Chaudhary Mahadeo Prasad College

(A CONSTITUENT PG COLLEGE OF UNIVERSITY OF ALLAHABAD)

E-Learning Module

Subject: Botany

(Study material for Post Graduate Students)

M.Sc. II Sem

COURSE CODE: BOT 514

Plant Morphology and Anatomy

Unit: III

Topic: Internal Structure of Root

Developed by
Name: Dr. Yashwant Kumar
Designation: Assistant Professor
DEPARTMENT OF BOTANY

Internal Structure of Root

The root develops from the radicle of the embryo. Due to the fact that the extreme tip of the root remains covered by a cap, the apical meristem here is subterminal, as opposed to the terminal apical meristem of the stem. However, the primary body consists of three tissues systems; and, in fact, boundaries between the tissue systems are more precise here.

The outstanding characters by which root differs from the stem are the following the epidermis in roots is usually uniseriate, composed of thin-walled cells. Cutinisation of outer walls and cuticle are absent. Hence the terms epiblema, piliferous layer and rhizodermis have been proposed for the epidermis of root.

The stomata, so characteristic in aerial organs, are absent. Formation of root hairs, which are prolongations of epidermal cells themselves, is confined to a particular zone of the root. The cortex is comparatively more simple and homogeneous. It is made of mainly parenchymatous cells and is often massive for the purpose of storage.

The endodermis, the last layer of cortex with characteristic Casparian thickenings, is of universal occurrence. Pericycle, normally uniseriate and rarely multiseriate, invariably occurs next to the endodermis. The vascular cylinder is more compact, firstly due to absence of gaps, and secondly, due to presence of endodermis and pericycle.

The complex tissues, xylem and phloem, occur as separate patches showing radial arrangement. Xylem is always exarch, due to centripetal mode of differentiation from the procambium, so protoxylem occurs towards circumference and metaxylem towards the centre.

According to the number of protoxylem groups roots may be monarch, as in Trapa natans, diarch, as in Lycopersicon, Nicotiana; triarch, as in Pisum; tetrach, as in Vicia, Cicer; pentarch, as in Ranunculus. Polyarch condition with many xylem groups is characters of monocotyledons.

In dicotyledonous roots Xylem plates usually join at the centre forming a solid core. Hence the stele is regarded as a protostele. Endogenous development of the branch roots from the pericycle, as opposed to exogenous formation of a branch from the growing point of a stem, is a marked feature.

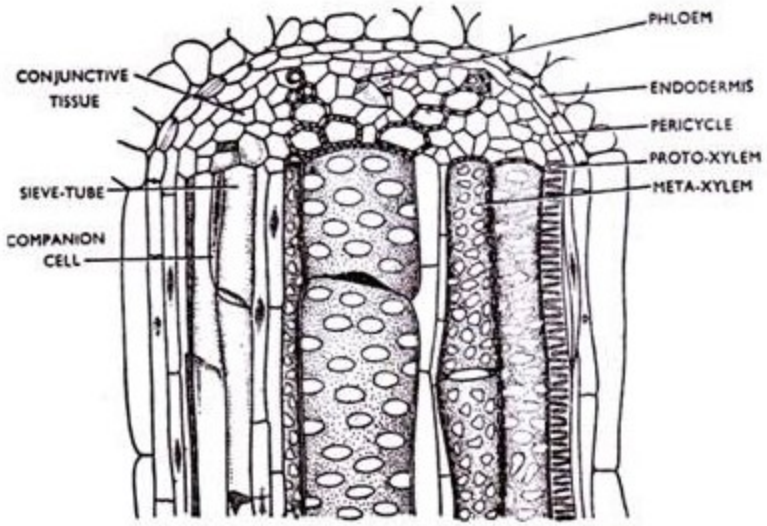

Fig. Stele of atypical dicot. Root in transvers and longitudinal section (diagrammatic)

Dicotyledonous Roots:

1. Root of Gram:

A transverse section of the root of gram (Cicer arietinum of subfamily Papilionaceae) is taken and stained suitably for the study of internal structure.

I. Epidermis:

Epidermis, also known as epiblema or piliferous layer, is typically uniseriate outermost zone consisting of tabular living cells. Cuticle on the outer walls and stomata are absent. Some epidermal cells prolong to form the typically unicellular root hairs, which occur at a particular zone of the root, referred to as root hair zone, located just above the region of active growth and elongation.

