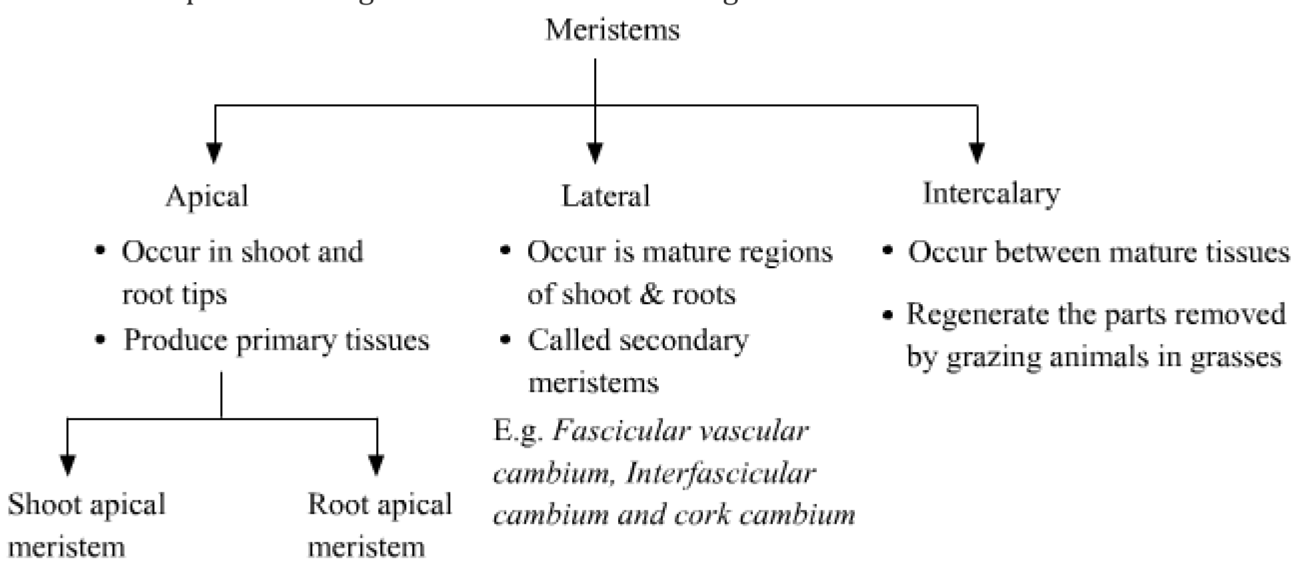
Anatomy of Flowering Plants

The Meristematic Tissues

- A tissue is a group of cells having a common origin and performing the same function.
- On the basis of their ability to divide, plant tissues can be divided into
- meristematic tissue
- permanent tissue

Meristematic Tissue

- Meristems - specialized region of cell division where growth is restricted



- Primary meristem = Apical meristem + Intercalary meristem

To test your knowledge of this concept, solve the following puzzle

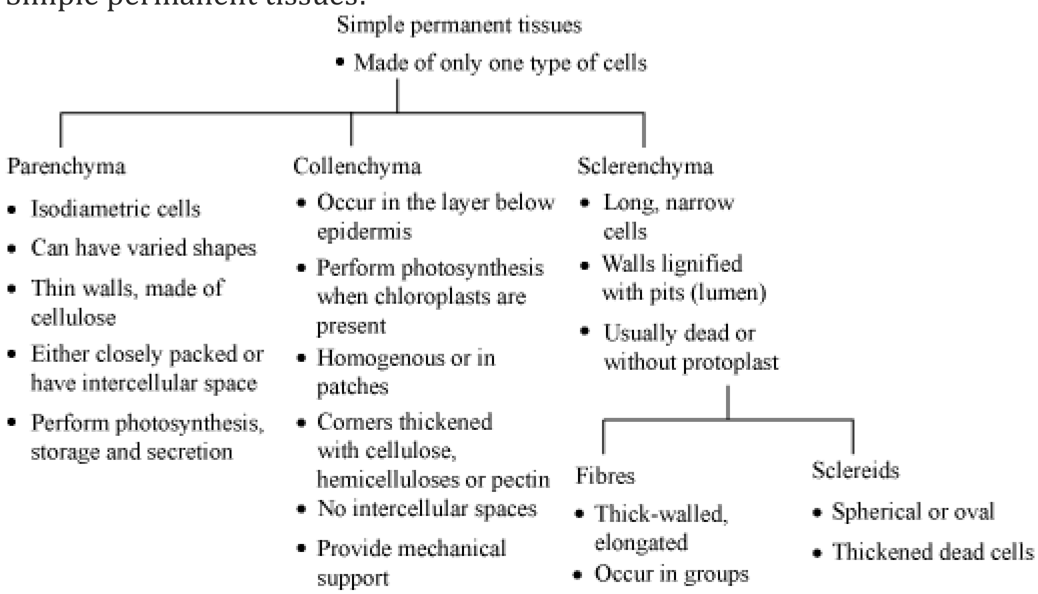
- Axillary bud – These are buds constituted by some apical meristems left behind during the elongation of stems and leaves. These buds are capable of forming branches and flowers.
- In course of formation of primary plant body, specific regions of apical meristem produce dermal, ground, and vascular tissues.

