Meristems
• A region of frequently dividing cells forming tissues (mitotic cell division), keeps the plant growing

• Anticlinal divisions = perpendicular to the outer surface
• Periclinal division = parallel to the outer surface
• When a meristematic cell divides in two:
  - **Initial**: remains into the meristem, continue dividing by repeating cell division
  - **derivative**: after several divisions of initials, derivatives are pushed farther away from the zone of active division. They stretch, enlarge and differentiate into other types of tissues as they mature.

The difference between the cells is their position.

• The differentiation involves expansion and elongation as well as internal changes in cells.
Meristematic cells

• Small cells
• The cells may be cubical, rectangular, spindle shaped or isodiametric.
• Tightly packed
• Living cells
• have large central nucleus with distinct nucleolus
• have lots of ribosomes
• Thin-walled (thin primary cell wall with lots of plasmodesmata)
• Primary meristematic cells less vacuolated than secondary (generally vacuoles are very small)
• Usually without intercellular among the cells
Cellules de la zone du méristème primaire
d'une racine de jacinthe
Meristematic cells
Types of meristems

Various systems of classification have been proposed.

Meristems based on stage of development:

- Promeristem or Primordial Meristem:

  Group of cells (limited no.) from the embryo found in region where new organ or parts of organ is initiated (stem & root), it give rise to all primary meristems.
Primary and Secondary Meristems:

Based on the type of tissue which will be produced

- **Primary meristems**: those that build up the primary part of the plant (gives rise to the primary permanent tissues)
  - Found in stems, roots, leaves and other appendages.
  - originate from promeristems
  - retains its meristematic activity

- **Secondary Meristems**: appears later at a stage of development of an organ of a plant body
  - arise in permanent tissues, may arise in tissues which is not meristematic (cork cambium).
Meristems based on their function
Primary meristem at the apex of the stem and root is distinguished into three tissues
- **Protoderm**: develops into epidermis
- **Procambium**: develops into primary vascular tissue
- **Ground (Fundamental) meristem**: develops into ground tissues like hypodermis, cortex, endormis, pricycle, pith.

Meristems based on position in plant body
- 1) **Apical Meristems**
- 2) **Intercalary Meristems**
- 3) **Lateral Meristem** (cork cambium, vascular cambium)
Apical meristems

• These are located at **opposite ends of the plant axis in the tips of roots and shoots.**

• Cell divisions and subsequent cellular enlargement in these areas **lengthen the above and below ground parts of the plant** (increases the organ length (linear growth of the organ))

• May found in apices of leaves)

• Cells if this region could be
  - single (apical cells) in lower vascular plants
  - groups (apical initials) in higher vascular plants [one tier or more than one tier of cells]
(a) Root tip showing apical meristem, pericycle, endodermis, cortex (ground meristem), central cylinder (procambium), and root cap.

(b) Cross-section of a root showing the outer epidermis (protoderm), cortex (ground meristem), central cylinder (procambium), and root cap.

(c) Cross-section of a root showing the order of tissues from outermost to innermost: root cap, protoderm, ground meristem, and procambium.
Apical Meristem

Root Cap

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Structure and organization of Apical Meristems

- **Shoot apex:**
  - derived from meristem present in *plumule* of the embryo
  - At the - tip of the stem
    - its branches as terminal bud
    - as inactive state in the axils of leaves as lateral buds.
  - Apical meristems give rise to the **primary meristems** that form the tissues of the plant (protoderm, procambium, ground meristems)
many theories have been put forward to explain shoot apex as:

- **Tonica corpus theory**: the shoot apex consists of two distinct zones (latest theory 1924)
  - **Tunica**: -single layer, forms epidermis
    -with smaller cells corpus
    - shows only anticlinal division which is responsible for surface growth.
  - **Corpus**: - central core
    - with larger cells than tunica
    - shows divisions in all planes which is responsible for volume growth.
• **Root apex (root apical meristems)**

- A group of initial cells at sub-terminal region
- Protected by root cap
- Formed from the radicle of the embryo
- Differ from shoot apex by being short and more or less uniform due to absence of appendages (leaves and branches)

- Many theories have been proposed to describe root apical meristems as

  **Quiescent center theory** (latest 1961) in addition to dividing cells (a zone of inactive cells) is present in the central part of the root apex called quiescent center
Plant Anatomy  254  lec no. 8
Rajaa Abueideh

quiescent center

live root cap cells

Root cap

sloughed off dead root cap cells
- **Intercalary meristems**
  - Portions of apical meristems which are separated from the apex during the growth of axis and formation of permanent tissues
  - Present mostly at the base of the node (ment) the base of internode (stem of many monocots) the base of the leaf (*Pinus*)
  - This meristems disappear and give rise to permanent tissues.
Internodes

Zone of Elongation

Intercalary Meristem

Nodes

Intercalary Meristem (only in monocot stem)
• **Lateral meristems**
- Occurs laterally in the axis parallel to the sides of stems and roots
- Cells divide mainly in one plane (periclinal) resulting in an increase in the diameter of an organ
- Examples of lateral meristems:
  - **Vascular cambium** (fascicular and interfascicular cambium) and **cork cambium** (phellogen)
Tilia 1-year stem, c.s.

- phloem
- vascular cambium
- xylem
- endodermis
- pith
- Vascular cambium is initiated between xylem and phloem within vascular bundles.
- It generates secondary xylem (wood) at its inner edge and secondary phloem at its outer edge.
- It is absent in monocots (primary and secondary thickening meristems near vegetative shoot) and some herbaceous dicots.
- It is a single layer of cells (uniseriate) or several layers (multiseriate) if xylem and phloem mother cells are included.
• It is complex tissue consisting of both
  - fusiform initials: that form axial system
    (form the axial elements of secondary tissues: tracheary elements, fibers and axial parenchyma in secondary xylem and sieve elements, companion cells and fibers in secondary phloem)
    - elongated cells with tapering ends (spindle shaped)
    - divide periclinally.
    - sometimes give rise to new ray initials as the stem increases in circumference.
      - ray initials: that form the radial systems.
• Those cells are vacuolated unlike meristematic tissue and rich in plastids.
  - isodiametric cells
  - form ray parenchyma cells in both xylem and phloem
10.1 Vascular cambium in relation to derivative tissues. A, diagram of fusiform initials.
• The cambium may be:
  - Storied (stratified)
  - Non storied (Non stratified)
• Depending on weather cells are arranged in horizontal tiers
  (as seen in tangential section)
Figure 10.2 Arrangement of cells in vascular cambium as seen in tangential section: nonstoried cambium of *Rhus typhina*. *B*, storied cambium of *Wisteria* sp.