II. Cortex:

It is relatively more simple and homogeneous, forming a massive zone which consists of unspecialised parenchyma cells with conspicuous intercellular spaces. The cells are living and possess abundant leucoplasts

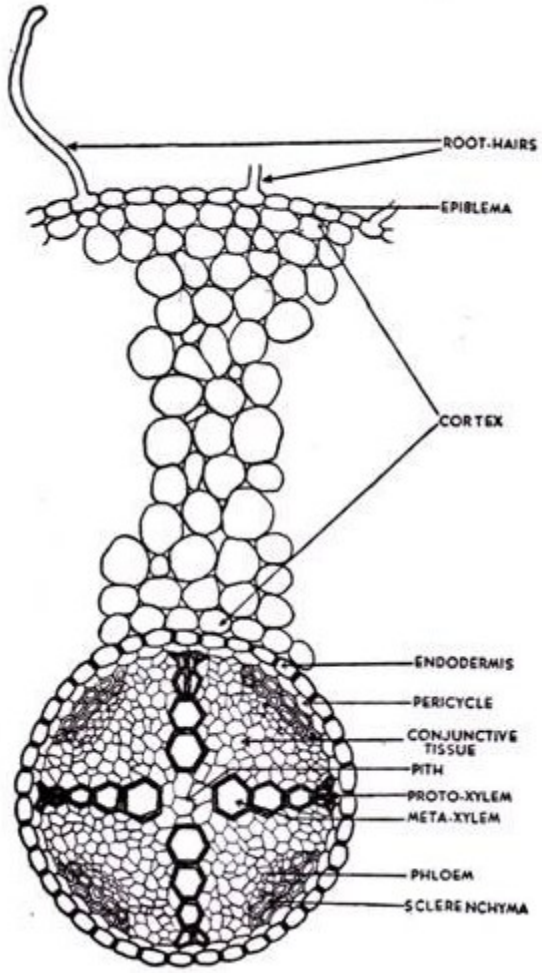

Fig. A portion of root of Gram in transverse section

They are particularly concerned with storage of food, though at the early stage they are responsible for translocation of water and solutes to the conducting elements. The last layer of cortex is endodermis.

It is of universal occurrence in roots and consists of compactly arranged barrel-shaped cells forming a distinct zone surrounding the stele. The endodermal cells possess Casparian thickenings on the radial walls.

III. Stele:

The stele or central cylinder is precisely demarcated from the cortex due to presence of endodermis. It includes the vascular tissues and intrastelar ground tissues. Next to endodermis there lies a layer of thin-walled parenchyma cells forming the pericycle. This non-vascular tissue occurring inside the stele is the seat of origin of branch roots.

The vascular bundles are radial. Xylem and phloem occur in separate patches arranged on alternate radii, intervened by small parenchyma cells. The latter form the conjunctive tissue.

The bundle is tetrarch here, because four patches of Xylem alternate with equal number of patches of phloem. Protoxylem vessels occur towards periphery and metaxylem towards centre, thus showing centripetal mode of differentiation from pro- cambium.

This is the typical exarch xylem of roots. The central portion is usually occupied by a metaxylem vessel, so that all the plates of Xylem are joined forming a solid core. Hence it is regarded as a protostele. Phloem patches are rather small and consists of sieve tubes, companion cells and phloem parenchyma.

The outer part of this tissue lying next to pericycle is protophloem and the inner is the metaphloem; of course they are not readily distinguishable like protoxylem and metaxylem. A few sclerenchyma cells occur against every phloem patch. Pith is normally absent in dicotyledonous roots. At early stages a few parenchyma cells may be located at the central portion, which is very soon obliterated by development of metaxylem.

2. Root of Pea:

A transverse section of the root of pea (Pisum sativum of subfamily Papilionaceae) is taken and stained suitably for the study of internal structure.

I. Epipermis:

It is the uniseriate outermost layer with typical root hairs.

II. Cortex:

Cortex is parenchymatous with intercellular spaces. The last layer is endodermis with distinct Casparian thickenings.

III. Stele:

It includes the vascular elements and intrastelar ground tissues. The bundles are radial. Here it is triarch, three patches of xylem alternating with three patches of phloem. Xylem is typically exarch having metaxylem towards centre and protoxylem towards periphery.

