaving large meaty spaces between them.

②**Central cylinder** (composed of endodermis, pericycle, conductive tissue, and medullary parenchyma).

by the endodermis (a layer of cells between the cortex and the stele). It is bounded by the pericycle (a single layer of cells responsible for the appearance of secondary roots). More centrally, the vascular tissues of the root are represented by the xylem vessels, which alternate regularly in a single circle with the sieve tubes of the phloem. Near the pericycle, the xylem cells are young and small (protoxylem), while toward the center they are large and old (metaxylem). Xylem differentiation is centripetal in the root. The medullary parenchyma or pith has no special function. It may be lignified. In this case it becomes a supporting tissue.

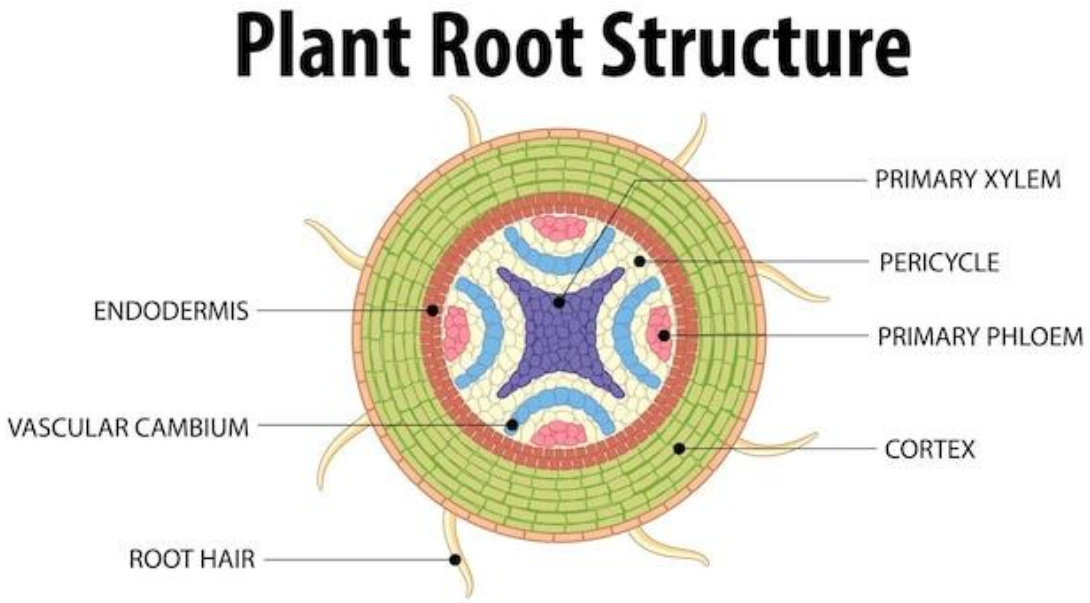

Figure 2: plant root structure. https://img.freepik.com/free-vector/isolated-root-plant-its-structure_1308-153399.jpg

A/Characteristics of a monocot root with primary structure

- The central cylinder (stele) is much more developed than in dicotyledonous roots,
- Numerous vascular bundles, from 8 to 20.
- No liberenchyma formation, metaxylem is more important,
- Marrow more abundant and filled by parenchyma.

- Cortical parenchyma shows large meats between cells,
- Endodermal lignification shows cells with completely suberized walls, except for the U-shaped outer wall

