Unit : 2

(a) Shoot apical meristem (SAM)
(b) Root apical meristem (RAM)

LESSON STRUCTURE

2.0 OBJECTIVE

Initiation of permanent tissues from meristematic tissue is a very common but important natural phenomenon by which a plant elongates and obtains its optimum length and width according to their genetic set up.

2.1 INTRODUCTION

Meristem - divided (divisible) Meristematic tissue are made up of those cells which have the capacity of division or they retain the dividing power. These cells are either spherical oval or polygonal in shape without inter cellular spaces. Thin walled homogeneous active and abundant protoplasm with large nuclei and vacuole almost very small or absent. According to Eames and MacDaniels (1947) meristem is also known as meristematic tissue meaning divisible. Meristem can be defined as the localized region where the cells

(a) Shoot apical meristem (SAM) (b) Root apical meristem (RAM)

are more or less orderly arranged and divide to produce new cells which undergo differentiation to form mature tissues.

Though Nageli (1844) coined the term meristem to designate the dividing cells, but in botanical literature, this term is applied to the undifferentiated, partly differentiated and mature cells, which has regained the power of cell division. The transformation of zygote into embryo and its subsequent growth and development leads to the formation of multicellural mature plant. These events occur because of multiple mitosis. In mature plants, the mitotically active centres are localized and are called meristem.

Meristem occurs in the root tip, stem tip, in the axil of leaf at the bases of internodes, in the flower buds, in the vascular bundle as fascicular cambium, at the peripheral side of cortex as cork cambium (Phellogen) and between the vascular bundles as inter fascicular cambium at the time of secondary growth.

The meristematic tissues give rise to permanent tissues. The permanent tissue system of plants comprise (1) The dermal tissue system, which makes up epidermis and periderm or protective tissues (2) The vascular tissue system, which includes xylem and phloem or conducting tissue and (3) The ground tissue system, which consists of all tissues except dermal and vascular tissues.

Characteristic features

(1) Shape Isodiametric

(2) Intercellular space more or less absent.

(3) Thin walled

(4) Protoplasm contains food, proplastids, crystals, large nucleus, vacuoles and plastids.

The region of undifferentiated meristem constitutes promeristem and these regions are the growth centres where the formation of new tissues are initiated. These initiating regions are sometimes referred to as embryonic meristem or primordial meristem. Promeristem is situated at the apical most part of the organ with undifferentiated cells. As soon as differntiation starts, they are no longer a part of promeristem.

Meristems are classified on the basis of certain factors

(a) According to their origin and development.

(b) According to their position.

(c) According to their function.

(A) According to their origin and development

- (a) Promeristem or primordial meristem.
- (b) Primary meristem.
- (c) Secondary meristem.

(a) Shoot apical meristem (SAM) (b) Root apical meristem (RAM)

(B) According to their position in the plant body

(a) Apical

(b) Intercalary

(c) Lateral

(C) According to their function

(a) Proto dermal

(b) Procambium

(c) Ground or fundamental meristem.

(A-a) Promeristem

Promeristem consists of a groups of meristematic cells representing the earliest or youngest stage of a growing organ and from this stage the differentiation of later meristem and finally of permanent tissues takes place. It occupies a small area at the tip of the stem and the root. The promeristem by cell divisions gives rise to the primary meristem.

(A-b) Primary meristem

Primary meristem is derived from the promeristem and still fully retains its meristematic activity. Its cell divide rapidly and became differentiated into distinct tissues. The primary permanent tissues which make up the fundamental structure of plant body mainly growing apical region of the root and stem, cambium of the stem give rise to primary meristem as well as secondary permanent tissues. The cambial cells divide mainly in single tangential plane while those of the primary meristem divide into three or more planes.

(A-c) Secondary meristem

Secondary meristem appears later at a certain stage of development of an organ of a plant. It is always lateral lying along the side of the stem and the root. It is seen that some of the primary permanent tissues become meristematic and they aquire the power of division then constitute the secondary meristem. The cambium of the root, the interfascicular cambium of the stem as well as cork-cambium are the best examples. All lateral meristems give rise to the secondary permanent tissues which are responsible for growth in thickness of the plant body.

B. According to the position in the plant body

(B-a) Apical meristem

On the basis of position the apical meristem lies at the apex of the stem and the root representing their growing regions and is of varying lengths. Usually ranging from a few millimetres to a few centimetres. It includes the promeristem and the primary meristem which give rise to the primary permanent tissues and is responsible for growth in length of the plant body. It is observed that the promeristem consists of a group of meristematic cells in higher plants where as in lower plant or in pteridophytes it is represented by a single cell.

(a) Shoot apical meristem (SAM) (b) Root apical meristem (RAM)

(B-b) Intercalary meristem

Intercalary lies between masses of permanent tissues either at the base of the leaf or at the base of the internode or some times below the node. It is a detached portion of the apical meristem separated from the later due to growth of the organ. Intercalary meristem also gives rise to the primary permanent tissues. It is generally short lived disappearing soon or becoming transformed into permanent tissues.

(B-c) Lateral meristem

Cambium of the stem lies laterally in strips of elongated cells extending from the apical meristem as in the stem of dicotyledons and gymnosperms it divides mainly in the tangential direction, give rise to the secondary permanent tissues to the inside and outside of it and is responsible for growth in thickness of the plant body.

(C) According to their function

(C-a) Protoderm

It is observed by Nageli (1858) that the apical meristem consists of a single apical cell in all plants and supported by Hofmiester what ever he observed that after a sequence of cell division it is responsible for the formation of different membranes of plant body, protodermal meristems are often common is lower plants which gives rise to the epidermal tissue system.

(C-b) Procambium

Before the intiation of cambium meristematic cells are known as procambium. Activation of procamibium differentiates the growing layers of plant body. Procambium can be absorbed in almost all the vascular plants which gives rise to the vascular tissue system.