- Following division in both primary and secondary meristems, the new cells so formed lose the capacity to divide and become permanent tissues.

Simple Permanent Tissues

Simple Permanent Tissues

- Based on the structural differences, plant permanent tissues are of two types:
- Simple permanent tissues
- Complex permanent tissues
- Simple permanent tissues:



Complex Permanent Tissues

Complex Permanent Tissues

Complex permanent tissues
(Made of more than one type of cells)

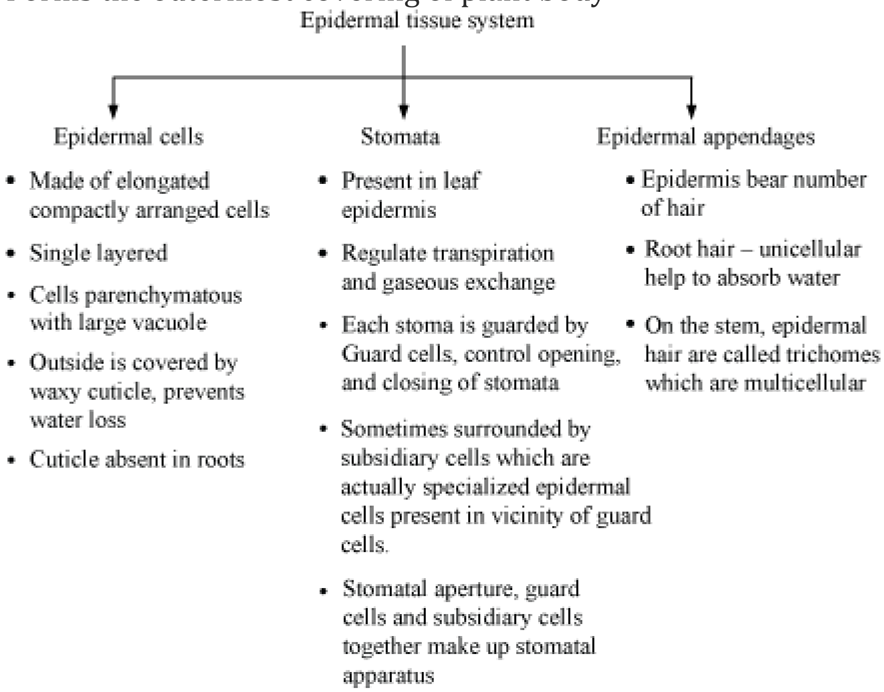
- Xylem
  - Conducts water and minerals from the root to the stem and leaves
  - Provides mechanical support
  - Consists of
    - Tracheids
      - Elongated and tube-like
      - Thick lignified walls
    - Vessels
      - Long, cylindrical
      - Walls lignified
    - Fibres
      - Highly thickened walls
      - May or may not be septate
    - Xylem parenchyma
      - Living cells
      - Thin-walled
      - Cell wall made of cellulose
      - Radial conduction by ray parenchyma
  - Primary xylem is of two types:
    - Protoxylem – towards centre is endarch
    - Metaxylem – towards centre is exarch
- Phloem
  - Transports food from the leaves to the other parts
  - Consists of
    - Sieve tube elements
      - Long, tube-like
      - Arranged longitudinally
      - End walls perforated
    - Companion cells
      - Specialised parenchyma
      - Associated with sieve tubes
    - Phloem parenchyma
      - Long, cylindrical
      - Stores food
    - Phloem fibre
      - Made of sclerenchyma
      - Thick cell wall
      - Jute, flax and hemp – commercial fibres
  - First-formed phloem is protophloem and later-formed phloem is metaphloem