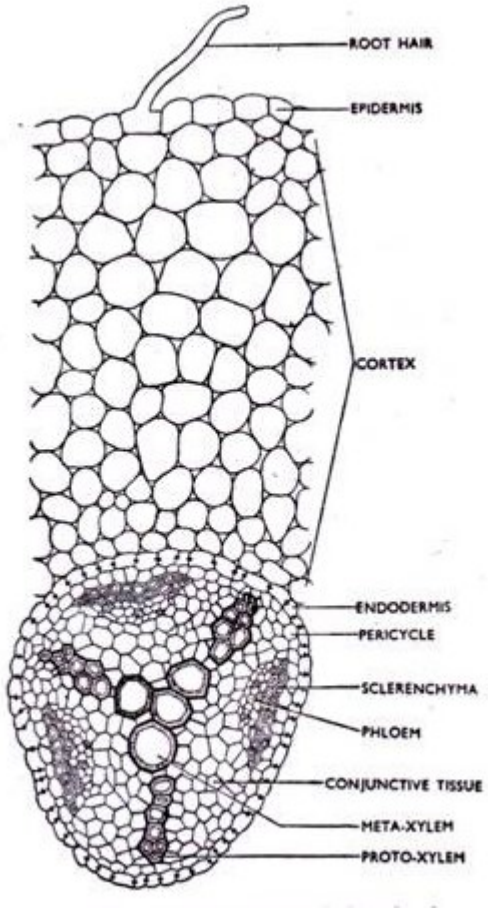

Fig. A portion of root of Pea in transverse section

Phloem is rather small with constituent elements— sieve tubes, companion cells and phloem parenchyma. A few fibres occur against every phloem group. Pericycle lying next to endodermis is single-layered and parenchymatous. Small parenchymatous conjunctive tissues occur between Xylem and phloem groups. A very small pith is noticed at early stage which is obliterated later.

3. Root of Buttercup:

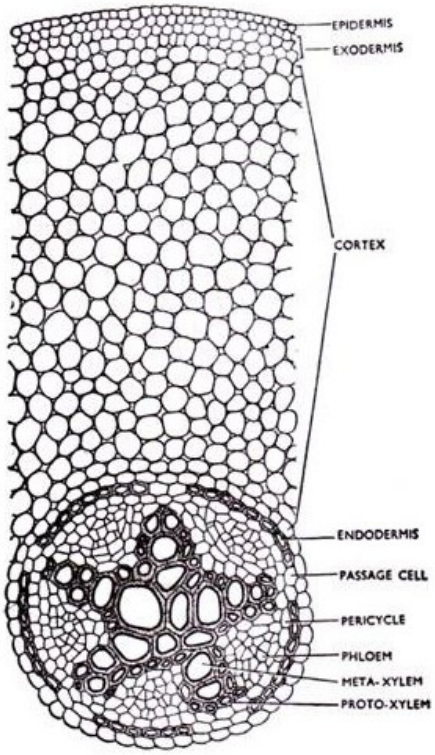

Fig. A portion of root of Buttercup in transverse section

I. Epidermis:

It is as usual a uniseriate zone, composed of a row of living tabular cells. It remains more or less in a collapsed condition and disorganised protoplast may be noticed in some cells.

II. Cortex:

It is quite massive, as in all roots, enveloping the stele. A narrow zone, called exodermis, corresponding to the hypodermis of stems, occurs next to the epidermis. It is composed of

comparatively -epidermis smaller cells rather compactly arranged with very scanty intercellular spaces. Exodermis may be called the outer zone of cortex.

So-called inner zone occurs internal to exodermis. It consists of quite a good number of larger parenchyma cells with conspicuous intercellular spaces. The cortical parenchyma cells contain abundant starch grains. The limiting layer of cortex is known as endodermis.

It is made of a row of barrel-shaped cells with Casparian thickenings. Secondary depositions on the endo-dermal walls are also noticed. In that case some thin-walled cells, in which secondary deposition has not taken place, often occur, particularly against the protoxylem groups. These are called the passage cells.

III. Stele:

The outermost portion of the stele is the uniseriate parenchymatous pericycle. Vascular bundles are radially arranged. Four or five strands of Xylem alternate with equal number of patches of phloem. Xylem is typically exarch. Phloem forms small patches. Parenchymatous conjunctive tissues occur between xylem and phloem. Pith is absent.

Monocotyledonous Roots:

1. Root of Arum:

I. Epidermis:

It is uniseriate, composed of a row of tabular cells attached end on end without having intercellular spaces.

II. Cortex:

The cortex is quite massive, as in other roots, and mainly consists of un-specialised parenchyma with profuse schizogenously formed spaces. In a slightly old root a few layers of cortex next to epiblema undergo chemical changes—suberisation, and thus give rise to a zone meant for protecting the internal tissues. This band is known as exodermis.

Formation of exodermis may be initiated before the epiblema loses its function, but once epiblema is decayed exodermis takes over the function of protection. The last layer of cortex is the endodermis. It is composed of barrel-shaped compactly-set cells with conspicuous Gasparian strips.