(C-c) Ground of fundamental meristem

Fundamental or ground meristem gives rise to the ground tissue system and responsible for the thickness of the plant body. Haberlandt (1914) explained it on the basis of physiological activities.

2.2 SHOOT APICAL MERISTEM (SAM)

A meridian T.S. and L.S. through the apex of a stem, when examined under the microscope, shows that the apical meristem or growing region is composed of a small mass of usually rounded or polygonal cells which are all essentially alike and are in a state of division, these meristematic cells constitute the promeristem. The cells of the promeristem soon differentiate into three regions dermatogens, periblem and plerome. The cells of these three regions grow and give rise to primary permanent tissues in the mature portion of the stem. The section further shows on either side a number of out growth which arch over the growing apex; these are the young leaves of the bud, which cover and protect the tender growing apex of the stem. Theories regarding apical meristem were formulated by Nageli (1858), Hanstein (1870) and Schmidt (1924) are known as:

(a) Apical cell theory

(b) Histogen theory

(c) Tunica corpus theory

(a) Apical cell theory

Nageli in (1844-1859) proposed this theory. He first coined the term meristem and said that the apical meristem consists of a single apical cell in plants, and that the sequence of cell divisions is responsible for the formation of different members of the plant body. Nageli believed that a single apical cell is present in the root and shoot apices of cryptogams. This apical initial may be lens or wedge shaped. Prismatic or tetrahedral. One side of the tetrahedral cells faces towards the apex and the other three sides face inner and peripheral sides. Nageli assumed that all the tissues of root and shoot are derived from this single apical cell, which is the basis of apical cell theory and considered as the structural and functional unit of apical meristem. Nageli's single cell theory is no doubt true of the thallophytes and vascular cryptogams but his assumption that this is applicable to all cryptogams and phanerogams has proved to be wrong. Though this single theory was supported by Hofmiester but he expressed doubts regarding its applicability to all cases, particularly phanerogams. After extensive investigation it is found that solitary apical cell theory is not universally supported and it was soon superseded by other theories.

(b) Histogen theory

Hanstein (1868-70) put forward this theory. The shoot and root apices consist of a group of homogeneous meristematic cells, which are promeristem. This theory postulates the existence of three cell initiating regions or histogens or tissue builder in the promeristem. According to Hanstein, the three regions originate from independent group or separate set of intials. These regions are histogen and termed as dermatogen.

PERIBLEM AND PLEROME

Dermatogen (meaning skin)

The outermost histogen of promeristem is designated as dermatogen. It forms a mandle like layer surrounding the periblem. It is single layered epidermis of root and shoot develops from this meristem.

Periblem (meaning clothing)

The intermediate zone (histogen) internal to dermatogen of the apical meristem is the Periblem. It remains covering the plerome. At the topmost apices of apical meristem, it is single layered and gradually it becomes multilayered and this histogen gives rise to cortex of root and shoot. The inner tissues of the leaf at the shoot apex are derived from periblem.

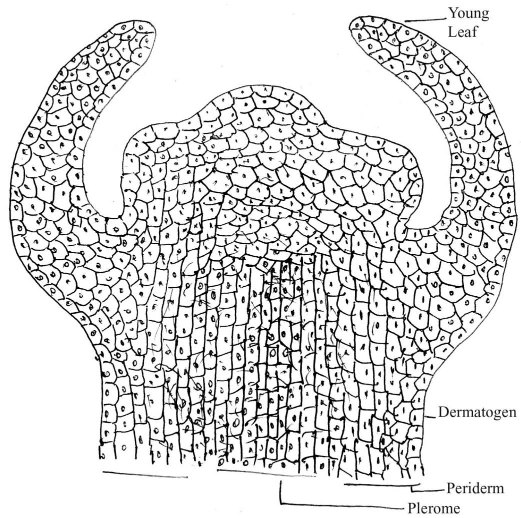


Fig. 1 Stem apex in median L.S., Longitudinal Section.

(a) Shoot apical meristem (SAM) (b) Root apical meristem (RAM)

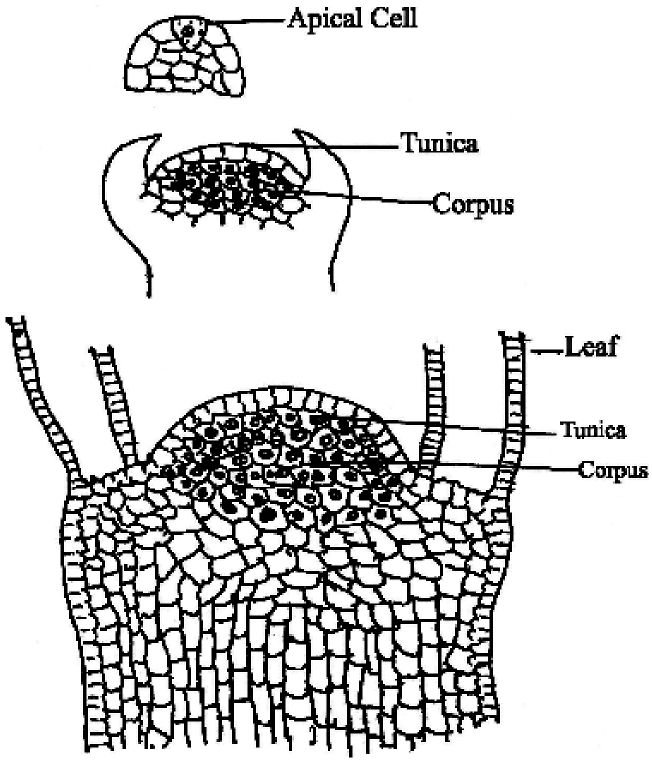


Fig. 2 : Apical Meristem Showing V.S.

Plerome (Greek word means-fills)

The innermost histogen which is situated at the central region of the apical meristem in the plerome. It remains surrounded by periblem. The cells of the histogen are thin walled and isodimetric. Plerome gives rise to entire vascular cylinder including pith. The pericycle and medullary rays also develop from this meristem. Precambian is formed from plerome at later stages, procambium gives rise to primary vascular bundles.

