

I. Physiological Function and Economic Application of the Root

(I) Physiological function

Uptake: Water, CO_2 and inorganic salt from the soil

Fixation and support:

Transfusion: Water, inorganic salt and organic nutrients

Synthesization: Amino acid, growth hormone and vegetable alkaloid

Storage and reproduction

(II) Economic application

For edible, medicinal and industrial use;
artistic handicrafts; embankment
protection and preventing water loss
and soil erosion



II. Types of root and root system

(I) Main root, lateral root and adventitious root

Main root: Root growing vertically downwards from division and elongation of radicle cells, which is the earliest root growing in the plant. It is also called tap root or primary root.

Lateral root: Many rootlets grow laterally from within at certain sections when the main root is developed to certain length, which are called lateral root. (First-order lateral root—secondary root; second-order lateral root—tertiary root)

Adventitious root: Parts other than the main root and its lateral roots of the plant, including stem, leaf, dying root or roots developed from the hypocotyl, which are collectively called adventitious root.





**Taproot system
of a dandelion.**



**Fibrous root system
of a grass plant.**



*Hedera
nepalensis*



*Bryophyllum
pinnatum*



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(II) Taproot system and fibrous root system

Root system: Referring to the sum of underground roots of a plant, including the main root and its lateral roots of all orders, or the adventitious roots or their lateral roots of all orders.

- Taproot system: The root system with obvious difference between the main root and lateral root
- Fibrous root system: The root system with no obvious difference between the main root and lateral root, or all composed of adventitious roots and their branches in a form of tassel with similar thickness and without differentiation between the main and lateral root.
- Deep root system: Having well-developed main root
- Shallow root system: Having the lateral roots or adventitious roots more developed than the main root

III. Root development

(I) Apical meristem

1. The vascular cylinder, cortex and root cap in the root have their own initial cells. The epidermis is derived from the outermost layer of the cortex.
2. All zones or at least the cortex and root cap, are concentrated on a group of horizontally arranged cells, and they have common initial cells.
3. Initial cell: Cells constantly renewing but always remaining in the meristem with capacity of division.
4. Quescent center: A group of initial cells at the far end of the root body with little change in size and low synthesis rate of nucleic acid and protein which are not often divided form a zone, which is called the quescent center.



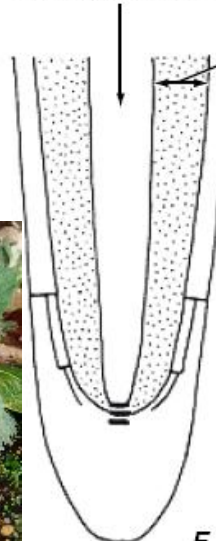
E, F, radish (*Raphanus*). Three layers of initials. The epidermis has common origin with the rootcap and becomes delimited on the sides of the root by periclinal walls (arrows in F). G, H, grass (*Stipa*). Three layers of initials, those of rootcap forming a calyptragen. The epidermis has common origin with the cortex. (E-H, from Esau, 1977)



