Characters of Meristematic Tissues :

- It is an **undifferentiated tissue** and also called **Juvenile tissue** or **formative tissue**
- Compactly set without evident intercellular spaces
- Have **dense cytoplasm** with small vacuoles (except cambium) and **large prominent nuclei**
- **Ergastic matters** are absent
- The cells are usually isodiametric in shape
- The plastids are in proplastid stages
- Cell wall, made of cellulose, is **thin and homogenous.**

According to their origin and development, meristems are classified as :

Promeristems (primordial meristems) :

- They are represented by few cells found **at the apices of embryonic shoots and roots**.
- They give rise to primary meristems.

Primary meristems : They originate **from promeristems.**

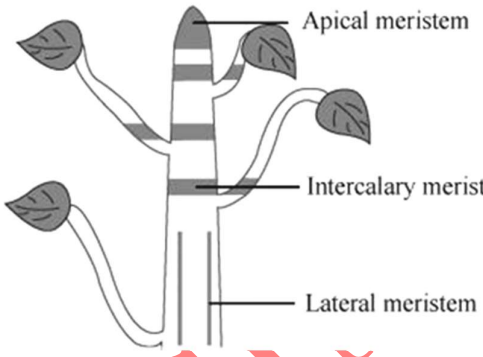
- It appears early in the life of a plant & contribute to the formation of the **primary plant body.**
- They are found at shoot and root apices, at the apex of leaves and in intercalary parts.
- They give rise to **primary permanent tissues.**
- **Ex : Apical meristem , intercalary meristem and intrafascicular cambium.**

Secondary meristems :

- They develop from primary permanent tissues by the process of **differentiation**
- They give rise to secondary tissues.
- **Ex: Interfascicular cambium, cork cambium and cambium in dicot roots.**

The meristem may also be classified according to their position in the plant body as :

- **Apical**
- **Intercalary**
- **Lateral**



Position of meristem

Apical Meristem :

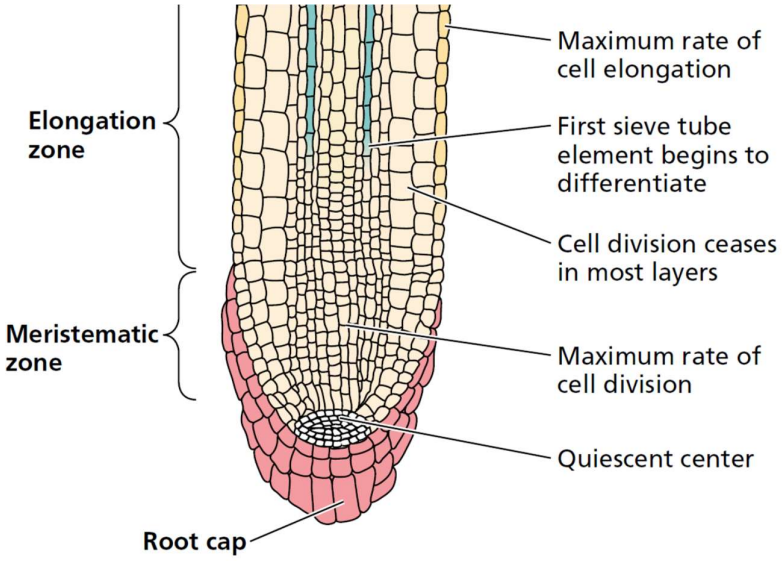
- The meristems which occur at the tips of roots and shoots and produce primary tissues are called **apical meristems**.
- Apical meristem lies at the apex of both the stem and the root. This usually exhibits a **dome shaped structure**

The cells of the apical meristem differentiate into three regions and give rise to different tissue systems.