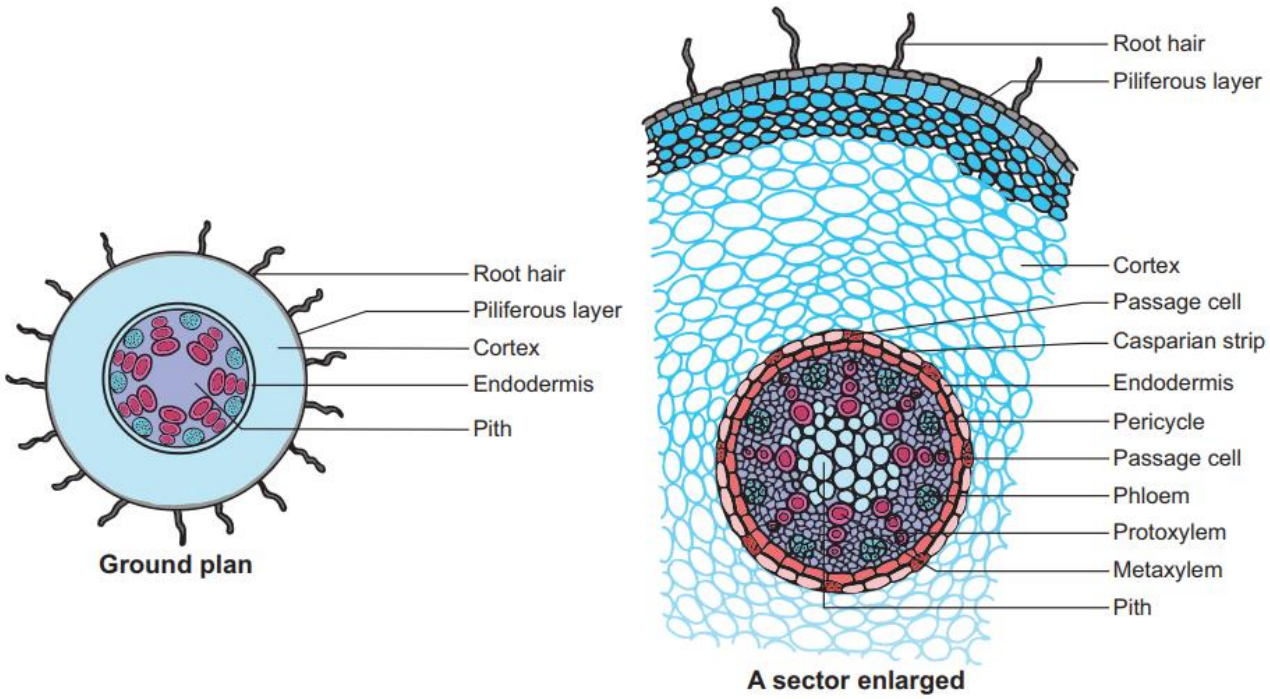

Figure 9.20: T.S of Monocot root (Maize root)

https://img.brainkart.com/article/article-Primary-Structure-of-cJx.png

B/General characteristics of a dicot root with primary structure

- **The cortical** parenchyma is sclerotized, with only the radial walls of the endodermis suberotized (Caspary band), often less visible than in monocots.
- **The endodermis** shows frame-like suberolignification,
- **Frequent appearance** of a cambium at the origin of secondary tissue formation, always between primary xylem and primary phloem. Presence of a cambium

- There are 5 or 6 vascular bundles.