vascular cylinder

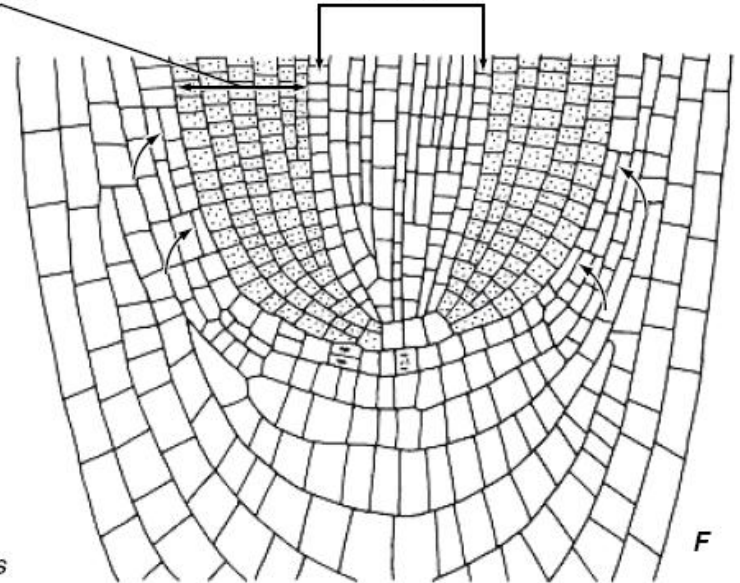
cortex

pericycle



E

Raphanus



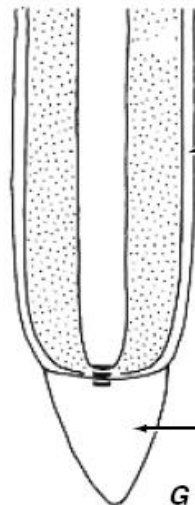
F

mucilaginous layer

epidermis

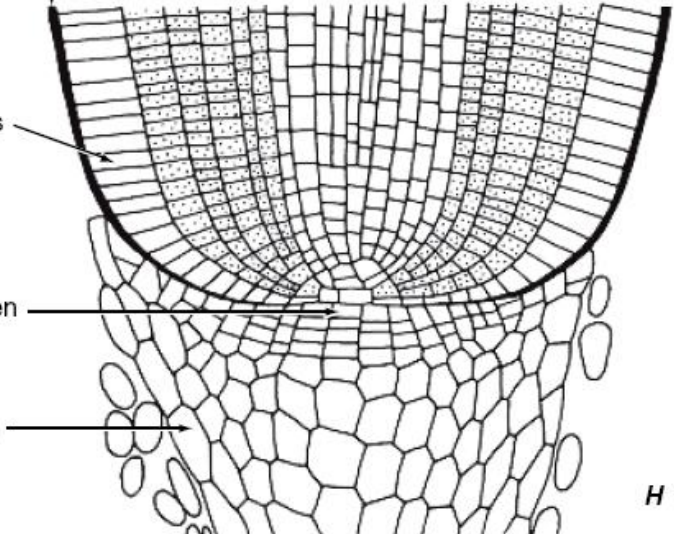
calyptragen

rootcap



G

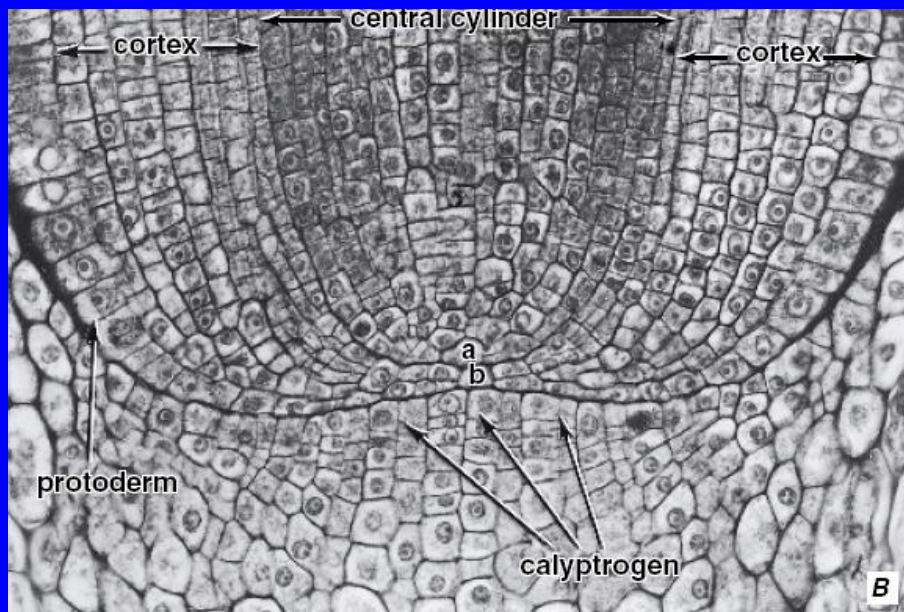
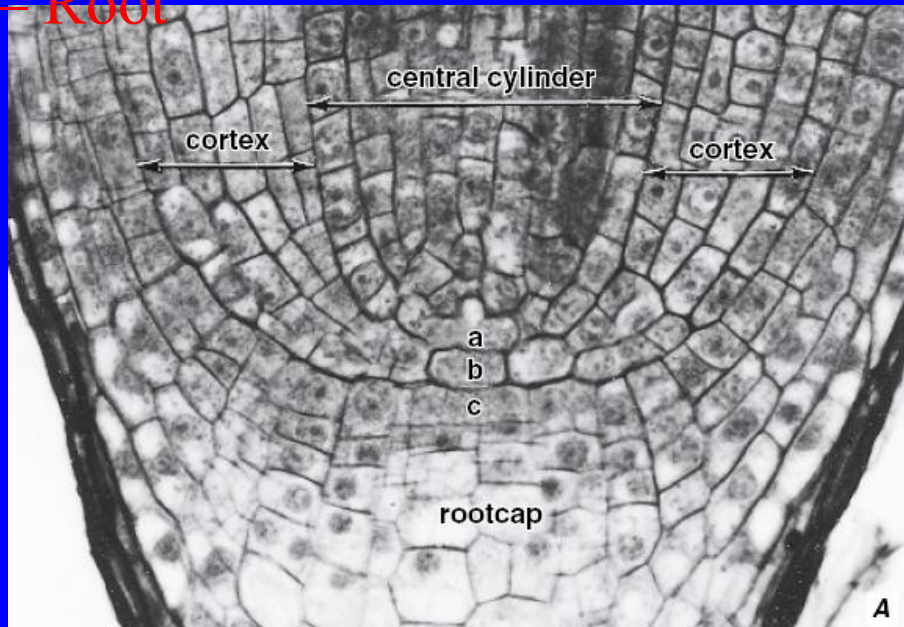
Stipa