- **Dermatogen / protoderm** *:* This is the single, outermost layer of cells. These divide and give rise to the skin layer (epidermis) of the stem. In roots, the cells of the dermatogen form a mass of tissue called **calyptrogen**
- **Periblem / ground meristem :** This is located internal to the dermatogens and forms the cortex of the stem and the root.
- **Plerome/ procambium** *:* This lies internal to the periblem These elongated cells form **procambium** that gives rise to the **vascular tissues** (xylem and phloem)

Quiescent center in Root apex :

- A group of cells in the center of the root apical meristem, termed the **quiescent center,** divide only very infrequently.
- Cells of **quiescent center h**ave low DNA ,RNA and protein content and have low mitotic activity.They act as **Reservoir meristem** or **waiting meristem**



Intercalary meristem :

- The meristem which occurs between mature tissues is known as **intercalary meristem**.
- These are the portions of apical meristems which are separated from the apex during the growth of the axis and remain intercalated between permanent cells.
- It is responsible for elongation of internodes.
- These meristem allow fallen stem of cereals to become erect.
- They are present in *Mentha* ,Wheat, *Pinus , Equisetum , Anthoceros* etc

Lateral meristem :

- The meristem that occurs in the mature regions of roots and shoots of many plants, particularly those that produce woody axis and appear later than primary meristem is called the **secondary** or **lateral meristem.**
- They are **cylindrical meristems.**

- **Fascicular vascular cambium, interfascicular cambium** and **cork-cambium** are examples of lateral meristems.
- These are responsible for producing the **secondary tissues.**

Theories on shoot apex organisation :

Apical Cell Theory :

- This theory was proposed by **Nageli and Hofmeister**.
- According to this theory, a single apical cell is the structural and functional unit of apical meristem.
- This theory is applicable only to bryophytes and lower vascular cryptogams (pteridophyta)

Histogen Theory :

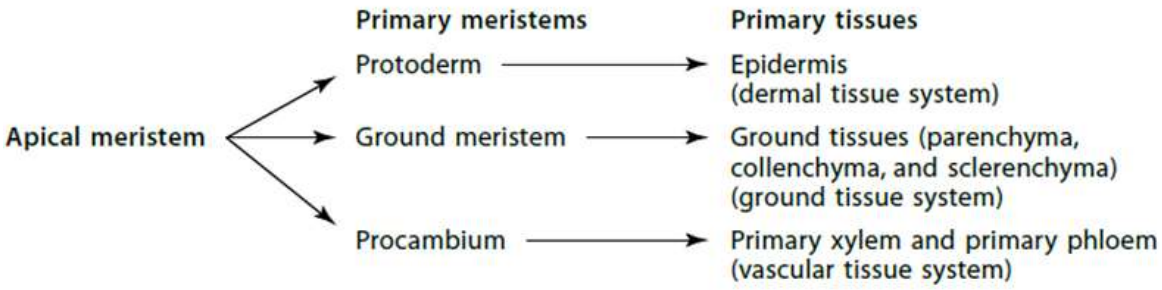
This theory was given by **Hanstein (1870) .**
According to him, shoot apex has three zones, which are called histogens.
They are of the following types.

- **Dermatogen**: Gives rise to epidermis.
- **Periblem**: Gives rise to cortex including endodermis.
- **Plerome**: Gives rise to vascular tissue including pith.

Tunica - Corpus Theory :

This concept was given by **Schmidt (1924) .**
According to him shoot apex has two region :

- **Tunica :** It is generally single layered outer region. It divides **only anticlinally.**
- **Corpus :** The inner mass of cells is called corpus. It divides **both anticlinally as well as periclinally**. Its activity results in the formation of cortex and stele.



Complex Tissues :

Parenchyma

- Most common tissue
- Isodiametric - spherical, oval, round, polygonal or elongated
- Ability to dedifferentiate
- Secondary meristems usually originate from parenchyma cells
- Photosynthesis
- Storage
- Secretion
- Provide turgidity

Types

- Aerenchyma
- Chlorenchyma
- **Idioblasts /secretory cells**
  - **Caox -----** druses /sphaerites
  - **CaCO3 -----** cystoliths

Collenchyma

- Colla - glue , shining wall
- Cell wall unevenly thickened - thickenings at the corners or angles of the cells
- **Wall thickening is primary -** cellulose, hemicellulose and pectic materials
- High percentage of water.