The Tissue System - Epidermal, Ground, and Vascular

- On the basis of their structure and location, tissue systems can be divided into
- epidermal tissue system
- ground tissue system
- vascular or conducting tissue system

Epidermal Tissue System

- Forms the outermost covering of plant body

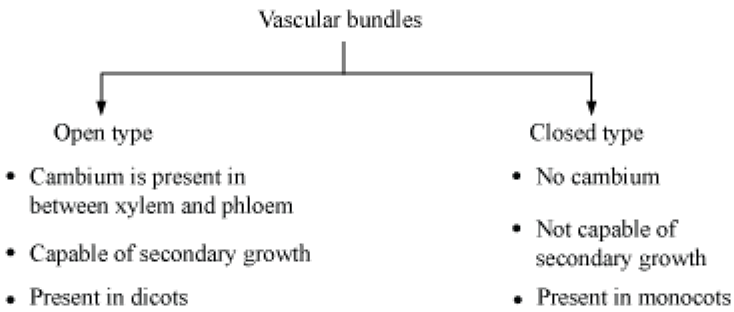


The Ground Tissue System

- Except epidermis and vascular bundles, all tissues are part of ground tissue system.
- Consists of simple tissues such as parenchyma, sclerenchyma, or collenchyma.
- In primary stem and roots – ground tissue is represented by parenchyma present in cortex, pericycle, pith, and medullary rays
- In leaves - ground tissue is represented by mesophyll (thin-walled chloroplast containing cells)

The Vascular Tissue System

- Vascular tissue system consists of vascular bundles.
- Vascular bundles = Xylem + Phloem
- There are two types of vascular bundles:



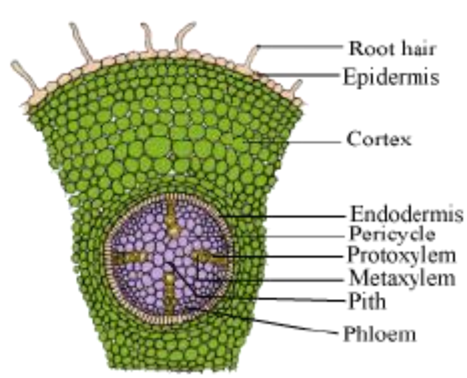
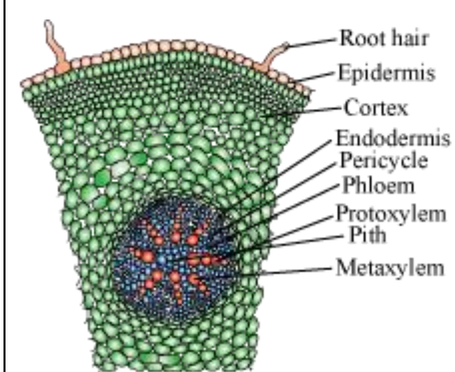
- Xylem and phloem can be arranged in two different kinds of arrangement within a vascular bundle.

- Radial arrangement - when xylem and phloem are present in alternate manner on different radii

- Conjoint arrangement - when xylem and phloem are present at same radius of vascular bundles. Such arrangement usually has phloem located outer to xylem.