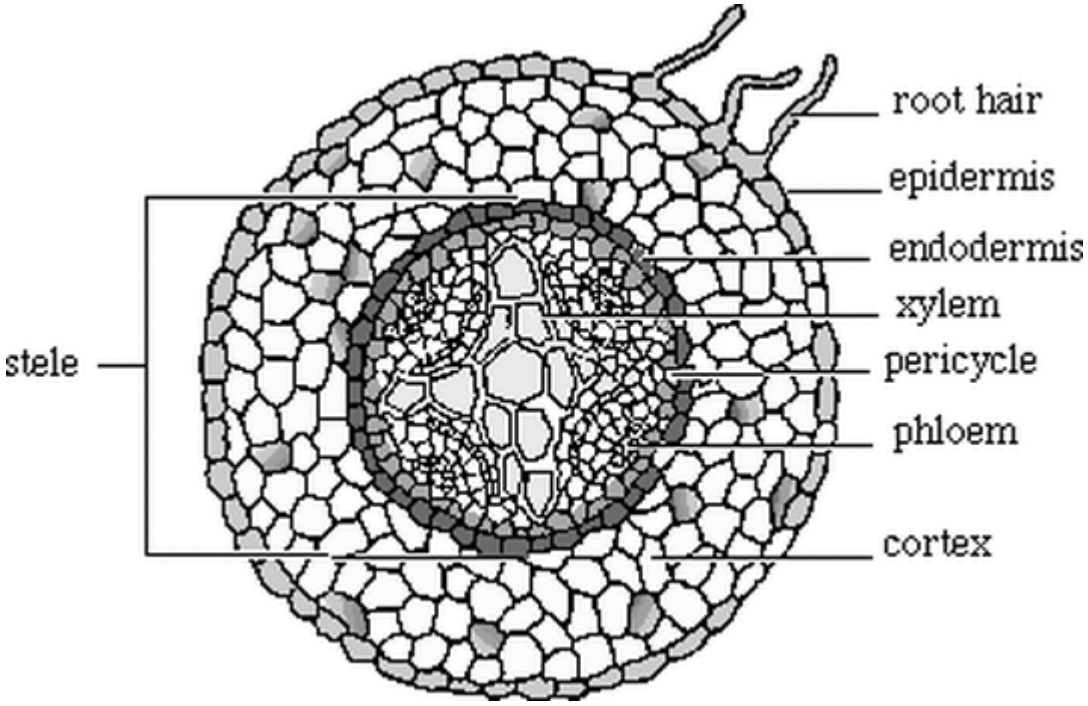

Figure 3: Annotated diagram of a dicot root **https://plant-structure.weebly.com/uploads/3/8/1/7/38170739/editor/image008.gif?1487646088**

C/ General characteristics of a dicot root with secondary structure

As the xylem and phloem bundles alternate, the cambium appears in the form of arcs on the inner surface of the phloem, by dedifferentiation (return of cells or tissues to a less differentiated state, closer to the embryonic state) of the medullary parenchyma, and on the outer surface of the xylem, by dedifferentiation of the pericycle. They unite to form a sinuous cambium, which produces wood (secondary xylem) (centripetal development) and liber (secondary phloem) towards the outside (centrifugal development). The extensive formation of secondary conducting tissues puts pressure on the sinuous cambium, which becomes circular. The

appearance of the subphyllodermal base is always much later than that of the cambium,

3.2 Studying the stem

3. 2.1. Anatomical structure of the trunk

3.2.1.1 General characteristics of the stem

The stem is made up of a series of nodes and internodes. It determines the habit of the plant by its mode of growth and branching. It is also the transit point for raw and processed sap between roots and leaves. In most dicots, this primary structure is completed by the formation of a secondary structure, thanks to the activity of two new meristems:

The cambium or libero woody generative zone, which produces the secondary xylem or wood and the secondary phloem or liber,

the phellogene or suberophellodermal generative zone, which gives rise to the cork or suber and the phelloderm.

Like roots, a cross section of a young stem shows axial symmetry and allows us to distinguish several structures from the outside to the inside:

- **The epidermis**, consisting of a layer of juxtaposed cells without chloroplasts. The outer surface is covered by a thin cuticle with hairs or spines and stomata.
- **Cortex** (cortical parenchyma), composed of large polyhedral cells with large flesh between them. Peripheral cells contain chloroplasts, but their number decreases as one moves inward. There are a few superficial layers of collenchyma. A continuous ring of sclerenchyma exists in the deepest part of the cortex.
- **Central cylinder:** is located under the cortex and unites in a medullary parenchyma, cribrovascular bundles (libero-ligneous bundles) distributed on the same cycle, presented in the form of

conductive tissues gathered in superimposed clusters (engainantes), the xylem is internal (tending towards the center), with centrifugal differentiation (the protoxylem, with a small diameter near the center, appears when the stem is growing, and the metaxylem, with a large diameter near the periphery, appears when the stem has finished growing); the phloem is external (moving towards the periphery). The phloem is also not homogeneous, although the differences between cells are less marked. It is possible to distinguish between protophloem and metaphloem. The differentiation of the phloem is centripetal. Each cribrovascular bundle is covered by a small mass of sclerenchyma.

- **Stem pith** is filled with extensive medullary parenchyma and supporting tissues.

A/Characteristics of a Monocot Stem with a Primary Structure

The primary structure of the monocot stem is characterized by :

➢ Bark absent or very reduced compared to the pith, which is highly developed and often lignified.

➢ Several concentric circles of criblovascular bundles.➢ Absence of secondary formations in monocots (no generative bases).

Thickness growth in monocots is achieved by multiplying the number of vascular bundles. The center of the stem is hollow in Poaceae (ex Graminaceae).