Homstein's histogen theory dominated for a long time to interpret the origin of tissues of an organ. On the basis, Haberlandt (1914) designated the histogens as protoderm. Procambium and ground meristem though these terms are quite distinct and not synonymous to Hanstein's dermatogen, periblem and plerome. Now a days this theory is of little use due to (1) there exists no distinction between histogens in an apex (ii) The distinction between periblem and plerome is not prominent in many gymnosperms and angiosperms. (iii) The derivatives of histogen is not constant. In some plants plerome forms pith only in other it gives rise to part of cortex and in still other the entire vascular cylinder. On the other hand, the periblem gives rise to cortex and peripheral layers of stellar tissue or part of the cortex.

(c) Tunica-Corpus Theory

Tunica-corpus theory was proposed by Schmidt (1924). In contrast to apical cell theory and Histogen theory, this theory is applicable only to the apical meristem of shoot and not to the root. This theory recognized two regions or zones the tunica and the corpus in the shoot apex.

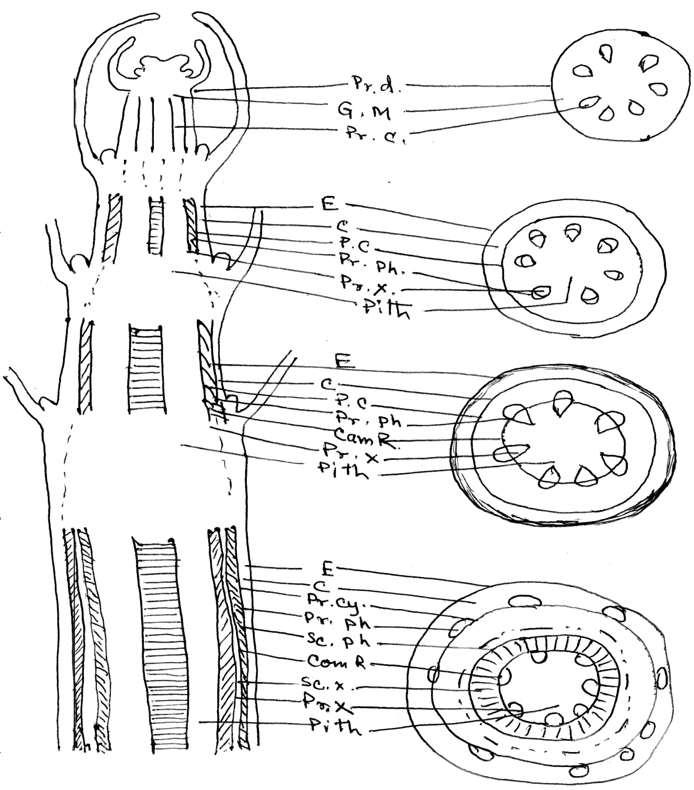


Fig. 3 : Apical Meristem (Redrawn after Meyar et al)
Pr.d.-Protoderm, G.M.-Ground Meristem, Pr.C.-Procambium, E-Epidermis, C-cortex, Pr.ph.-Primary phloem, Pr.X-Primary Xylem, Camel-Cambium Ring.Sc.Ph.-Secondary phloem, Sc.X-Secondary Xylem.

Tunica : It is the surface layer of shoot apical meristem. It consists of one or more peripheral layers of cells. Which are not always constant and usually range from one to nine. One single layer, called as monostrotose is probably most common, followed by two to four, known as multistrotose. The number of layers may even be more or varies in families, genera and species at different stages of development. The cells to tunica are compactly set and regularly oblong in longitudinal section. The cell division in this layer is predominantly anticlinal, it means walls are laid perpendicular to surface especially at the point of origin of leaf and exillary bud. Therefore, these layers have only surface growth and thus shoot apex grows in surface area.

There are separate initials for each tunica layer, the number of initials corresponds to the number of layer of tunica present in the shoot apex.

There are two zones can be distinguished in tunica:-

(a) Peripheral zone

(b) Central zone

Peripheral zone surrounds Central zone where as Central zone consists of a single or few initials. The cells of the central zone are larger in size and possess larger nuclei and vacuoles than the cells of peripheral zone. The peripheral zone lies between the control apical zone leaf primordia. In the peripheral zone sometimes periclinal divisions are observed in addition to anticlinal divisions which is the chief mode of division of tunica. Periclinal division also occurs in tunica of some monocotyledons. In general the outermost layer of tunica differentiates into epidermis. The other zones like cortex and stele may also arise from tunica and it varies in different plants.

CORPUS : This meristematic zone lies beneath the tunica. The cells are larger than the cells of tunica. The cells of corpus divide in all direction and form the central core of the shoot apex, generally corpus originates from a single tier of initial cell situated below the tunica. This initial layer becomes several layers by periclinal division and then divides in all planes to increase the volume of the shoot apex. In most cases corpus gives rise to cortex and stele.

It is the position and plane of cell division that differentiates tunica and corpus, the tunica is more homogeneous. Recent electron microscope study reveals that the ultrastructural differences between these two layers are mainly quantitative.

The tunica-corpus concept is applicable to angiosperm shoot apex only. The two-zone tunica and corpus cannot be distinguished in cryptogames and Gymnosperms except ***Gnetum*** which shows tunica-corpus pattern of growth in the shoot apices. The number of layers, plane of cell division and the destiny of tunica and corpus is not constant and varies from families, genera and species and even at different stages of development. There is no precise definition of tunica and corpus. This theory is purely descriptive and served well to describe the shoot apex of angiosperm.