H

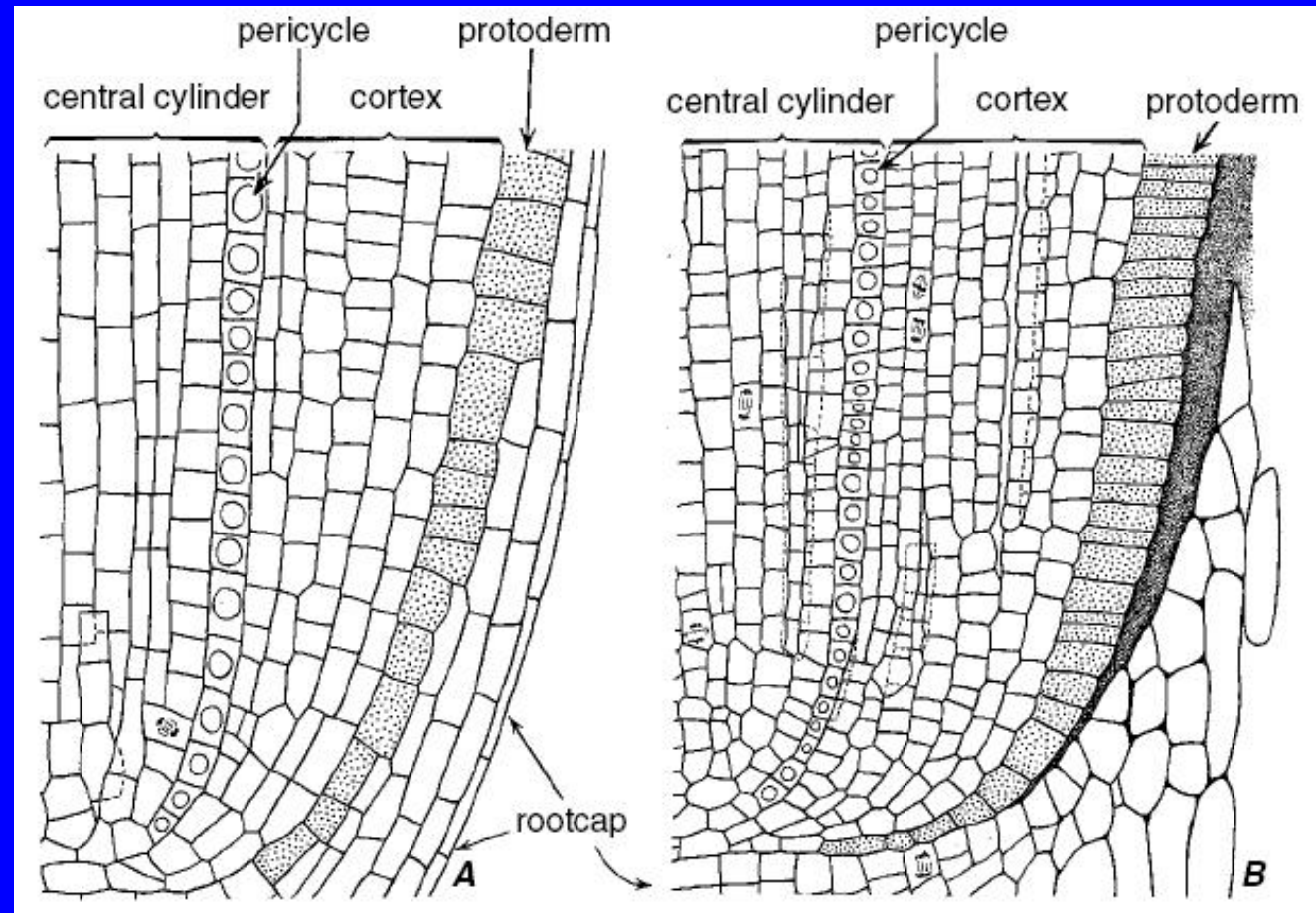
Chapter IV Vegetative Organ of a Seed Plant

— Root



Longitudinal sections of root apical meristems of *Nicotiana tabacum* (A) and *Zea mays* (B). These apices have a closed organization with three distinct tiers or layers of initials, designated a, b, and c in A. In *Nicotiana* (A), the epidermis and rootcap have common initials (c); a gives rise to the central cylinder and b to the cortex. In *Zea* (B), the epidermis and cortex have common initials (b) and the rootcap arises from a calyptragen; a designates the initial layer of the central cylinder. (A, $\times 455$; B, $\times 280$. B, slide by Ernest M. Gifford)

Longitudinal sections of root tips of *Nicotiana tabacum* (A) and *Zea mays* (B), illustrating two contrasting methods of origin of epidermis. A, epidermis separates from the rootcap by periclinal divisions. B, epidermis arose



from same initials as the cortex through periclinal division in a recent derivative of a cortical initial. The densely stippled area in B indicates the gelatinized wall between the rootcap and protoderm. (A, $\times 285$; B, $\times 210$)

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Root tip of bean.

A micrograph of a bean root tip stained with safranin. The tissue is a deep reddish-pink color. The apical meristem is visible as a dense, rounded cluster of cells at the very tip. The surrounding cells are elongated and arranged in a regular pattern.

Root tip of corn.

A micrograph of a corn root tip stained with toluidine blue. The tissue is a light blue color. The apical meristem is visible as a distinct, rounded cluster of cells at the tip. The surrounding cells are elongated and arranged in a regular pattern.



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Longitudinal section of apical meristem of *Allium sativum* root. This apex has an open organization; the tissue regions merge in a common initial (i) group. (×600. From Mann, 1952. *Hilgardia* 21 (8), 195-251. © 1952 Regents, University of California)



(II) Structure and development of root tip

Root tip refers to the section from the top of root to the portion growing root hairs, which is the most important part with the most vigorous vital activities in the root. The elongation of root, water and nutrient uptake as well as formation of tissues in the root is mainly accomplished by the root.