Anatomy of Root

Dicot and Monocot Root

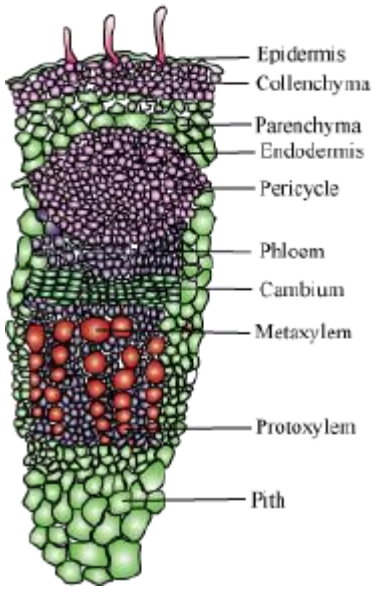
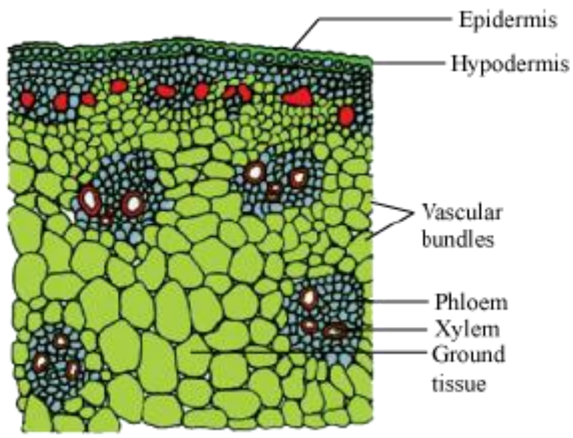
Tissue organization	**Dicot**	**Monocot**
Figure		
Epidermis	Has a single layer of epidermal cells, some of which protrude to form root hairs	Same as that of dicot root

Cortex	Has several layers of thin-walled parenchymatous cells, with intercellular spaces	Same as that of dicot root
Endodermis	Single layer of barrel-shaped cells, without intercellular space, and contains Casparian strips (water impermeable layer consisting of waxy suberin)	Same as that of dicot root
Pericycle	Has thick-walled parenchyma Initiation of lateral roots and vascular cambium during the secondary growth takes place in these cells.	Secondary growth is absent in monocots.
Pith	Small and inconspicuous	Large and well-developed
Vascular bundle	Single (Monoarch)	More than six (Polyarch)

- **Conjunctive tissue –** These are the parenchymatous cells that lie between xylem and phloem. On maturity, a cambium ring develops between xylem and phloem.
- **Stele –** structure represented by all tissues on inner side of endodermis such as pericycle, pith and vascular bundles.

Anatomy of Stem

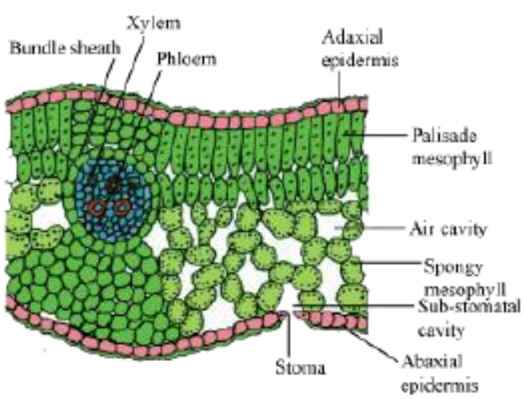
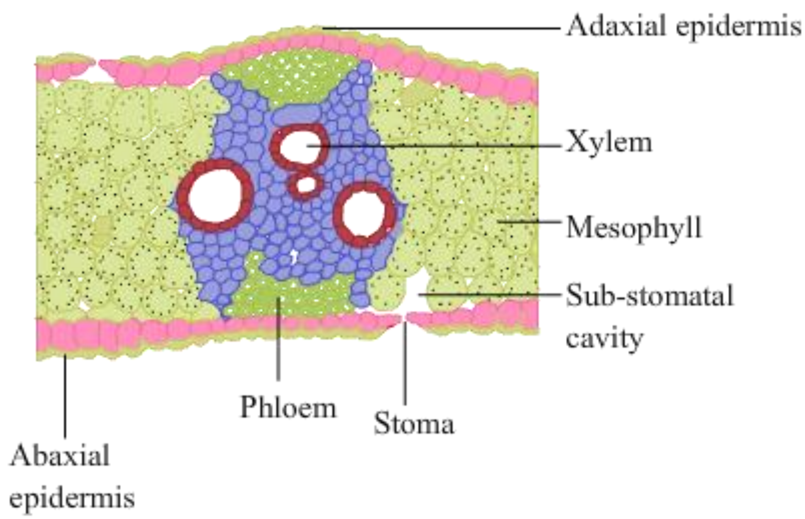
Dicot and Monocot Stem