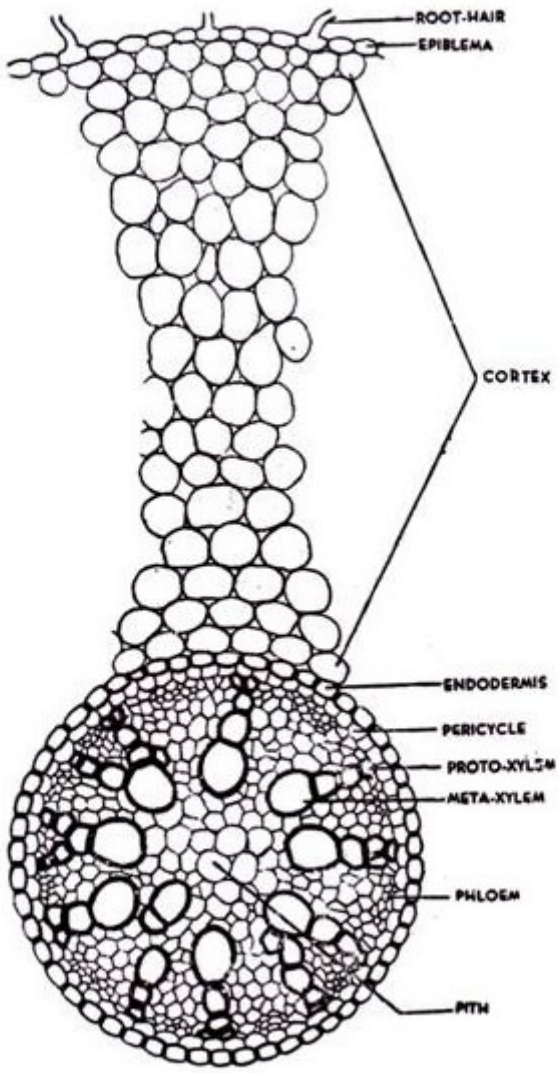

Fig. A portion of root of Arum in transverse section

Due Jo secondary thickening the endodermal cells may have considerably thick radial and inner walls. In that case some thin-walled cells usually occur against the protoxylem groups; obviously they are meant for ready diffusion of fluids. These are known as passage cells or transfusion cells.

III. Stele:

The central cylinder consists of radially, arranged vascular strands and intrastelar ground tissues. Uniseriate pericycle, made of thin-walled parenchyma cells, occurs next to endodermis. Xylem and phloem remain arranged alternately as separate patches, the xylem being typically exarch.

As a good number of vascular strands are present, as opposed to the limited number of dicotyledonous roots (triarch, tetrarch, etc.), this is referred to as polyarch. Phloem is composed of sieve tubes, companion cells and parenchyma. Though protophloem occurs on the outer side and metaphloem on the inner, the two can hardly be distinguished.

Small conjunctive parenchyma cells are present between xylem-and phloem patches. The central part of the stele is occupied by a fairly large pith.

2. Root of *Maize*:

The internal structure of the maize root (Zea mays of family Graminaceae) is more or less similar to that of arum, so far as epiblema and cortex are concerned. Formation of exodermis is common in almost all monocotyledonous roots. The endodermis is composed of thick-walled cells; in fact, secondary and tertiary layers are deposited, so that the Casparian strips are no longer recognisable.

The pericycle is uniseriate, but unlike that of the previous one, it is partly scle- renchymatous here. Vascular bundles are as usual polyarch with a pretty good number of Xylem and phloem strands.

Parenchyma cells associated with xylem undergo sclerosis and thus become thick-walled. The central portion is occupied by a large pith—made of loosely-arranged parenchyma cells containing abundant starch grains.

