

# Chaudhary Mahadeo Prasad College

(A CONSTITUENT PG COLLEGE OF UNIVERSITY OF ALLAHABAD)

## E-Learning Module

### Subject: Botany

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### Plant Morphology and Anatomy

### Unit: II

**Topic:** Theories of Structural Development of Root and Shoot Apices

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## Theories of Structural Development of Root and Shoot Apices

Read this essay to learn about the theories of structural development of root and shoot apices:- 1. Apical Cell Theory 2. Histogen Theory 3. Tunica-Corpus Theory.

### 1. Apical Cell Theory:

In cryptogams like algae, bryophytes and pteridophytes the solitary apical cell found to be constantly present leads to the whole process of growth. Many researchers believe that the same condition prevails in all higher plants. On that assumption apical cell theory put forward by Hofmeister and supported by Nageli in 1878.

Subsequently it was found that the complex apices of gymnosperms and angiosperms could not be interpreted by this apical theory. So, soon it became consistent that the apical cell theory is not applicable to seed plants.

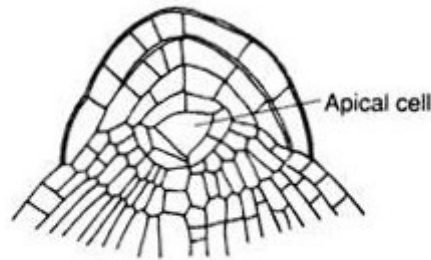


Fig. 5.41 : Solitary apical cell in the fern root apex from which other tissues originate

### 2. Histogen Theory:

The older 'apical cell theory' was replaced by the histogen theory proposed by Hanstein (1870) and supported by Strasburger (1868). The theory states that the main plant body arises from a mass of meristem of considerable depth consisting of three zones or histogens – the dermatogen, the Plerome and the periblem. This theory is concerned with the shoot and root apices.

#### (i) The Dermatogen:

Dermatogen is the outermost single cell-layer the cells of which usually divide by radial walls and give rise to epidermis. In some cases the cells of this layer divide by tangential as well as radial walls giving rise to multiple epidermis e.g. Ficus leaf.

**(ii) The Plerome:**

Plerome is the massive central core of the apices consisting of cells extended in longitudinal direction. The cells of this region divide in all planes giving rise to the central cylinder i.e. the stele consisting of pericycle, primary vascular tissues, medullar rays and pith. The plerome remains covered by the dermatogen and the periblem.

**(iii) The Periblem:**

Periblem is the intermediate zone lying in between the dermatogen and plerome. This zone is composed of isodiametric cells. From this region primary cortex is formed. The innermost layer of the cortex differentiates into the endodermis.

**Hanstein's histogen theory, though it is applicable in root apex, is still criticised in case of shoot apex of angiosperm mainly for the following two reasons:**

- (a) Sharp distinction between periblem and plerome in the apical meristems is absent,
- (b) The origin of different regions of the plant body from the sharply- defined histogens cannot be demonstrated.

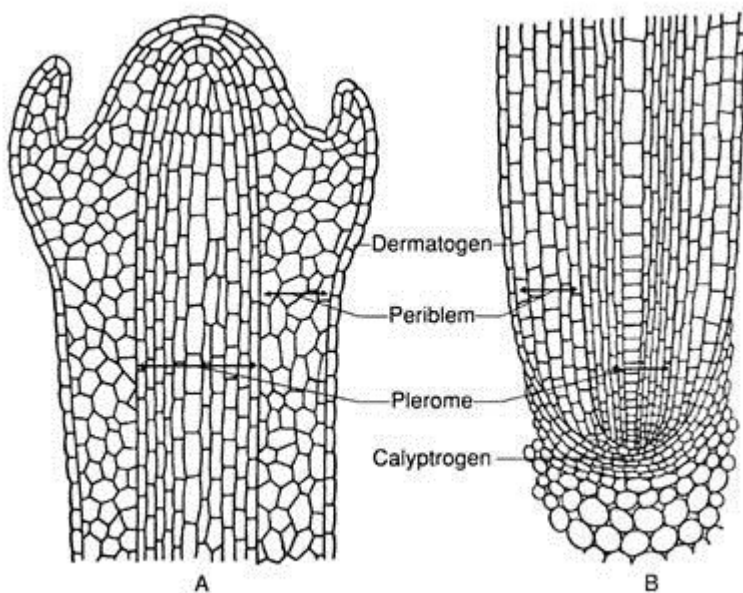


Fig.5.42 : L.S. through shoot apex (A) and root apex (B) showing histogens

**3. Tunica-Corpus Theory:**

Third theory of structural development and differentiation is the Tunica Corpus Theory propounded by Schmidt (1924) and supported by Foster (1949). The theory is based on the observations on angiosperm shoot apices.