Tissue organization	Dicot stem	Monocot stem
Figure	 	
Epidermis	Covered by cuticle	Same as dicot stem
Cortex (divided into three parts) Hypodermis Cortical layer Endodermis	Contains few layers of collenchymatous cells Contains parenchymatous cells with conspicuous intercellular spaces Rich in starch	Contains few layers of sclerenchymatous cells - Rich in starch
Pericycle	On the inside of endodermis and above the phloem in the form of semi-lunar patches of sclerenchyma	Same as dicot stem

Vascular bundle	These are arranged in a ring. This arrangement is a characteristic of dicot stem. They are conjoint, open, and have endarch protoxylem.	Vascular bundles are scattered and closed with peripheral bundles being smaller than central. Phloem parenchyma is absent and water containing cavities are present.
Pith	Present	Absent

Anatomy of Leaf

Dicot and Monocot Leaf

Tissue organization	**Dicot leaf (Dorsiventral)**	**Monocot leaf (isobilateral)**
Figure		
Epidermis	Covers both upper (adaxial - bearing less/no stomata) and lower (abaxial - bearing more stomata) surface of leaf and bears a cuticle	Stomata present on both sides

Mesophyll	Differentiated into palisade (has parallel arranged elongated cells) and spongy parenchyma (with loosely arranged oval/round cells); it possesses chlorophyll	Not differentiated into palisade and spongy parenchyma
Vascular Bundle	Present in midrib and veins (reticulate venation); surrounded by bundle sheath cells	Leaves have parallel venation. Bulliform cells (modified epidermal cells) are present along the vein which absorb water and get turgid.

Secondary Growth in Stem and Root

Secondary Growth

- Primary growth: The growth of the root and the stem lengthwise brought about by the apical meristem
- Secondary growth: Increase in girth exhibited by most dicot plants
- The tissues involved in secondary growth are collectively known as lateral meristems. Lateral meristems consist of:
- Vascular cambium
- Cork cambium

Vascular Cambium

- Meristematic layer responsible for vascular tissue formation
- In the young stem, it is present in patches between the xylem and the phloem; later, it forms a ring
- Formation of the cambial ring:
- **Intrafascicular cambium –** cells of the cambium present between primary xylem and primary phloem in a dicot stem

- Cells of medullary rays adjoining the intrafascicular cambium also become meristematic, and form **interfascicular cambium** thereafter.

- Thus, a continuous ring of cambium is formed.