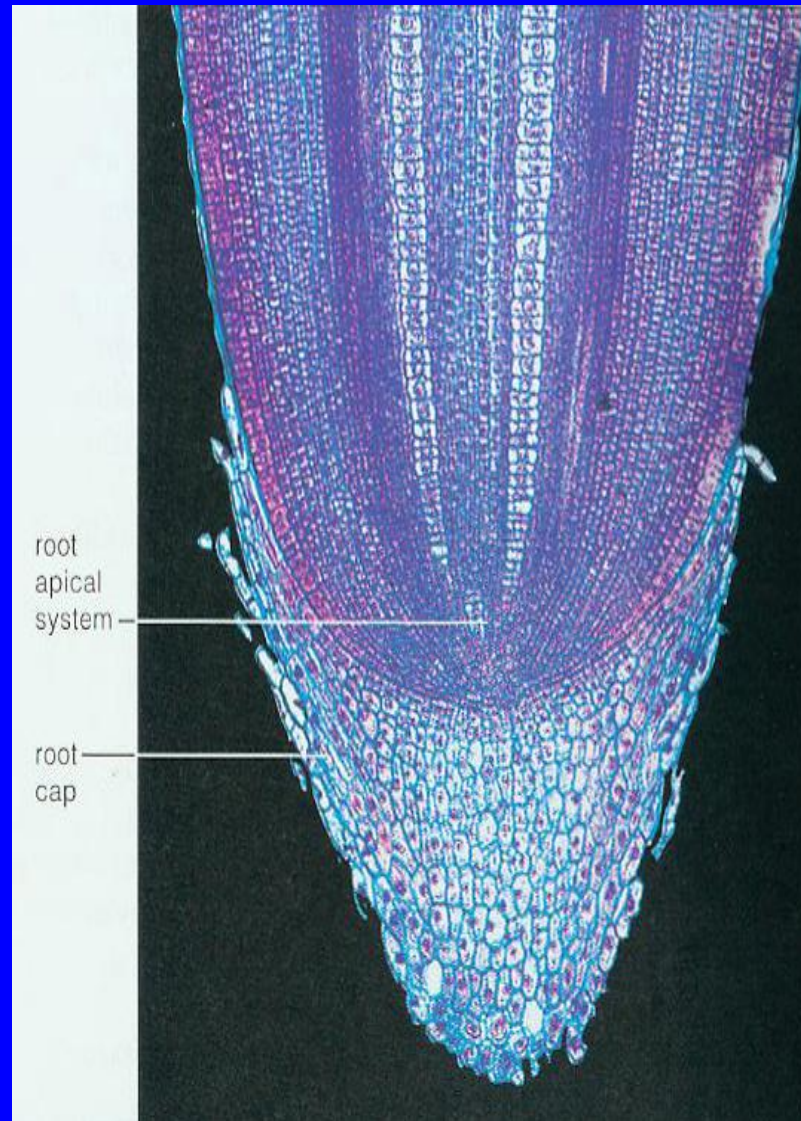
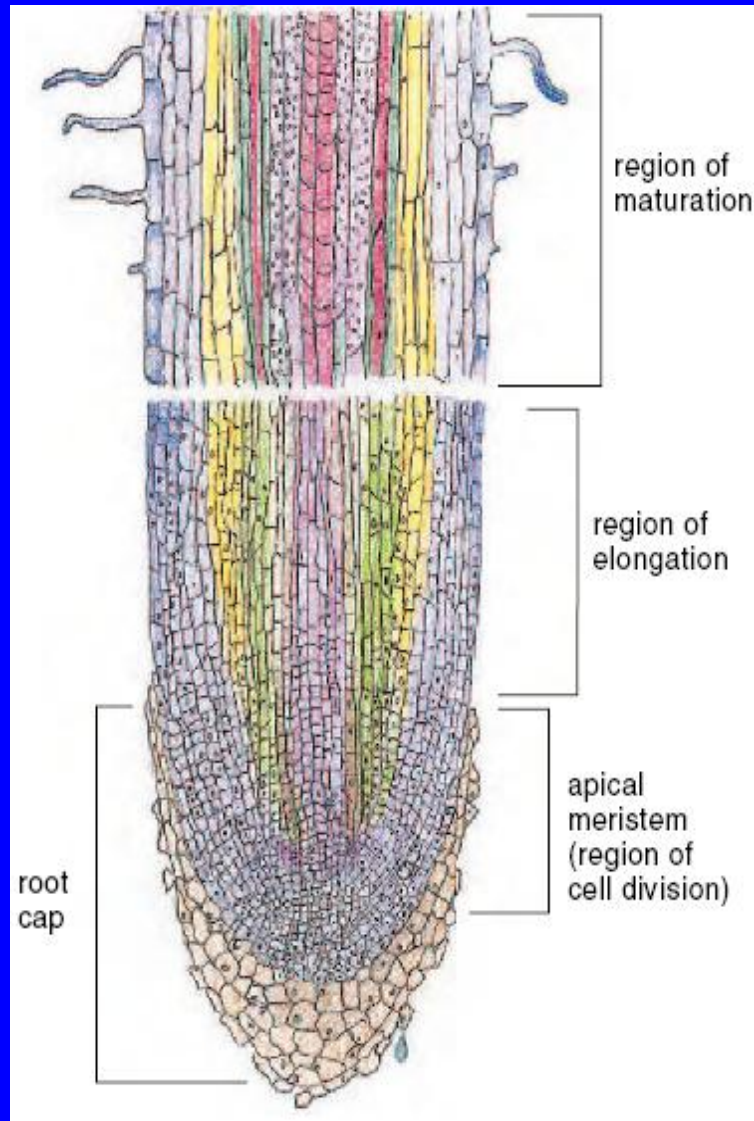
1. Root cap

Locating at the tipmost end of the root, the root cap refers to a kind of conical tissue specific to the root formed by many parenchyma cells irregularly arranged, covering the meristematic zone like a hat, which can maintain a certain shape and thickness.