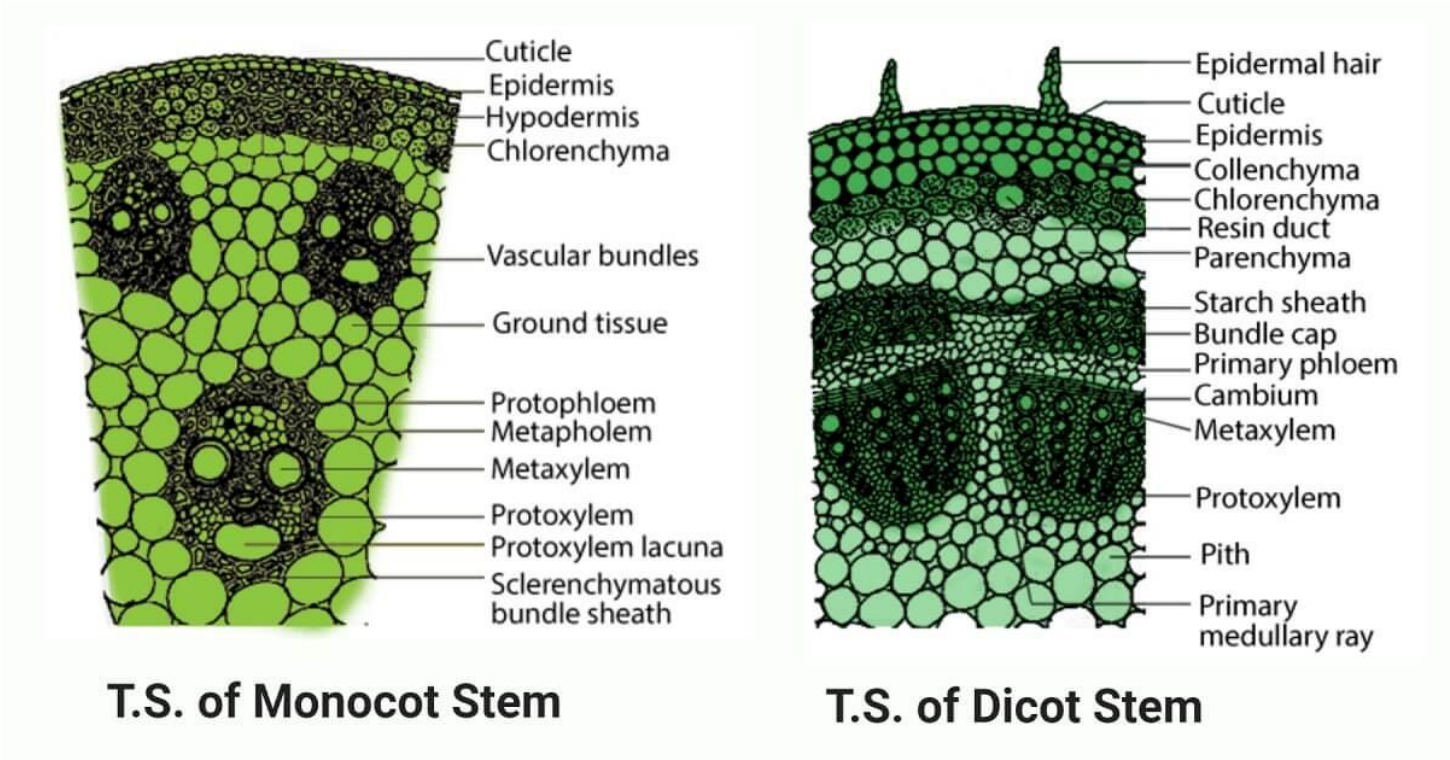

Figure 4: monocot and dicot stem. https://microbenotes.com/wp-content/uploads/2021/02/Monocot-and-Dicot-Stem.jpeg

B/General characteristics of a primary structured dicot stem

A young dicot stem is characterized by:

- A reduced number of vascular bundles (single circle) compared to monocots, which are represented by several concentric circles.
- The presence of cambium cells, which give rise to secondary structures. intra- and interfascicular
- The medullary parenchyma is more important than the cortical parenchyma and there is a ring of continuous sclerenchyma in the deep part of the cortex, sometimes there is a gap in the middle of the stem.

C/ General Characteristics of a dicot stem with secondary structure

Presence of secondary tissues (suber, phellogen, phelloderma, liber, cambium and wood)

3.3 Study of the leaf

3.3.1 Anatomical structure of the leaf

3.3.1.1 General features of the leaf

The leaf is formed by the cauline meristem at the tip of a bud and is usually composed of a petiole and a blade. Its flattened shape allows it to capture a maximum amount of light, enabling photosynthesis in the parenchyma cells. Photosynthesis allows the synthesis of organic matter, which is then distributed to other organs through the phloem. The cross-section of a leaf is bilaterally symmetrical. It is composed of:

Palisading parenchyma: located beneath the upper epidermis. It is composed of chloroplast-filled cells. Lacunar parenchyma.