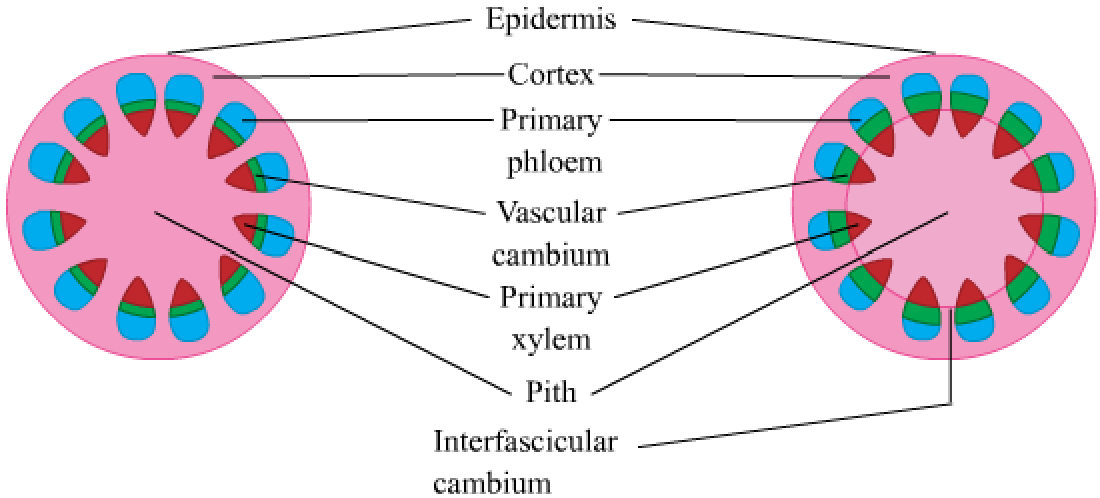
- **Activity of the cambial ring:**

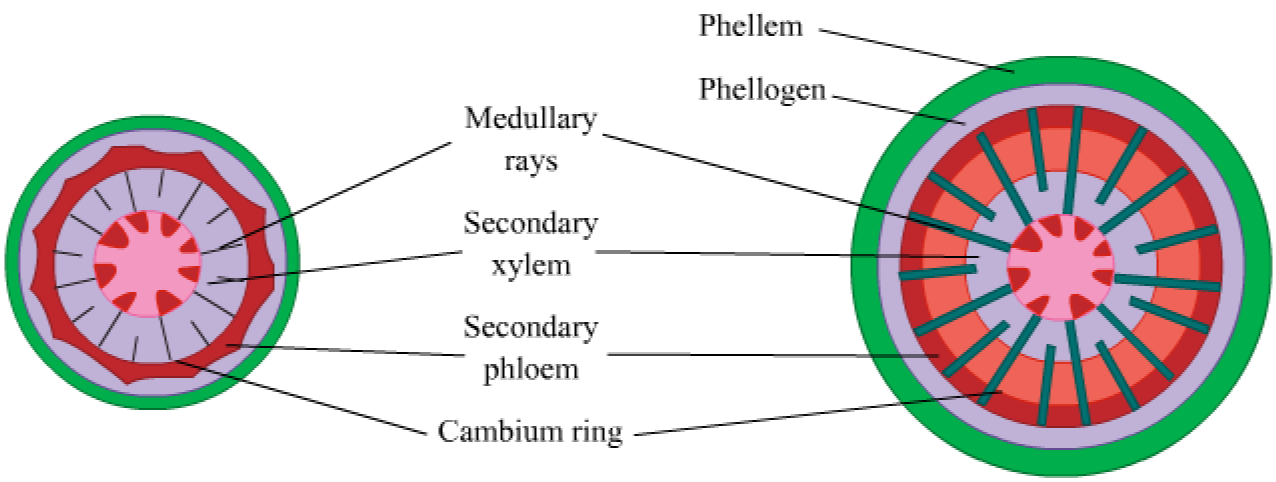
- Cambial ring cuts off cells both on the inner and the outer sides; generally active on the inner side

- Cells towards the pith form the secondary xylem, and those towards the periphery form the secondary phloem. Since the activity towards the inner side is greater, more secondary xylem is produced than secondary phloem.

- This may lead to the crushing of phloem at some places due to continuous accumulation of the secondary xylem.

- At some places, the cambium forms narrow bands of parenchyma known as medullary rays. These pass through the secondary xylem and phloem in a radial fashion, and so they are known as secondary medullary rays.