Cell characteristic: Live cell, usually containing starch, having little differentiation. Cells close to the meristematic zone are small while those close to the outside are larger.



Root tip from corn.

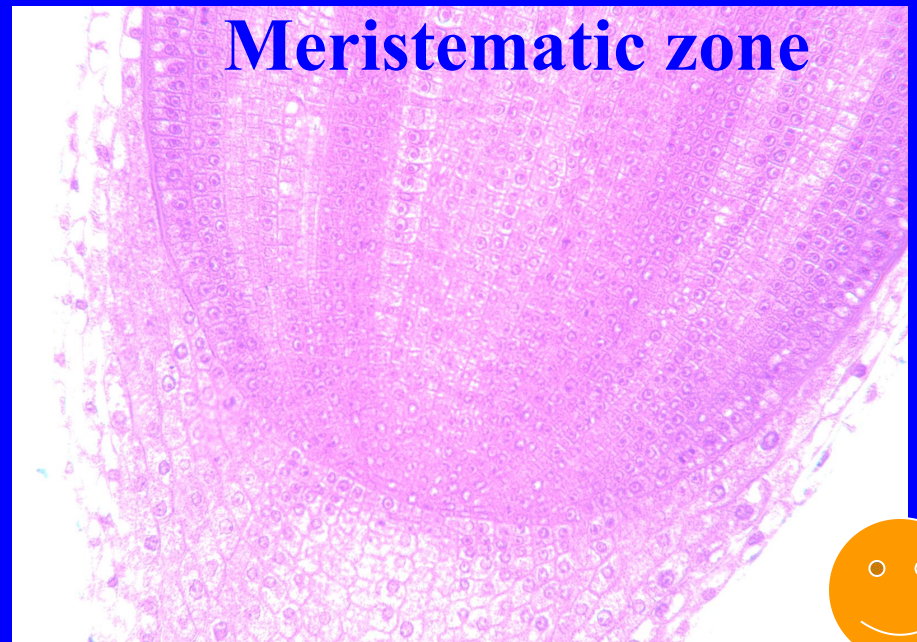




**Root tip
of corn.**



Root cap

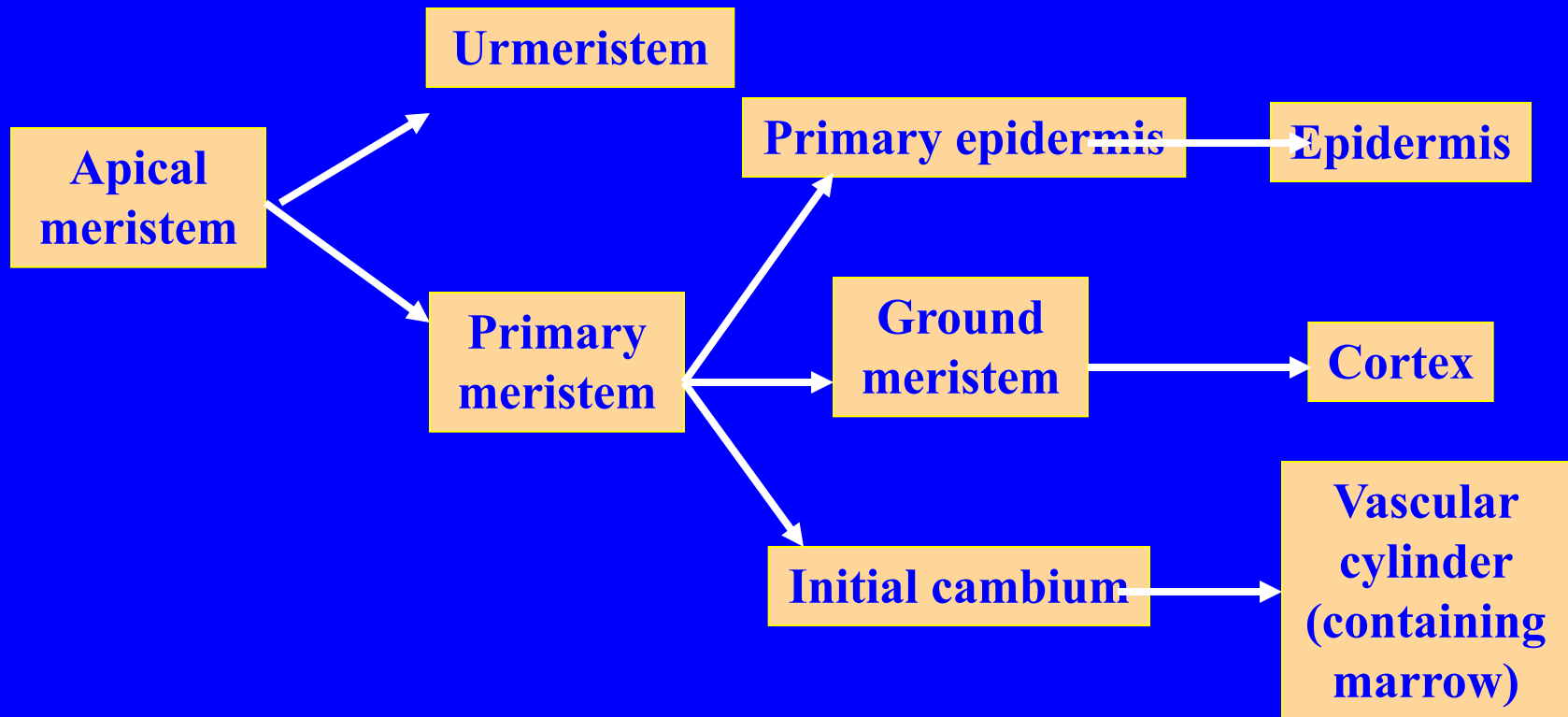


Meristematic zone



2. Meristematic zone

Referring to the apical meristem in inner side of the root cap. The meristematic zone always keep its original volume and function due to existence of the initial cells. It forms the rootcap cell forward while forming all tissues of the root afterward.



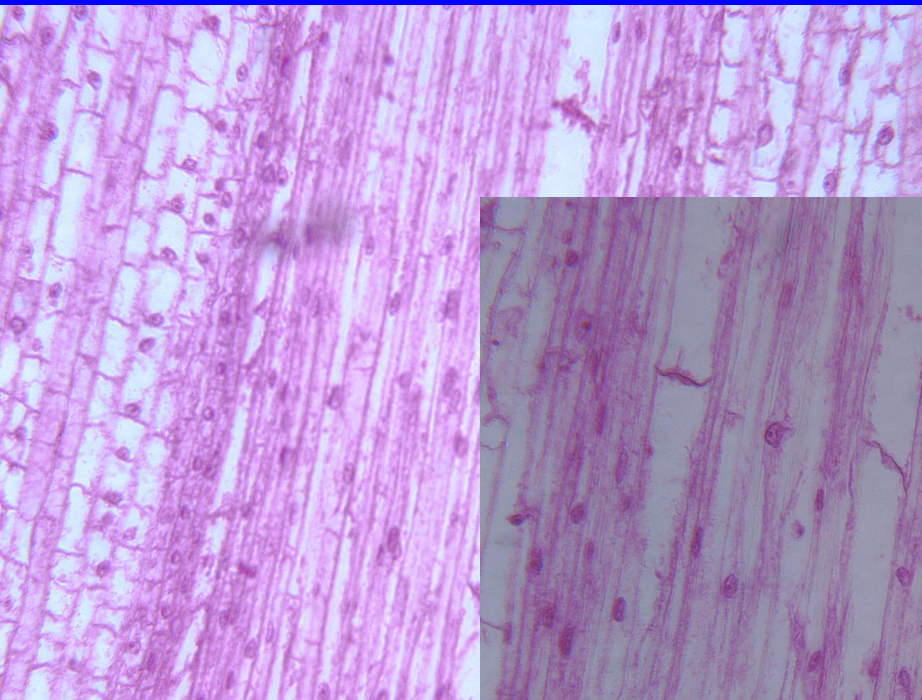
3. Elongation zone

Locating a little bit behind the meristematic zone, cell division in this zone has died down, the volume is expanded, and the cells are significantly elongated along the long axis of the root. Differentiation of the cells has been accelerated. The earliest sieve tube and annular vessel often emerge in this zone.

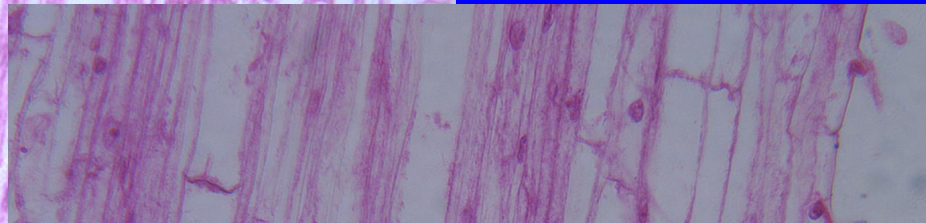
4. Maturation zone

All cells in this zone have stopped elongation, which are divided and mature. The epidermis grows root hairs. It is formed by elongation of the epidermal cell ectexine, which is a tubular structure specific to the root with very thin cuticle but without branches having grume and pectin substance in its exine. It has a fast growth rate but a short life span.