2.3 ORIGIN AND EVOLUATION OF MERISTEMATIC TISSU

ORGANISATION

Since the origin of the cellular organisation there was a tendency of each and every individual to prove it self to be the fittest one in the existing environmental conditions. As different authers differ widely in their lines of thinking with regard to the origin and evolution of meristematic tissue. It is felt necessary to review those possible lines instead of expressing one's personal opinion in this aspect of meristematic tissue. This will give every one a wide scope for independent thinking after giving due consideration of every body's line of thought. This discussion is primarily based on the solitary or single layered meristematic cells upto differentiation zones.

The difficulties associated with the interpretation are mainly wide variation in the differentiation zone due to the biochemical and metabolic activities. As well as variable pigmentation in meristematic zones of plant body.

It is too difficult to say that when and how the meristematic initial tissue was originated but some principles, theories and hypothesis are leading to show the possible path of this natural evolution in the absence of the evidences, only on the basis of same assumptions and postulates of some renouned thinkers philosophers as well as the fossil history and foot prints which are shown below for disclosing this mystery.

There are two lines of evolution which are recognised and supported by various scientists

(a) **Gametophytic generation :** (Haploid cells and tissues as well as Haploid thallus reorganisation) usually the apical initial meristem single cell was observed there) Prominent in cryptogamic flora.

(b) **Sporophytic generation :** (Diploid cells and tissues) where the apical initial meristematic cells were observed.

Prominant in phanerogames.

Similarly there are two contradictory views of evolution of stem apical meristem.:

(1) Up grade or Progressive evolution theories:

These supporters are:

Nageli (1858-60)

Hanstein (1870)

Lotsy (1909), Campbell (1940),

Smith (1955), Calakovsky (1874)

Feldmann (1952)

(2) Down-grade or Regressive evolution theory: supporters are - Haberlandt (1914) Takhtazan and Zimmermann (1966), Mehra (1953), Evans (1939), Wettstein (1903-1908), Harris (1938), Church (1919), Bold (1938) and Fritsch (1945).

(a) Shoot apical meristem (SAM) (b) Root apical meristem (RAM)

It is assumed that the evolution started from, volvoxlike colony and forwarded like.

Volvox - Coleochaete - Chara - Nitella - Laminaria - Fucus - Polysiphonia - Peziza - Agaricus - Sphagnum - Funaria - Lycopodium - Selaginella - Marsilea - Pteris - Cycas - Pinus - Gnetum and then Angiosperms growing regions.

Successive cuts of cells in apical pyramidal cell, it supports apical cell theory of (SAM) development of stele in pteridophytes, development of antheridium and archegonium in gymnosperms and finally in every growing stem regions of angiosperms are the examples of the (SAM). Now some diagrammatic representation of cyto-histological zonation in the promeristem of vegetative shoot apices,

1. Pteridophyte type
2. Selaginella type
3. Cycas type
4. Ginkgo type
5. Cryptomeria - Abies type.
6. Opuntia
7. Usual Angiosperm type
   (Redrawn of Fahn 1997)

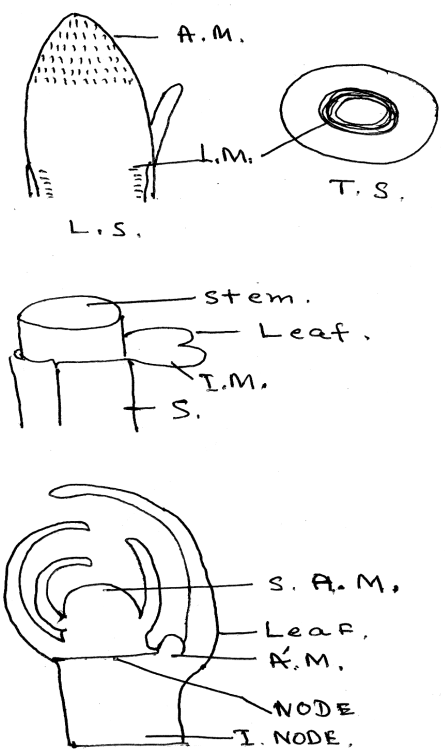


Fig. 4 (Redrawn after Lyndon, 1988)
A.M.-Apical Meristem, L.M.-Lateral Meristem,
L.S.-Longitudinal Section, T.S.-Transverse Section,
I.M.-Intercalary Meristem, S-Seath, A.M.-Axillary Meristem.

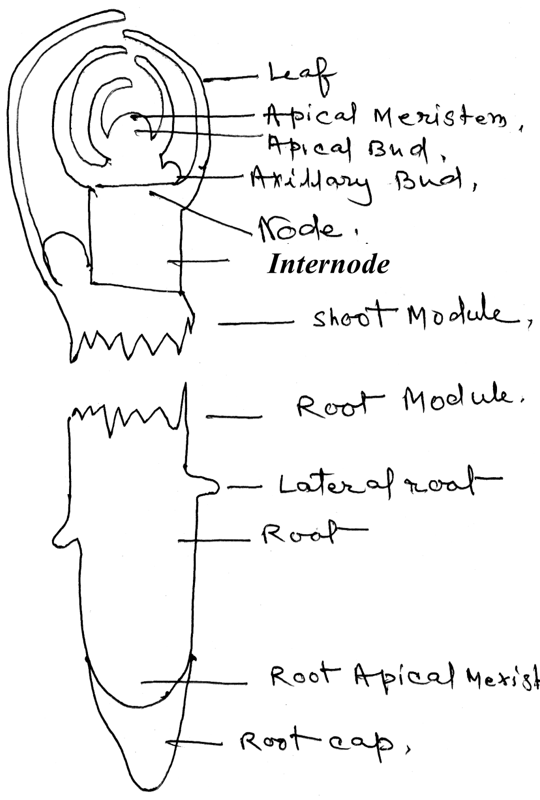


Fig. 5 (Redrawn after Lyndon, 1990)
A Typical plant showing Meristematic zones.

Buvat (1955) advocated the idea of existence of quiescent centure in the shoot apex. Buvat (1955) divided the shoot apical meristem into

(a) Waiting meristem.

(b) Initiating ring.

