Developmental Anatomy

by

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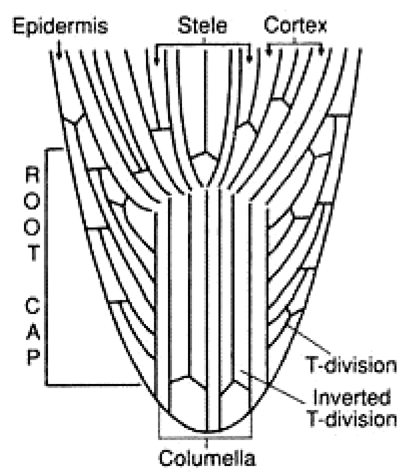
Organisation of shoot apex (Tunica–Corpus) and Root apex (Korper-Kappe)

The Korper-Kappe Theory of Root Apex

The **Korper-Kape theory** is similar to the tunica-corpus theory of the shoot apex. The theory was put forward by **Schuepp (1917).** It is based on differences in the planes of cell division. According to the theory, the cells in the root apex divide in a pattern called **T-divisions**. The outer region of the root apex is called the Kappe and the cells in this region **initially divide horizontally**. Later the lower daughter cell divides longitudinally **(at right angles to the plane of the first division**). The planes of two divisions form a T shape in the root's longitudinal section. The inner region of the root apex is called the Korper. In the inner region, the cell division forms an **inverted T pattern** where the second division occurs in the upper daughter cell. **'Korper is equivalent to corpus** and **Kappe to Tunica'.** This type of division has been found among the members of Gramineae and Fagaceae.



Diagrammatic representation showing the root apex meristem according to the Körper-Kappe theory

Tunica-Corpus Theory of shoot apex

- Two regions: TUNICA and CORPUS
- No constant relationship can be traced between the particular initials of the promeristem and the inner tissues of the shoot
- 2 regions can be distinguished by their plane of cell division

TUNICA

- Outermost layer
- Surrounds the inner cell mass (corpus)
- Anticlinal division
- Enlarges in surface area
- Layer: 1-9

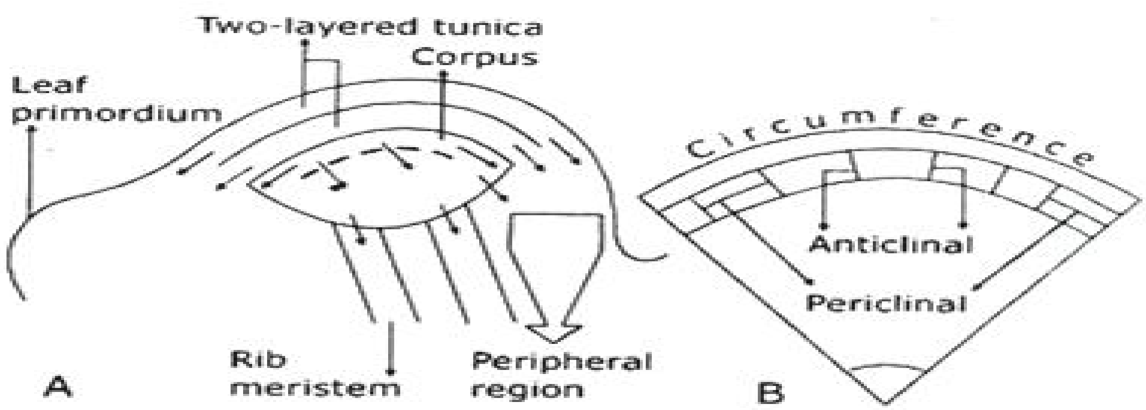
CORPUS

- Inner cell mass
- Divides in all directions
- Enlarges in volume

Schmidt in 1924 postulated tunica-corpus theory on the basis of studies of **shoot apices of angiosperm**. This theory is concerned with planes of cell division in the apex. In contrast to apical cell theory and histogen theory tunica-corpus theory is applicable only to shoot apex and not to root. Schmidt distinguishes two tissue zones in the shoot apex and termed them as **tunica** and **corpus**.

Majority of angiosperm shoot apex exhibits tunica consisting of two layers of cells and corpus. Researchers designate the layers as **L1, L2 and L3 to denote respectively outer layer of tunica**, **inner layer of tunica and corpus**.

Plasmodesmata exist between the cells of tunica and corpus. It is thought that plasmodesma controls the gene expression that leads to the formation of protoderm, ground meristem and provascular tissue



A. Diagram illustrating the tunica-corpus organization in dicotyledonous shoot apex. Arrows indicate the direction of cell formation in apical meristem. B. Schematic representation of anticlinal (= division wall perpendicular to surface) and periclinal (= division wall parallel to circumference) division.

Tunica

Tunica is the peripheral tissue zone of shoot apex. It consists of one or more peripheral layers of cells. **Dicotyledons exhibit one to five layers of cells in tunica**; two layers of cells are represented by largest number of species. **Monocotyledons** have one to **four layers** of cells in tunica; one and two layered tunica predominates in it. One single layered tunica is termed as monostratose.

Many layered tunica is termed as **multistratose.** ***Xanthorrhoea*** media shows eighteen layered tunica.

Tunica is characterized in having **anticlinal plane of cell division**, i.e., the division wall is laid down perpendicular to the surface. This division reflects to the surface growth in the apex. As a result tunica grows as a sheet but not in thickness.

To increase in **thickness a tunica cell will have to undergo cell division with periclinal wall**, i.e. the cell wall will have to be laid down parallel to surface. Normally, **periclinal division does not occur in tunica where anticlinal division predominates** except at the point of origin of leaf primordium and axillary bud.