- Mechanical support to the young stem and petiole of a leaf floral stalks and the leaves.
- Occur in the hypodermis of herbaceous dicots
- Provides sufficient tensile strength
- Provide elasticity/extensibility and support to the growing organs.
- Keeps organs soft

Sclerenchyma

- For mechanical support
- Thick-walled and lignified with simple or bordered pits in their walls
- Thick lignin cell wall of lignin except **cotton flax (cellulose)**

Fibres

- Elongated and needle like spindle shaped
- **Occur in groups**
- **Chiel mechanical tissue**
  - **Bast / phloic - hemp , flax , jute , sunnhemp**
  - **Leaf -- Agave Musa**
  - **Xylary**
  - **Cortical**
  - **Perivascular /pericyclic**

Sclereids

- Isodiametric, polyhedral, short and cylindrical Broad oval
- Excessive thickness of the cell wall.
- Occur singly or in loose clusters
- Provide stiffness
  - **Brachysclereids / stone cells**
  - **Osteo / bone cells**
  - **Macro /rod cells**
  - **Astro / star cells**
  - **Tricho / filiform/ internal hairs**

Xylem or wood or Hadrome :

Tracheids :

- Tracheids are elongated with blunt ends.
- Its lumen is broader than that of fibres.
- Their secondary wall is **lignified.**
- In cross section, the tracheids appear **polygonal** and thick walled.
- Tracheids are imperforate cells with bordered pits on their end walls.
- They are arranged one above the other.
- Tracheids are **chief water conducting elements in gymnosperms and pteridophytes**.

Vessels :

- It is a long cylindrical tube-like structure made up of many cells called **vessel members,** arranged in longitudinal series in which the transverse walls are perforated and as such the entire structure looks like a water pipe.
- Have lignified walls and a wide central cavity.
- Serve as a more efficient mode of transport of water and minerals as compared to tracheids.
- Also give mechanical support to the plant body.
- Vessels are present in almost all angiosperms but also found in some **pteridophytes** (e.g. *Pteridium, Selaginella*) and **gymnosperms** (e.g. *Ephedra, Gnetum*).
- **Vesselless angiosperms** are *Drimys , Degeneria,* and family like Trochodendraceae ,Tetracentraceae, Wintereaceae.

Xylem fibres :

- They are present both in primary and secondary xylem.

Xylem parenchyma :

- These store food material in the form of starch or fat, and sometimes tannins, and other substances.

On the basis of origin, xylem is of two types :

Primary Xylem :

- It is derived **from procambium** during the formation of primary plant body.
- It is differentiated into **protoxylem** and **metaxylem** .

Secondary Xylem :

It is formed from **cambium** during secondary growth.

Phloem or bast or Leptome :

- The phloem elements which are formed from the procambium of apical meristem are called **primary phloem.**
- The phloem elements which are produced by the vascular cambium are called **secondary phloem.**

In pteridophytes and gymnosperms in place of sieve tube elements, **sieve cells** are present. Those are **narrow, elongated cells** with **less conspicuous sieve areas** located laterally. They taper at the end or have inclined walls. Gymnosperms have **albuminous cells and sieve cells**. They lack sieve tubes and companion cells.

Sieve tube elements :

- Sieve elements are the conducting elements of phloem. They have **thick primary walls.**
- Their end walls are **transverse or oblique.**
- The end wall contains a number of pores and it looks like a sieve. So it is called a **sieve plate.**
- The sieve elements are arranged one above the other and form **vertical sieve tubes.**
- In matured sieve tube, **nucleus is absent.** It contains a lining layer of cytoplasm.
- Sieve tubes associated with the companion cells.
- In mature sieve elements, sometimes the pores in the sieve plate are blocked by a substance called **callose.**
- Sieve cells found in gymnosperms have **no sieve plates and there is no P-protein.**
- Mature sieve elements are unique among living plant cells .