Criblovascular bundles: these are the superimposed vascular tissues,

Epidermis (upper and lower): made up of closely packed cells covered with a cuticle, a waxy substance impermeable to water and air, the epidermis is dotted with stomata for gas exchange. The ostiole is the opening at the center of the stomata.

Mesophyll: basic tissue for photosynthesis, composed of Palisaded parenchyma, located just below the upper epidermis. Consists of chloroplast-rich cells Lacunar parenchyma consisting of a layer of less regular, loosely connected cells with large gaps between them. These cells are poorer in chloroplasts, especially toward the center of the leaf.

Nerves (cribrovascular bundles): The cribrovascular bundles are identical to those found in the stem. They are, in fact, a continuation of those on the stem and petiole and correspond to the veins on the leaf blade. They consist of superimposed xylem and phloem bundles, with the phloem bundles oriented toward the upper epidermis and the xylem

bundles toward the lower epidermis. Secondary formations appear rapidly in dicotyledons.

A/Characteristics of the Monocot Leaf

- Mesophyll generally homogeneous
- Parallel veins, stomata evenly distributed on ventral and dorsal surfaces

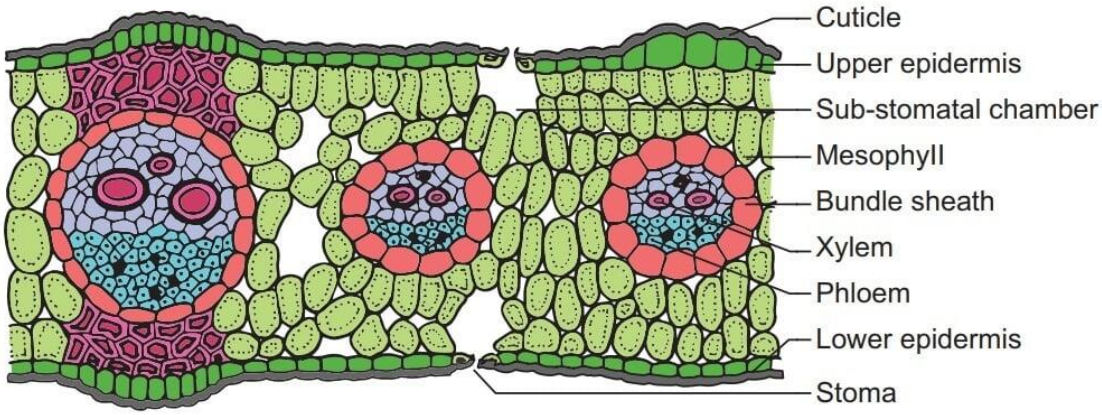

Figure 5 : T.S. of a monocot leaf (grass). Image Source: BrainKart. https://microbenotes.com/wp-content/uploads/2021/02/Monocot-Leaf-Structure-Grass.jpg

B/General characteristics of dicotyledonous leaves

- Reticulate venation, midrib very prominent, stomata more numerous on the dorsal surface.
- Heterogeneous mesophyll.