(a) Waiting meristem is apical in position and it rarely divides during vegetative development, they become active when the vegetative apex become reproductive at the time of formation of terminal flower or inflorescence. It is postulated that all reproductive growth is due to the activity of waiting meristem. Buvat (1955) recognised four meristematic zones in the vegetative shoot apex.

(1) Initial

(2) Sporogenous promeristem

(3) Receptacular promeristem

(4) Pith meristem

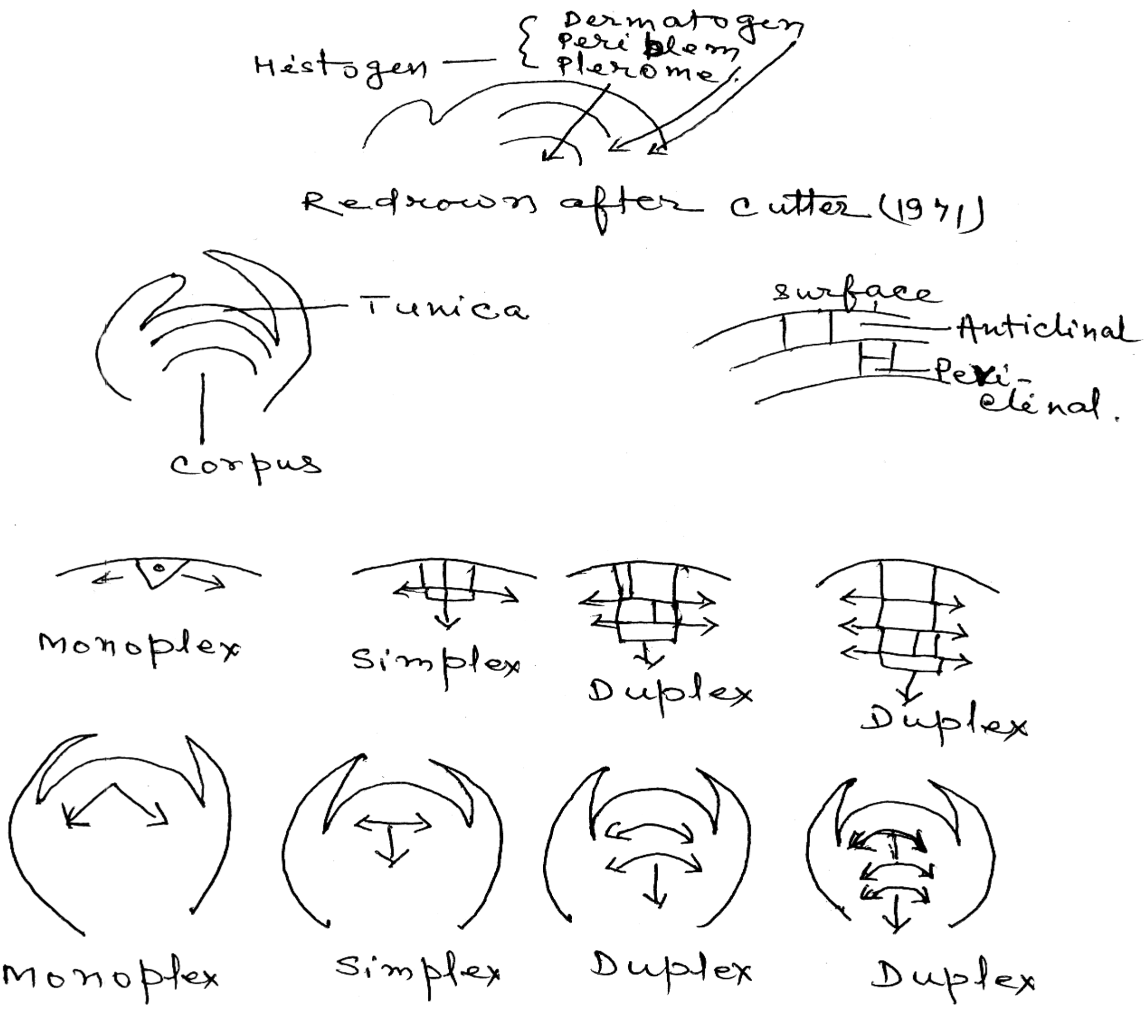


Fig. 6 (Digram showing C.M.C. and arrows showing the direction of cell displacement from the cmc. Redraw after Newman (1965).

A Typical plant showing Meristematic zones.

Initial and sporogenous correspond to tunica layer and remaining two represent the corpus. Another interpretation was put forward by Newman (1965) regarding apical meristem. Where no cell is a permanent cell. According to this view the apical meristem is continuing meristematic residue (c.m.r.) on the basis of (c.m.r.) Newman (1965) proposed three basic types of shootapex in vascular plants.

(1) Monoplex apex.

(2) Simplex apex.

(3) Duplex apex.

(1) **Monoplex apex:** It is found in mostly Algae and Fern. Continuing meristematic residue may consists of a single cell, two cells with a common wall or three or more cells which have a common angle. During division cell wall is formed parallel to inclined wal. This type of division contributes to increase in both length and breadth. This also provides for increase in both length and breadth as well as increase in bulk growth.

(2) **Simplex apex:** In gymnosperm (c.m.r.) lie on the superficial layer only. It may consist of a single cell more than one cell that have a common wall and three or more cells which have a common angle. The cells of c.m.r. are parallel with each other.

Division of walls occur in two ways:

(a) Perpendicular to outer face.

(b) Parallel with outer wall.

or

(a) Anticlinal divi-sion

(b) Periclinal divi-sion

Anticlinal division causes the increase in breadth, where as periclinal division contributes in the increase of length. Peri and anticlinal-these two divisions are necessary for bulk growth. These division are restricted to a single layer and is named as simplex.

(3) **Duplex apex:** In Angiospermic flora the cells of (c.m.r.) appear to be paralled with each other, at least in two successive layers, Peripheral being the surface layer and the innermost layer behaves as simpex apex. Periclinal and anticlinal divisions occur in the innermost layer only. Which causes the increase in length and breadth and thus the bulk growth. The place where the anticlinal division occurs is responsible for the increase in surface or breadth only, therefore duplex apex, shows two modes of growth.