- Sieve elements **lose their nuclei** and **tonoplasts**.
- **Microfilaments, microtubules, Golgi bodies, and ribosomes are also absent from the mature cells**.
- Organelles that are retained include somewhat **modified mitochondria, plastids**, and **smooth endoplasmic reticulum.**

Companion cells :

- Specialised parenchyma cells closely associated with the sieve tube elements
- Originate from the same meristematic cells that give rise to the sieve tube elements.
- Sieve tube elements and companion cells are **connected by pit fields** present in their longitudinal walls .

Phloem parenchyma :

- **Phloem parenchyma is absent in monocots.**

Phloem fibres / Bast fibres :

- Elongated, unbranched (rarely branched) cells having pointed, needle-like apices.

Distribution of treachery elements in vascular plants :

Plants	Tracheids	Vessels	Sieve tubes	Companion cells	Sieve cells	Albuminous cells
Pteridophyts	(+)	(–)	(–)	(–)	(+)	(–)
Gymnosperms	(+)	(–)	(–)	(–)	(+)	(+)
Angiosperms	(+)	(+)	(+)	(+)	(–)	(–)

Tissue System :

1. **Epidermal tissue system**
2. **Ground or fundamental tissue system**
3. **Vascular (stele / conducting tissue system)**

Epidermal tissue system :

- **Epidermal cells**
- **Stomata**
- **Epidermal appendages (trichomes and hairs)**

Ground or fundamental tissue system :

- **Cortex**
  - **Hypodermis**
  - **General cortex**
  - **Endodermis**
- **Pericycle**
- **Pith and medullary rays**

Vascular tissue system

- **Phloem**
- **Xylem**

The vascular bundles are of the following types :

Radial vascular bundles

- have xylem and phloem which are arranged in an alternate manner on different radii.
- Such bundles are mainly found in the roots.

Conjoint vascular bundles

- have xylem and phloem situated at the same radius and form a vascular bundle together.
- Such vascular bundles are common in stems and leaves.

- The conjoint vascular bundles usually have the phloem located only on the outer side of xylem.

Depending upon the mutual relationship of xylem and phloem, these are divided into three types :

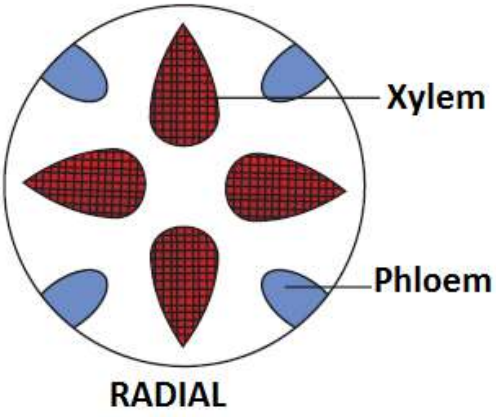
a. **Collateral**
b. **Bicollateral**
c. **Concentric**

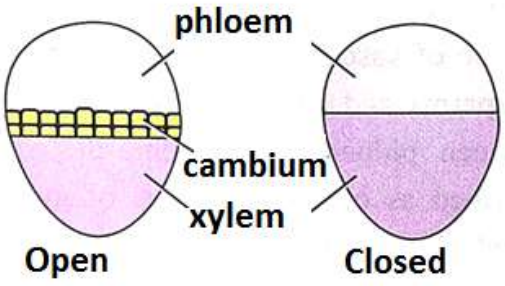
Collateral :

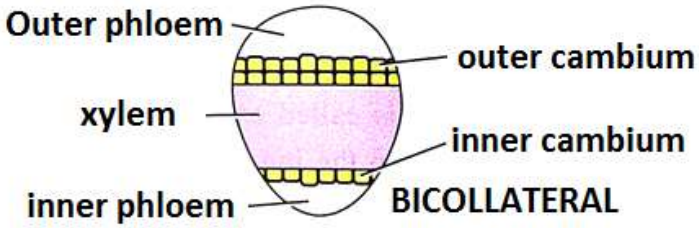
- When xylem and phloem lie together on the **same radius**, xylem being **internal** and phloem **external**, such vascular bundles are called collateral.
- A collateral bundle may be **closed** or **open**.
- This vascular bundle is found in **gymnosperms** and **angiosperms**.