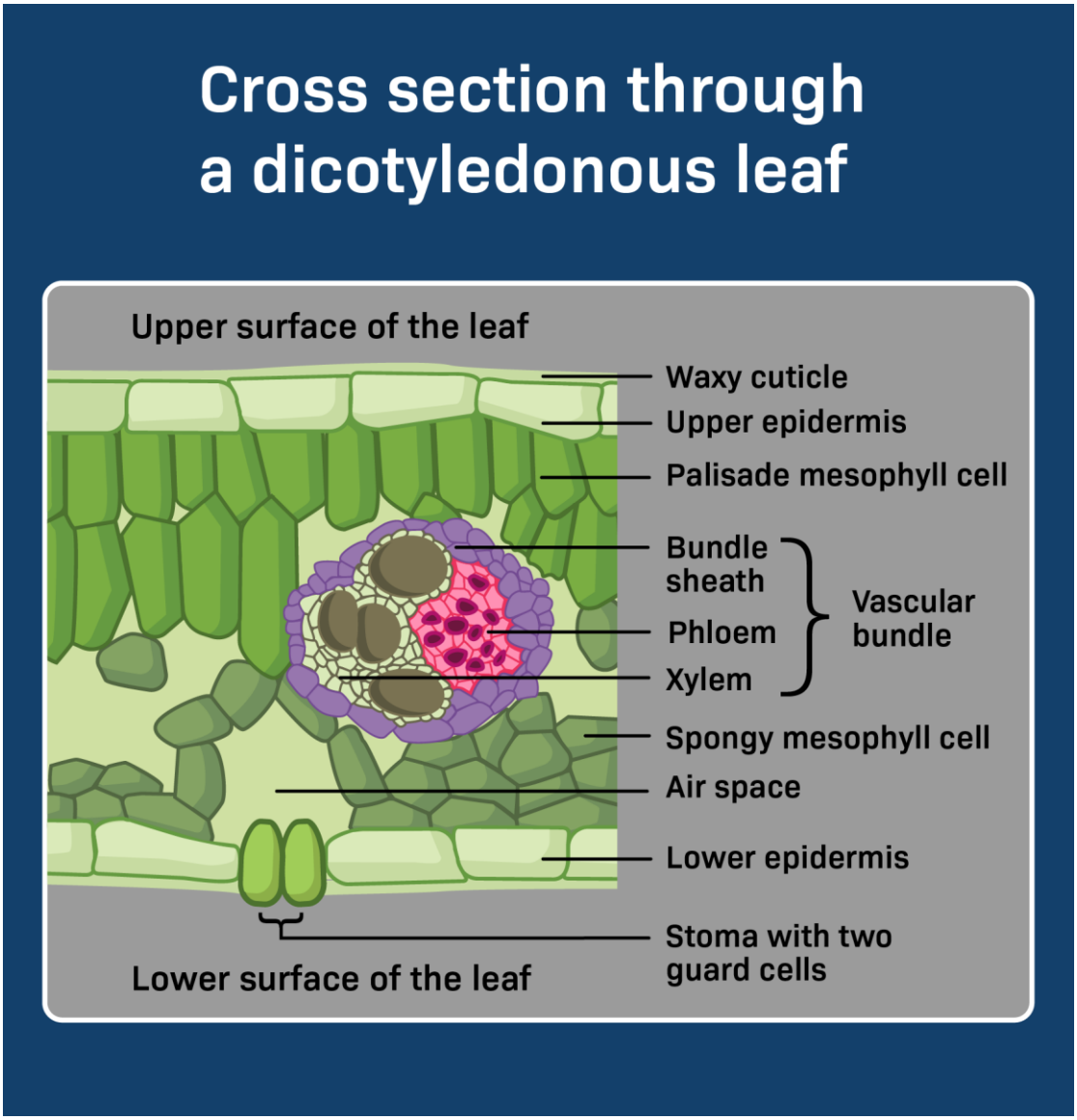

Figure 6: gross section though a dicotledonous leaf. *Image by LabXchange © The President and Fellows of Harvard College* https://api.www.labxchange.org/api/v1/xblocks/lb:LabXchange:55d1c136:lx_image:1/storage/d_o2_snapshots10-4406b470149620d9ead5011818c45e2b.png

4. Anatomical differences between dicot stem and monocot stem

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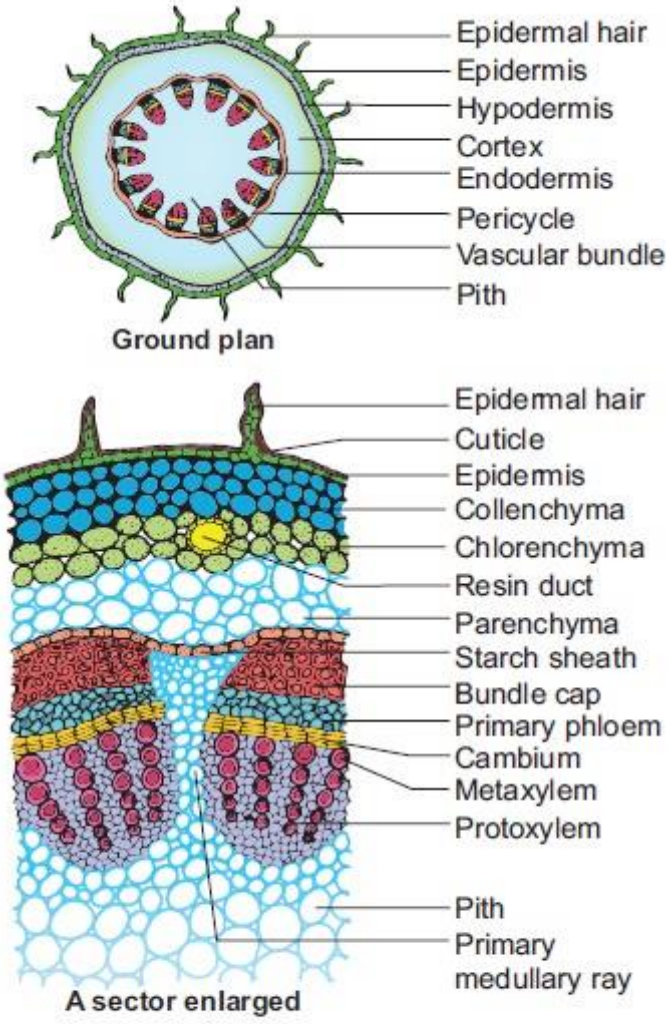