According to this theory, two tissue zones occur in the apical meristem, viz. (i) the tunica, and (ii) the corpus. In fact, in lower vascular plants like pteridophytes and even in some gymnosperms a sharp distinction between tunica and corpus is lacking. But in angiosperm, however, the demarcation between the two zones is prominent.

**(i) The Tunica:**

Tunica is the outer covering zone composed of one or more peripheral cell layers enclosing a central mass of tissue. The cells of tunica divide mainly anticlinally bringing about surface growth. The tunica cells are smaller than the corpus cells. Each tunica layer develops from a small group of separate initials.

The number of tiers of initials is equal to the number of layers of tunica. From the outermost layer of the tunica epidermis develops; but other tissues (cortex, pith, vascular tissues etc.), may also be developed from the tunica or from the corpus or from both (Esau, 1965). It, of course depends on plant species and the number of tunica layers present.

**(ii) The Corpus:**

Corpus is the central core, a mass of cells surrounded externally by tunica layers. The two regions differ in structure and appearance due to varying rates of cell division and methods of growth.

The corpus cells are larger and divide in various planes, so that a mass of irregularly arranged cells is formed bringing about increase in volume. The corpus originates from its own initials located beneath those of tunica. The corpus zone gives rise to the pith, the vascular bundles and a part of cortex.

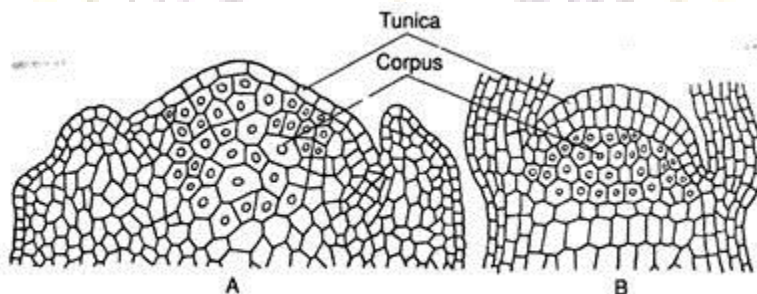


Fig. 5.43 : L. S. through shoot apex showing tunica (A) and corpus (B)

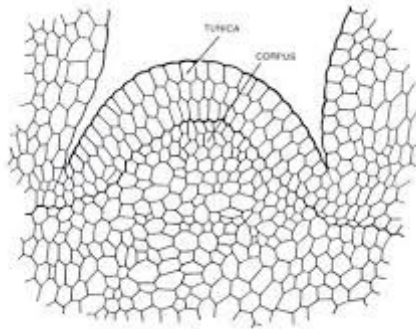


Fig. 36.11. Apical meristem. L.S. through shoot apex of *Vicia*, showing three-layered tunica and corpus

**Other theories to explain the structural organisation of the shoot apex are discussed:**

### **1. Histogenic Layer Concept:**

The concept was proposed by H. Dermen in 1947. Instead of naming the different layers of the apical meristem he named the different layers as L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub>, L<sub>4</sub>, and so on. The layers could be recognised microscopically and also by the assumptions based on the orientation of cell divisions.

### **2. Mantle Core Concept:**

This concept was proposed by Popham and Chan in 1950. The term mantle is used for the dome-shaped outer layers of the apex, and the core for the inner cell mass covered by the mantle. In this concept mantle is used for tunica and the core for corpus.

**Newman (1961) classified vegetative shoot apex into three types:**

### **3. Monoplex:**

Where there is only one initial dividing periclinally. This type is found in many vascular cryptogams.

### **4. Simplex:**

In this type the apex is composed of several initials in a single cell layer. The initials divide periclinally as well as anticlinally. This type is found in most gymnosperms.

## 5. Duplex:

In this type several initials in many layers are present at the apex. The initials of the surface layer divide anticlinally while cells of the inner layer divide in many planes. This type is found in most angiosperms.

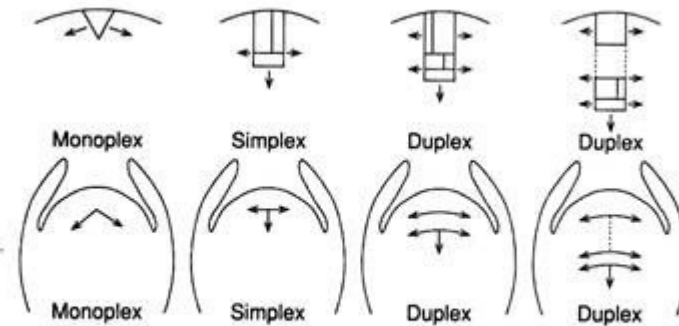


Fig. 5.44 : Diagram showing the different types of meristematic derivatives. The arrows indicate the displacement from the meristem derived cells

## The Korper-Kappe Theory of Root Apex

Read this essay to learn about the korper-kappe theory of root apex.