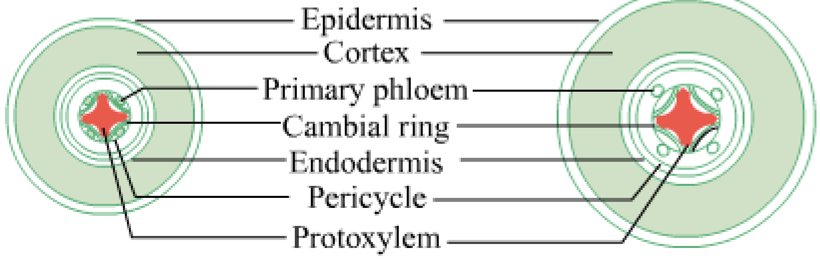


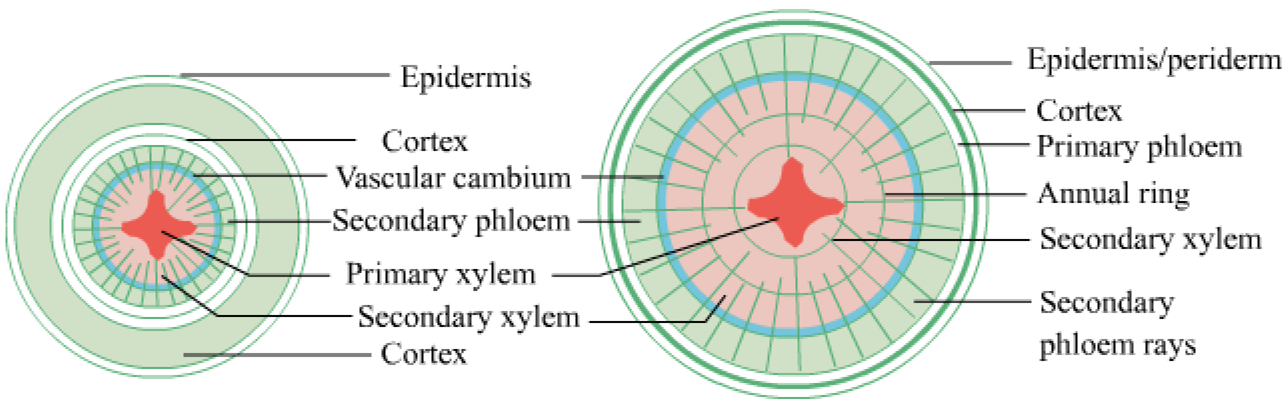
Let us understand secondary growth in details with the help of this animation.

Secondary Growth in Roots

- In a dicot root, the vascular cambium is completely secondary.
- It originates from a portion of the pericycle below phloem bundles.
- Formed in a wavy manner, but later on becomes circular

- Further events are similar to the secondary growth in a dicot stem





Products of Secondary Growth

Spring Wood and Autumn Wood

- The activity of cambium is under the control of many physiological and environmental factors.

- In spring season, cambium is very active and produces a large number of xylary elements with wider vessels. This wood is called spring wood or early wood. It is lighter and has lower density.

- In winters, xylem is less active and forms fewer xylary elements with narrow vessels. This wood is called autumn wood or late wood. It is darker and has higher density.

- Annual ring: When two kinds of wood appear in alternate concentric rings; these help us to estimate the age of a tree

Heart wood and Sap wood

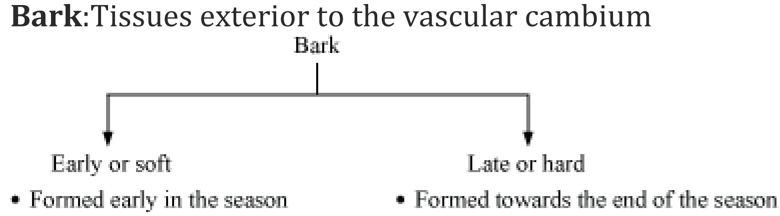
- Heartwood:

- Composed of dead elements, with highly lignified walls

- Imparts dark brown colour to the older trees as organic compounds such as tannins, resins, essential oils, gums, etc., are deposited on it
- Makes the plant durable and resistant to attack by microbes and pests
- Non-conducting
- Sapwood:
- Constitutes the peripheral region of the secondary xylem
- Lighter in colour
- Conducting

Cork Cambium (Phellogen)

- As secondary growth starts, the outer cortical and the epidermis layer break down. These are replaced by another meristematic tissue called the cork cambium.
- Made of narrow, thin-walled, rectangular cells, and is a couple of layers thick
- Leads to the formation of cells on both sides:
- Outer cells – Differentiate into the cork (**Phellem**)
- Inner cells – Differentiate into the secondary cortex (**Phelloderm**)
- Phellogen + Phellem + Phelloderm = **Periderm**
- Phellogen exerts pressure on its peripheral layers, and due to this, these layers die.
- Cork has suberin deposits on the cell wall. This makes it impervious to water.
- **Bark**:Tissues exterior to the vascular cambium



- At some regions, the phellogen cuts off closely arranged parenchymatous cells on the outer side instead of cork cells, which rupture to form lens-shaped openings called **lenticels**. These openings permit the exchange of gases.