Figure 9.21: T. S of Dicot Stem
(Sunflower stem)

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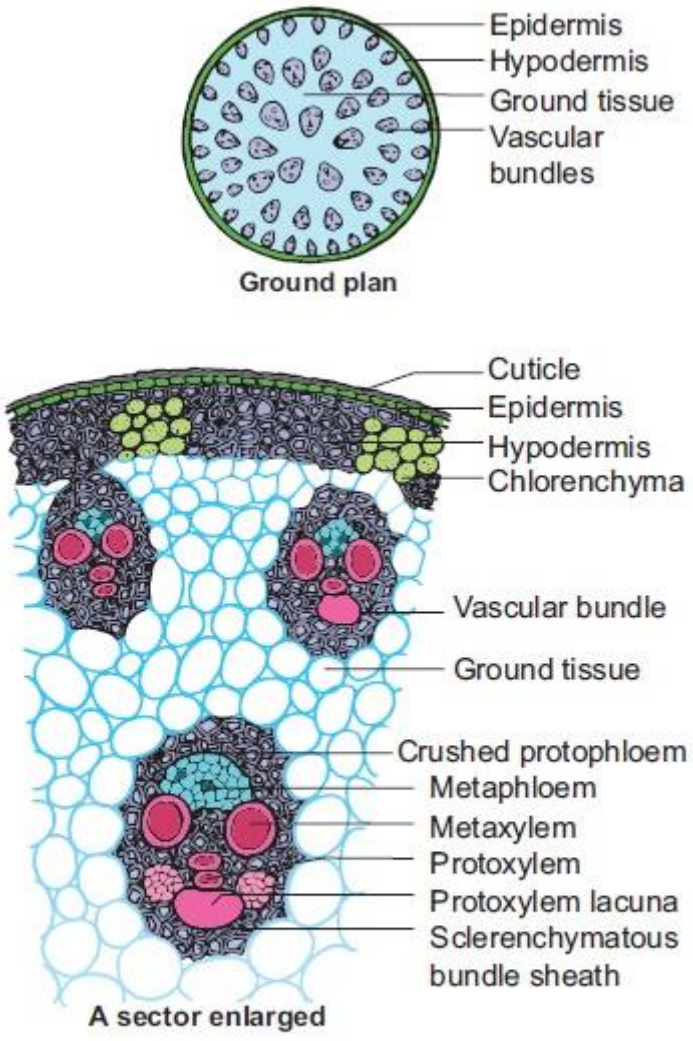

Figure 9.22: T.S. Monocot stem
(Maize stem)

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1. Hypodermis

Characters of Dicot Stem : Collenchymatous

Characters of Monocot Stem : Sclerenchymatous

2. Ground tissue

Characters of Dicot Stem : Differentiated into cortex, endodermis and pericycle and pith

Characters of Monocot Stem : Not differentiated, but it is a continuous mass of parenchyma

3. Starch Sheath

Characters of Dicot Stem : Present

Characters of Monocot Stem : Absent

4. Medullary rays

Characters of Dicot Stem : Present

Characters of Monocot Stem : Absent

5. Vascular bundles

Characters of Dicot Stem : (a) Collateral and open

Characters of Monocot Stem : (a) Collateral and closed

Characters of Dicot Stem : (b) Arranged in a ring

Characters of Monocot Stem : (b) Scattered in ground tissue

Characters of Dicot Stem : (c) Secondary growth occurs

Characters of Monocot Stem : (c) Secondary growth usually does not occur.