(i) Outer anticlinal division causing surface growth.

(ii) Inner cells have both anticlinal and periclinal divisions. As a result, increase in length and breadth occurs. Thus causing bulk growth.

(a) Shoot apical meristem (SAM) (b) Root apical meristem (RAM)

Difference between root apical meristem and shoot apical meristem

ROOT APICAL MERISTEM	SHOOT APICAL MERISTEM
1. It is less complicated than the shoot apical meristem. It produces lateral roots only. It functions in a constant manner.	1. It is more complicated than the root apical meristem. It has lateral organs like leaves or floral organs and cyclic. The position of new organs is predicatable of those already present.
2. It is sub-terminal in position. It remains covered by vaculated tissues of root cap.	2. It is terminal in position. It remains over-arched by leaf primordia.
3. Due to the absence of lateral primordia, there is no rhythmic change in size and form.	3. There is a regular rhythmic change due to presence of leaf primordia.
4. Phenomenon of ageing is prominent in excised roots.	4. Phenomenon of ageing is combated when grown in light.

2.4 ROOT APICAL MERISTEM (RAM)

A median longitudinal section through the apex of the root shows that it is covered over and protected by a many layered tissue which constitutes the root cap. The apical meristem or growing region lies behind the root cap. The promeristem as in the stem, early differentiates into three regions.

(1) Dermatogen

(2) Periblem

(3) Plerome

At the embryonic stage the root apical meristem is organized opposite to the shoot apex. In contrast to shoot, It is simpler in gross structure but is complicated at apex due to root cap, which develops from the root apical meristem, thus the meristematic region remains well protected. The root apex may consist of a single cell or a group of cells. The apical cell theory of Nageli in 1978 and the Histogen Theory of Hanstein (1868) is applicable to root apex but Tunica corpus theory is not applicable.

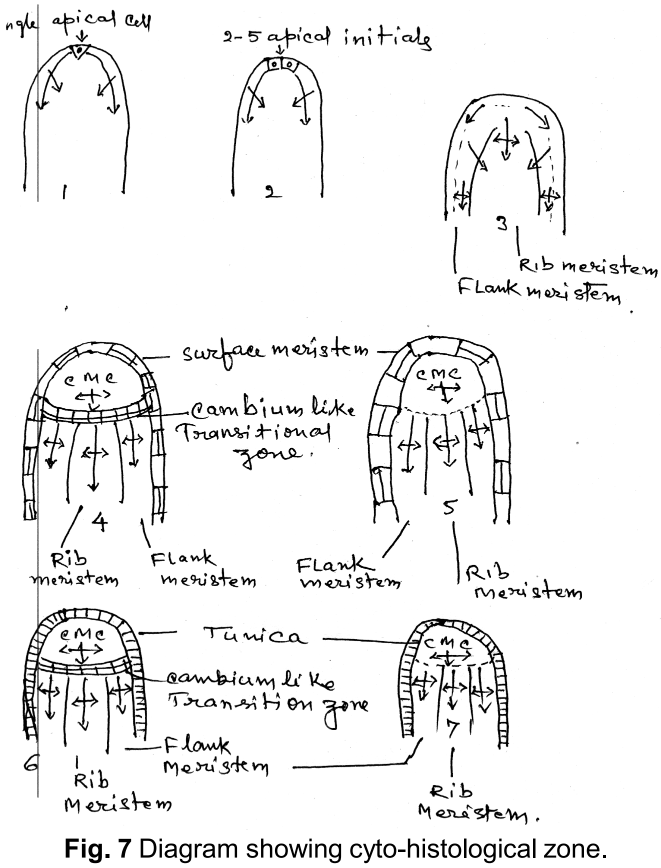


Fig. 7 Diagram showing cyto-histological zone. (Redrawn after Fahn (1997))

(1) Dermatogen

As in the stem, this is also single layered, but at the apex it merges into the periblem; many new cells cuts off just out side the dermatogen and forms calyptrogen means cap producing small celled tissue. These small celled tissues are responsible for the formation and replanishing or renewing the root caps under the hard soil. In some plants the dermatogen directly gives rise to the root cap without the intervention of the calyptrogen. The walls of outer cells of the root cap may be modified into mucilage which helps the root to push forward in the soil more easily. Sometimes in dicotyledons generally the dermatogen is exhausted in the formation of the root cap so that the outermost layer of the root is derived from the outermost layer of the periblem.

(2) Periblem

As in the stem, this is also single-layered at the apex and many layered higher up. In monocotyledons generally the outermost layer of the periblem forms the outermost layer of the root forms the middle region or cortex of the root.

(3) Plerome

The plerome's structure and function are practically the same as those of the stem. But here some procambial strands give rise to bundles of vessels and others to bundles of sievetubes or phloem in an alternating manner.

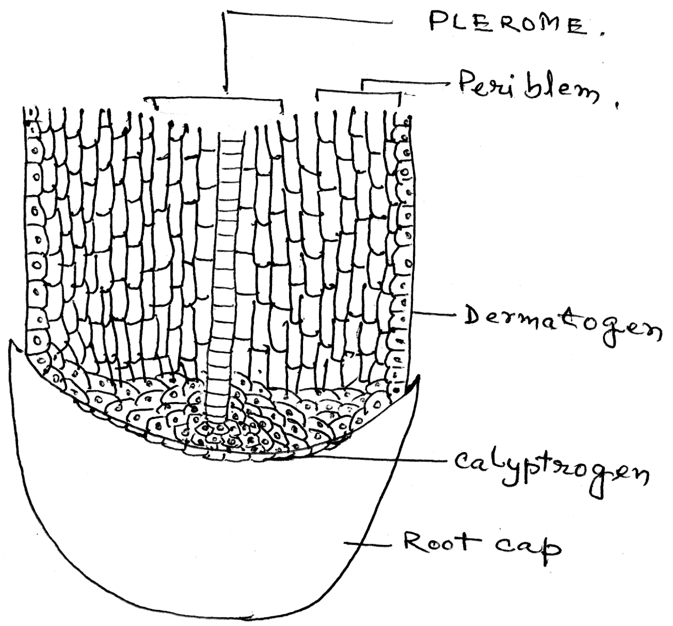


Fig. 8 Diagram Showing Root-apex in median longitudinal section.