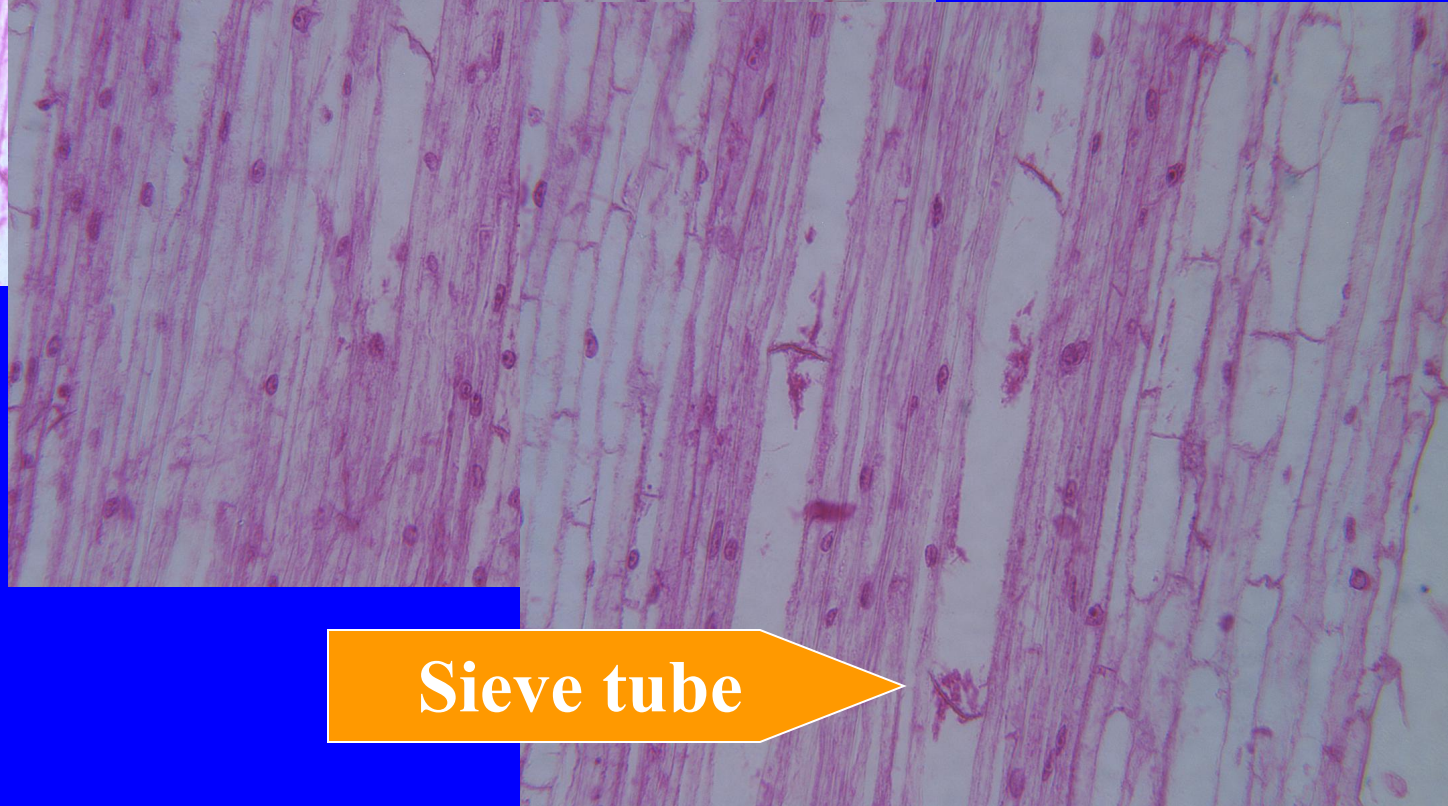




Elongation zone

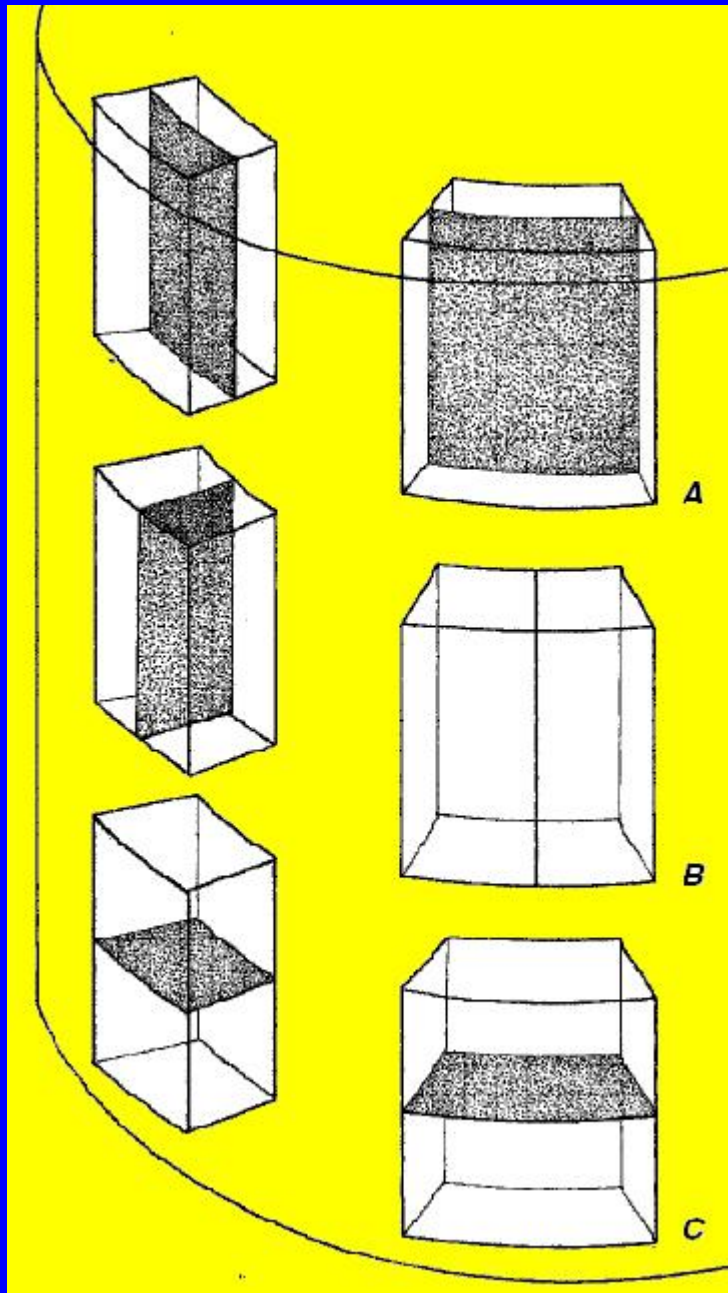


Maturation zone



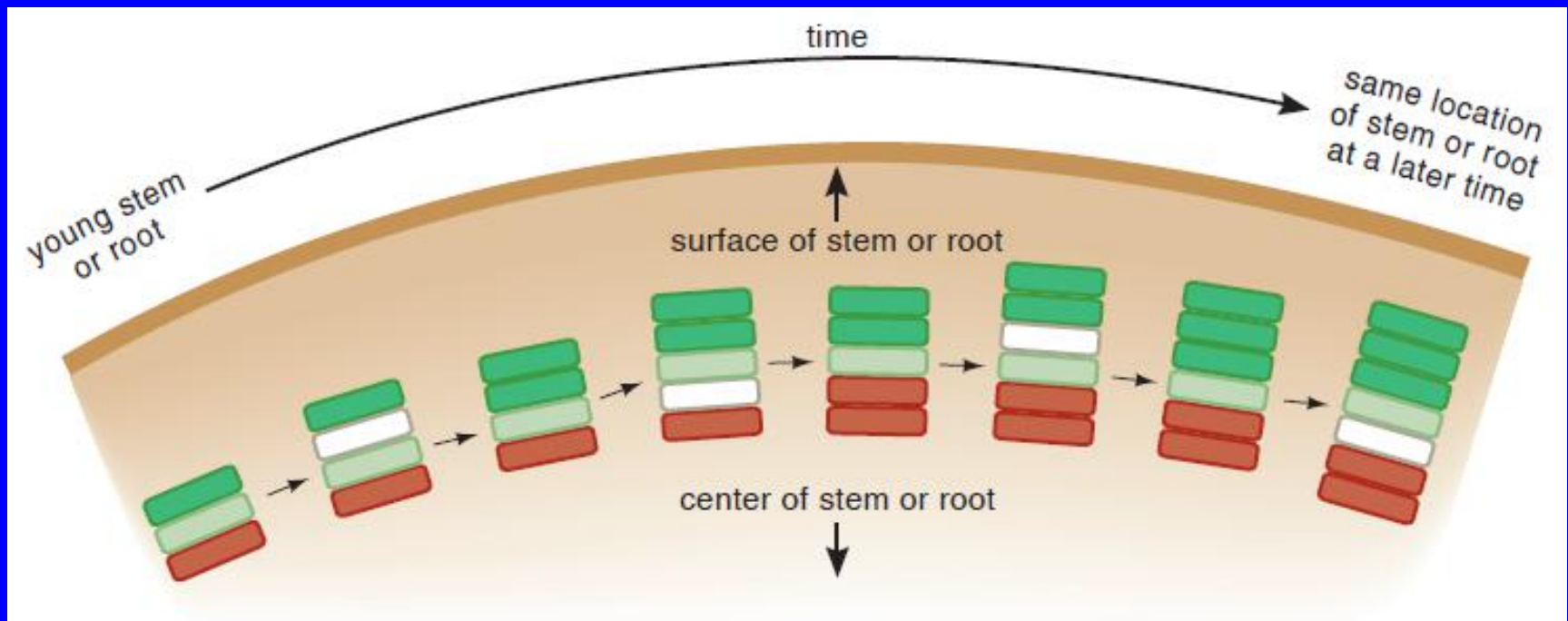
Sieve tube





Diagrams illustrating planes of division in a cylindrical plant structure. A, periclinal (parallel with the surface). B, radial anticlinal (parallel with the radius). C, transverse (anticlinal division at right angles to the long axis). (From Evert 2006)

¶Tangential division (periclinal, tangential division): Cell division is in parallel with tangent line in the nearest circumference of the root, which increases internal and external level of the cell and thickens the organ. The new wall of daughter cells is tangential wall, and the cells are radically (internally and externally) arranged.



¶ Radial division: Cell division is perpendicular to tangent line in the nearest circumference of the root, which expands the circumference of cell formation and widens the organ. The new wall is radial wall and the cells are tangentially (or left and right) arranged.

Transverse division: Cell division is in parallel with transection of the root axis, which prolongs the vertical line of cell formation and elongates the organ. The new wall is transverse wall, and the cells are vertically (or up and down) arranged.