The theory was put forward by Schuepp (1917). It is similar to the tunica-corpus theory of the shoot apex. It is based on differences in the planes of cell division. The theory says that the cells in the root apex divide in a pattern called T-divisions. The outer region of the root apex is the Kappe. The cells of this region divide first horizontally. The lower daughter cell then divides longitudinally, i.e. at right angles to the plane of the first division.

Thus the planes of the two divisions form a T in a median longitudinal section of the root. The inner region of the apex is the korper. In this region the T is inverted, i.e. the second division takes place in the upper daughter cell. This type of division has been found among the members of Gramineae and Fagaceae.

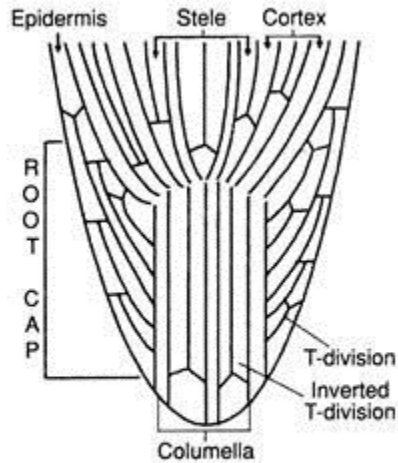


Fig. 5.48 : Diagrammatic representation showing the root apex meristem according to the Körper-Kappe theory

### Root apices in angiosperms:

#### Dicots:

Dicot root apices are of the following three types according to the number of initials present:

#### (a) Common type:

This type is found in majority of dicotyledonous plants. In this type, three groups of initials are found at the apex – outer (dermatogen), middle (periblem), and inner (plerome). The dermatogen forms the epidermis and the cap, the periblem forms the cortex, and the plerome gives rise to the central cylinder.

#### (b) Ranunculus type:

The members of Ranunculaceae, Juglandaceae, Salicaceae, Casuarinaceae, Leguminosae etc. exhibit this type of root apex. In this type there is a single row of initials which, ultimately, gives rise to various zones of the root including the root cap. Some of the cells of the root cap differentiate into the epidermis.

#### (c) Casuarina type:

This type of root apex development is evident in the members of the families Proteaceae, Casuarinaceae and in some members of Leguminosae. In this type, generally two rows of initials are observed at the apex. One of the layers gives rise to the stele and the other to the cortex and root cap.

The epidermis develops from the outermost layer of the cortex. In certain members of the families Juglandaceae, Rosaceae, Leguminosae, Tiliaceae etc. one of these two rows

of initials gives rise to the stele and the inner cortex, while the other gives rise to outer cortex and the root cap. The epidermis arises from the outermost layer of the cortex.

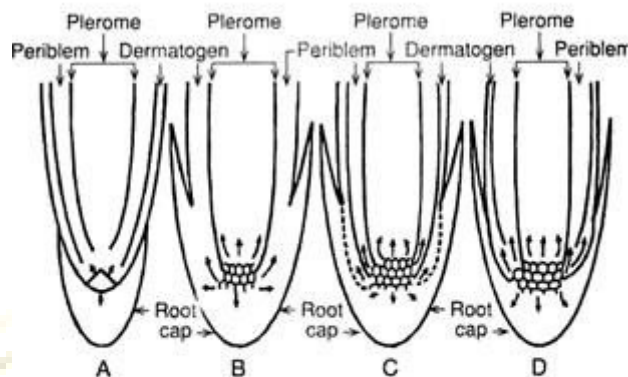


Fig. 5.49 : Diagrammatic representation of root apices :  
 A. Pteridophytic type with solitary apical cell.  
 B. As found in gymnosperms. C. Common dicotyledonous type. D. Monocot (maize) type

### Monocots:

In addition to the above discussed types in dicots there is a fourth type in monocotyledonous plants. The first type is found in *Zephyranthes* sp. The second type is very rare and found in *Allium sativum*, *Aloe vera*, *Amaryllis*, *Eucharis* etc. The third type is found in *Haemanthus coccineus*.

In the fourth additional type, there are four rows of initials giving rise to the root cap, the epidermis, the cortex and the stele, independently. The root cap developing row of initials is called the calyptragen which produces layers of cells outside to form a caplike structure.

### 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.