2.5 ROOT MERISTEMATIC TISSUE ORGANISATION AND EXAMPLEX OF (RAM)

At the embryonic stage the root apical meristem is organised opposite to the shoot apex. In contrast to shoot, it is simpler in gross structure but is complicated at apex due to the presence of root cap, which develops from the root apical meristem.

Now same examples of root meristematic tissue organisation.

(1) Root of Pteridophyta

The apical cell theory of Nageli holds for the root apex of vascular cryptograms. The root apex of Equisetum, Dryopteris, Ophioglossum and other members of pteriodophytes possess a single tetrahedral apical cell in their root apices. This single initial cell has four cutting faces, which on repeated division contributes to growth in root cap, epidermis cortex and stele. The upper three sides of the initiating cell forms epidermis, cortex and stele and the root cap develops from the lower side.

All cells of the root can be traced back to a single apical initial. The immediate derivatives of this apical initial are also mitotically active. Therefore, the root apex appears to constitute a multi cellular meristem. The idea of an inactive root apical meristem or quiescent was applied to the root tips of many vascular cryptogams. However recent investigation reveals that entire root tip is mitotically active

(2) Root apex of Gymnosperm

Allen (1974) described the root apex in **Pseudotsuga.** It consists of four zones one permanent initials and three groups of temporary initials. The first group of temporary initial gives rise to meristem of vascular cylinder that form stele. The cortex is formed from the second group of temporary initials, which form the meristem of cortex the peripheral layer of cortex gives rise to protoderm from where epidermis develops. The third group of temporary initial is the collumella mother cell and it produces columella. Wilcox (1954) reported the presence of two groups of temporary initials in **Abies procera.** One group of temporary initial gives rise to the vascular cylinder, and the columella develops from the other group. The columella by cell division contributes to growth in both root cap and cortex.

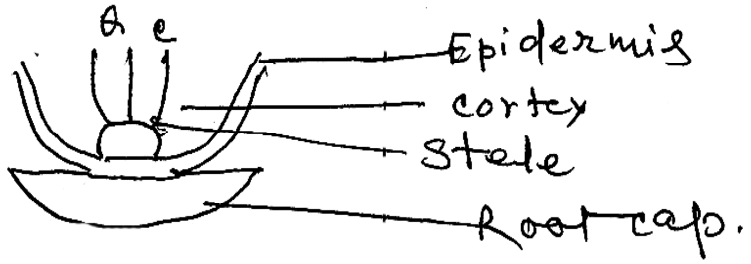
Schematic diagram showing the zones of a root apical meristem.

(Redrawn after Mauseth 1988)

(3) Root apex of Angiosperm

Gutten Berg (1960) distinguish three groups of temporary initials and a central group of permanent initials in the root apex of angiosperm. The derivatives of temporary initials may vary from plant to plant, as for example in **Brassica,** the meristem of vascular cylinder develops from one group of temporary initial. Other group give rise to meristem of cortex, protoderm and root cap originates from the last group of histogen or temporary initials. Protoderm gives rise to epidermis. The root cap and epidermis have common histogen and this special temporary initial is called dermatocalyptrogen (Gutten Berg, 1960). Dermotocalyptrogen is also observed in other members of Solanaceae, Rosaceae and Asteraceae etc. However in Zea mays, protoderm and cortex originate from a common temporary initial. The vascular cylinder develops and cortex originate from a common temporary initial. The vascular cylinder develops from another temporary initial. The root cap originates from a separate histogen or temporary initial. This special temporary initial or meristem of root cap was termed as calyptrogen by Janczewski in 1874, some member of Arecaceae and Zingiberaceae also possess calyptrogen.

Eames and Mac Daniels (1947) described the root apex of Cryptogams, Gymnosperms and Angiosperms. Diagram demonstrating the type of root apex in (A) Cryptogams (B) Gymnosperm (C) Dicotyledon (D) Monocolyledon based on concept of Eames and Macdaniels (1947).



Q.C. - Quiescent Centre

Theories of Root Apical Meristem

1. Apical cell theory by Negeli (1844)
2. Histogen Theory by Hanstein (1865)
3. Korper - Kappe theory by Schuepp (1917)

Apical cell theory by Nageli (1844) put forward this theory on the root apex of cryptogams where as Histogen theory of Hanstein (1865) proposed this theory to prove and show the three distinct cell initials or histogen in the apical meristem of root of angio-sperms. Recent investigations discarded the histogen theory still several authors described the root apex based on histogen concept. Korperkappe thory Schuepp (1917) put forward this theory Korper and Kappe means body and cap respectively. The body-cap concept is based solely on planes of cell division and deals with different aspects of apical activity.

Newman (1965) proposed five types of root apex based on the types described by Eames and Macdaniels (1947) and Esau (1953) the amalgamated the types as follows.