Bicollateral :

- In the vascular bundles of this category, the phloem is found in two groups, one outside the xylem elements and the other inner to them.
- These are characteristically found in the stems of members of the **family Cucurbitaceae.** Ex : *Cucurbita pepo* , *Luffa cylindrica*.
- Bicollateral vascular bundles are also found in **Solanaceae**







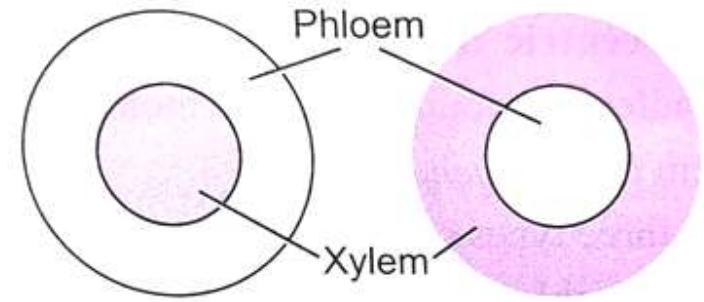
Concentric :

The bundle in which either phloem surrounds the xylem or xylem surrounds the phloem completely, is known as concentric.Concentric vascular bundles are **always closed.**

This is of two types :

1. **Amphicribal or Hadrocentric :** The xylem is in the centre surrounded on all sides by phloem, such vascular bundle is termed **amphicribal** or **hadrocentric** (i.e.; **hadrome** or **xylem** in centre).Such types of vascular bundles are found in **ferns** and **lower gymnosperms**.

2. **Amphivasal or Leptocentric** The phloem is in the centre surrounded on all sides by xylem. Such vascular bundle is termed **amphivasal** or **leptocentric** (i.e.; leptome or phloem in centre). Such vascular bundle exceptionally formed in **Angiosperms** e.g. *Dracaena, Yucca* etc.



Amphicribal **Amphivasal**

Dicotyledonous Root :

- **Epiblema** also called **piliferous layer** is single layered and some cells bear unicellular root hair.
- **Cuticle and stomata are absent.**
- Cortex - several layers of parenchymatous cells.
- The innermost layer of cortex is the endodermis. It comprises a **single layer of barrel-shaped** cells without any intercellular spaces.
- The **tangential as well as radial walls of** the endodermal cells have a deposition of water impermeable, waxy material in the form of **casparian strips**.
- The Casparian strips contain **lignin, suberin** and other encrusting substances, among them are **phenolic oxidation products** that lend the strips a dark colour.
- Certain endodermal cells which are present opposite to the xylem bundles remain thin-walled. These are known as **passage cells**.
- **Pericycle** is made up of **thick-walled parenchymatous cells.**
- **The pericycle is the seat of origin of lateral roots or the root branches. Initiation of vascular cambium occurs during the secondary growth takes place in these cells.**
- **Vascular bundles** are **radial**
- **Xylem is exarch**
- Number of xylem bundles and also the phloem in dicot roots may be two to six, i.e. **diarch to hexarch**
- **Polyarchic condition is found in *Ficus* (Banyan tree).**

- The parenchymatous cells which lie between the xylem and the phloem are called **conjuctive tissue.**
- **Pith** is generally absent in dicotyledonous roots and, if present, it is small or inconspicuous.

Monocot Root :

- The anatomy of the monocot root is similar to the dicot root in many respects.
- As compared to the dicot root which has fewer xylem bundles, there are usually more than **six (polyarch)** xylem bundles in the monocot root.
- **Pith is large and well developed** and parenchymatous
- Monocotyledonous roots do not undergo any secondary growth.

Differences

	Dicotyledonous Root	Monocotyledonous Root
Xylem bundles	Vary from 2 to 6	Usually more than six (polyarch)
Pith	Small or lacking	Very large and well developed
Secondary growth	Takes place	Does not take place