Corpus

Corpus is the inner tissue zone of shoot apex. It consists of cells that are several cell layers deep. **Tunica overarches corpus**. Meristematic tissues composing this zone are larger than tunica. The initial cells of corpus occur below the tunica. They are orderly arranged in contrast to haphazardly arranged cells in the mass of corpus. So the initials of corpus are difficult to differentiate from the initials of tunica.

The initials arise independently and not related to tunica. The initial cells divide **periclinally** and the derivatives divide to form the core of the shoot apex. In the division of derivative cells there is no definite orientation of cell wall formation, i.e. cells divide in all planes. As a result the shoot apex **increases in volume.** Generally corpus is destined to give rise **cortex and vascular tissue**.

Usually **corpus is not homogeneous.** It consists of several zones. The zones are illustrated by Popham (1952) in the usual angiosperm type. In this type the meristem is composed of **tunica and corpus**. The tunica consists of one or more layers of cells that overlie the corpus.

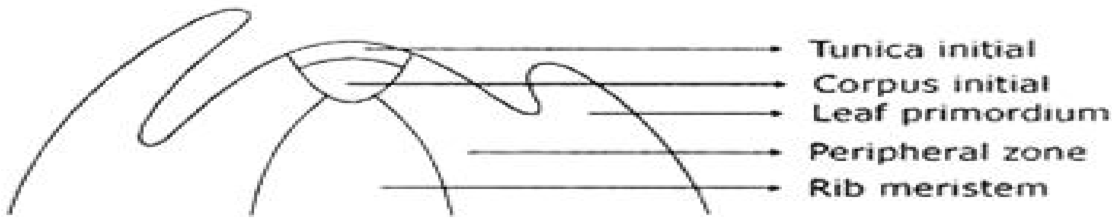


Diagram illustrating the cytohistological zonation of apical meristem.

Merits of tunica-corpus theory

i. It deals with one thing, i.e. **planes of cell division**. As a result the description of meristem becomes precise.

ii. It has topographical value in the studies of development of different tissue system in plants.

iii. The destiny of derivatives of corpus is not predetermined.

iv. The derivatives of the zones are not **rigid like histogen theory**.

v. It explains clearly the growth pattern in the **shoot apex of angiosperm**.

vi. It enables to understand the development of leaves as they arise close to apex.

vii. The specific variation in the number of tunica layers may be of taxonomic significance, e.g. grasses.

Differences between the shoot apex and the root apex

1. In contrast to that of the shoot apex, the apical meristem of the root apex generates cells not only toward the axis but also away from it to form the root cap.

2. The apical meristem of the root is sub-terminal in position as the root cap remains terminal.

3. The root apex forms no branches, and no lateral structures like the leaves. For that reason the root apex shows no change in morphology.

4. The root apex grows uniformly as it never produces nodes and internodes.

5. The root branches arise endogenously beyond the region of most active growth.

Plastochrone

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Plastochron is defined as the **time interval between the formation of one leaf primordium and the initiation of next leaf primordium.**

Plastochron is a developmental measure and is expressed as **'plastochron index'.** The index indicates the developmental status of each leaf and relates the observation to time. The developmental index is the plastochron age of a shoot. **Plastochron Index (P. I.)** can also be defined as a **measure of plant growth and is used to determine the rate of growth based upon the initiation of successive leaf primordia.**

Plastochron Index provides a **morphological time scale rather than chronological age in studies relating to morphological and physiological development of a whole plant or plant organ**. Similarly Leaf Plastochron Index (L. P. I.) provides a morphological time scale rather than chronological in studies relating to morphological and physiological development of a leaf.

In developmental studies plastochron is used as **the unit of developmental scale**. It is observed that morphologically similar leaves may be of quite different chronological age, while leaves with similar chronological age may also have quite different stages of development. Leaves of same plastochron age reveal similar morphology and development.

In developmental studies it is to relate an aspect of developing leaf directly to time. When the aspect is leaf development the length and breadth are measured in relation to time and the leaf remains intact. The aspect may be the dry weight, development of mesophyll tissue etc. and in this case the leaf is to be sacrificed to obtain data.

In this type of study one has to deal with many parallel samples when each is sacrificed at a given time for the required data. These parallel samples must be of same plastochron because P. I. eliminates the variation due to growth rate and creates a linear scale to measure development based on morphology.

Plastochron Index applies to shoot. So it is very useful in developmental studies in which interest centres on characteristic of the shoot. The characteristic may be the rate of metabolic process, content of a biochemical constituent, total fresh weight or dry weight of shoot etc. and these can be determined at various stages of development.

Easu (1965) observed that **plastochron** could be used to indicate the developmental age of the plant as a whole, as well, and the **plastochron index** provided a refinement of this age that proved more useful in characterizing leaf development, than chronologic age, in that tight developmental trends emerged among many morphological and physiological parameters when it was used **Michelini (1958).** According to **Mc Master (2005)** current general usage typically employs plastochron for the rate of primordia initiation on the shoot apex, and phyllochron for the rate of leaf emergence from the shoot bud.

The plastochron index

The **'PI'** is typically calculated by $\mathrm{PI} = n + (\ln L_n - \ln R)/(\ln L_n - \ln L_{n+1}),$ (1) where n is the sequential index number of the organ for which the PI is being calculated, with n increasing in an acropetal direction, R is the reference length of the organ, L_n is the length of an organ that is equal to, or just slightly longer than R, and L_{n+1} is the length of an organ that is just slightly shorter than R. If leaves on seedlings are being studied, typically $n = 0$, for the cotyledons.