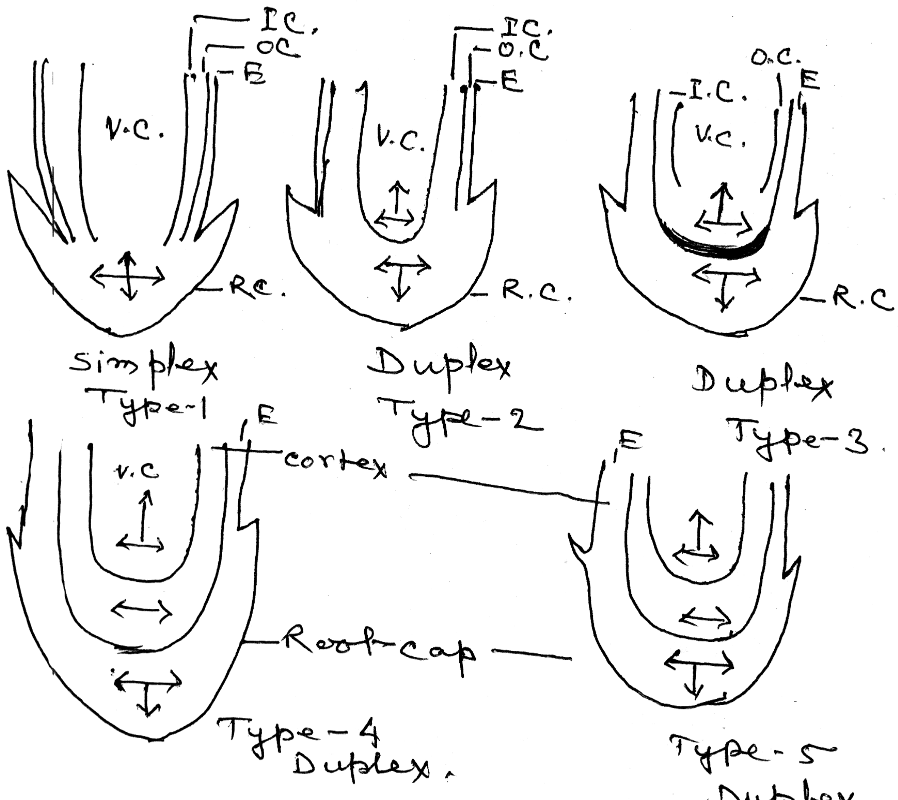


Fig. 9 : Diagrams showing types apical meristem. Arrows showing direction of cell displacement from CMC.
Redrawn after Newman 1965
V.C. - Vascular Cylinder, E-Epidermis
O.C. - Outer Cortex, I.C. - Inner Cortex
R. C. - Root cap

(a) Shoot apical meristem (SAM) (b) Root apical meristem (RAM)

(Redrawn after Newman (1965)

Diagrams demonstrating types of root apical meristem in longitudinal section arrows show the direction of cell displacement from the continuing meristematic residue.

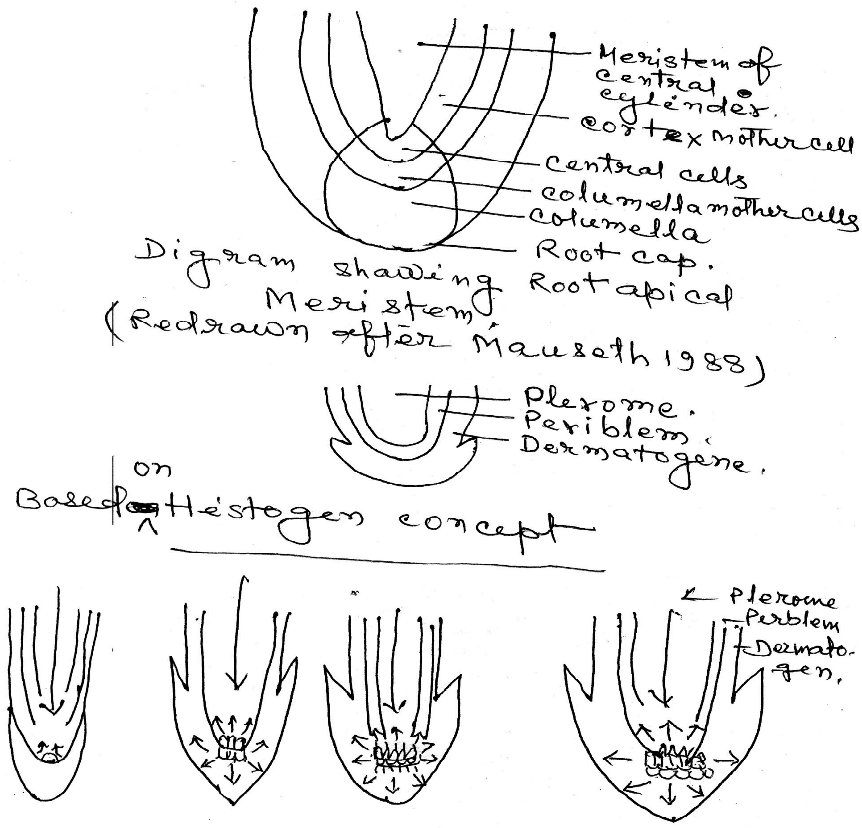


Fig. 10 : Diagram showing Root apex.
Based on Concept of Eames and MacDaniels (1947)

2.6 QUESTIONS FOR EXERCISE

1. **Give an account of organisation of root apical meristem.**
2. **Give a detailed account of shoot apical meristem.**
3. **What are the main differences in organisation of root apical meristem and shoot apical meristem.**
4. **Write short notes on the following :–**

(a) (RAM)	**(b) (SAM)**
(c) Dermatogen	**(d) Periblem**
(e) Plerome	**(f) Apical cell theory**
(g) Histogen theory	**(h) Protoderm**
(i) Procambium	**(j) Cambium**
(k) Fundamental meristem	

(a) Shoot apical meristem (SAM) (b) Root apical meristem (RAM)

5. Give a detailed account of meristem.

6. Discuss the theories related to the development of (SAM).

7. Discuss the tissue organisation of (RAM).

2.7 SUGGESTED READINGS

1. Collage Botany - Kar
2. Botany for Degree student - A. C. Dutta.
3. Botany - J. Ben. Hill
4. Plant Anatomy - Piyush Ray.
5. Plant Anatomy - E. G. Cutter.
6. Plant Anatomy - K. Esaw.
7. Plant Anatomy - A. Fahn.

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