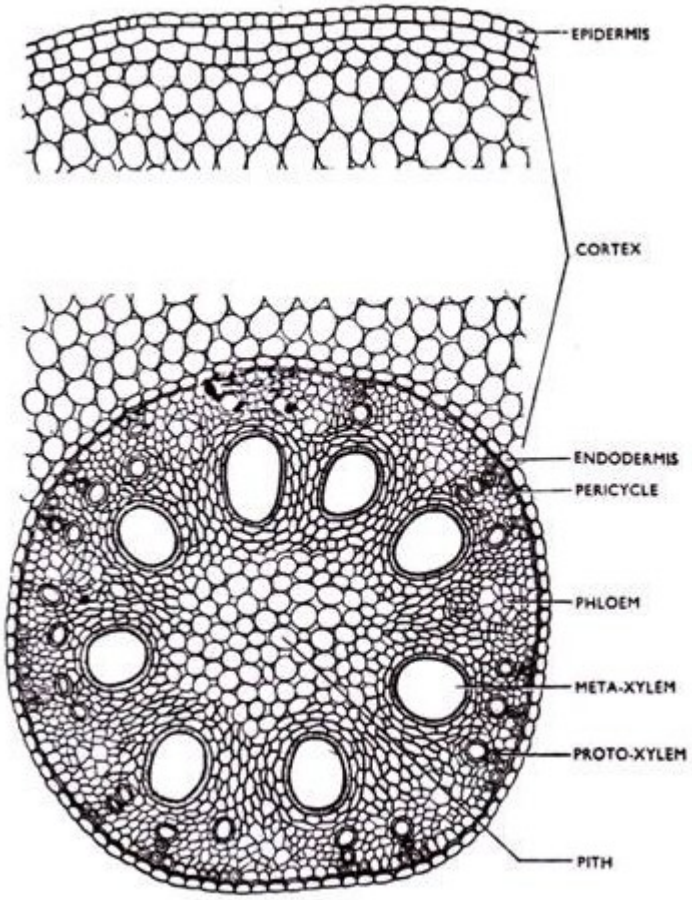

Fig. A portion of root of *Zea* in transverse section

3. Root of *Smilax*:

It (Smilax sp. of family Liliaceae) is a herbaceous monocotyledon, the roots of which are quite suitable for the studies of internal structure. Though in general it shows the same plan as found in other monocotyledonous roots, but some distinctive features are to be noted.

Epidermis is as usual uniseriate—made of parenchyma cells with rounded outer walls. A single row of heavily thick-walled cells occur just internal to epidermis, forming the exodermis.

The rest of the cortex is composed of thin-walled parenchyma cells with distinct intercellular spaces. Starch grains are abundantly present in the cortical cells. Endodermis is of thick-walled type, where radial and inner walls in particular undergo considerable secondary thickening.

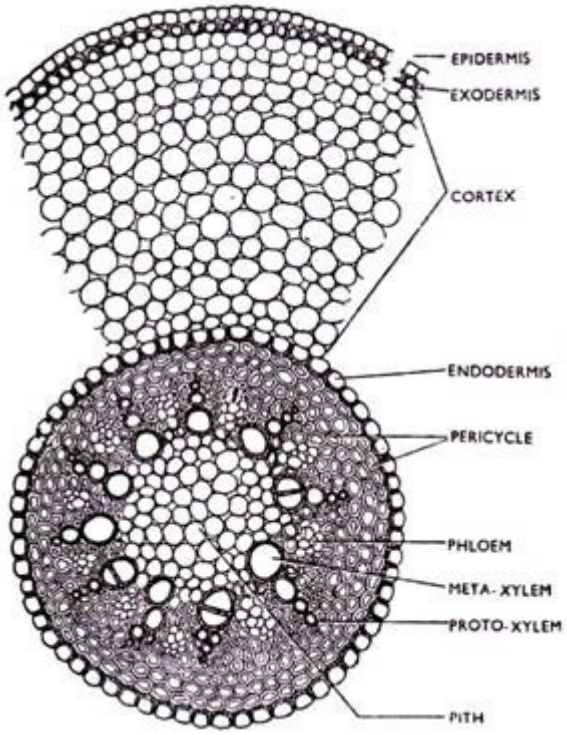

Fig. A portion of root of *Smilex* in transverse section

The stele consists of a large number of xylem and phloem strands arranged alternately, so it is also polyarch. The pericycle, unlike that of other roots, is multiseriate and consists of a few layers of thick-walled sclerenchyma cells. Protophloem occurring on the outerside are smaller than the metaphloem elements. Pith occupying the central portion of the stele is fairly large, and is made of thick-walled parenchyma.

4. Root of *Orchid:*

The roots of epiphytic orchids (Vanda spp. of family Orchidaceae) possess a spongy outer tissue for absorbing moisture from the atmosphere. This tissue is known as velamen. It consists of a few layers of compactly-set dead cells, which often form a silvery outer coat.

The walls are usually porous, so that the cells work like a sponge. These empty cells have walls variously thickened by spirally or reticulately arranged fibres which take up the form of supporting ribs. During dry weather the cells remain filled with air, and during rains they quickly absorb water.

Special structures, called pneumatoses, consisting of groups of cells with dense spiral wall thickening are present. They are helpful in gaseous exchange when the roots are saturated with water. Velamen is derivative of protoderm, and hence may be interpreted as a typical multiseriate epidermis, specially adapted to serve as an absorbing tissue. The outermost layer of velamen is known as limiting layer.

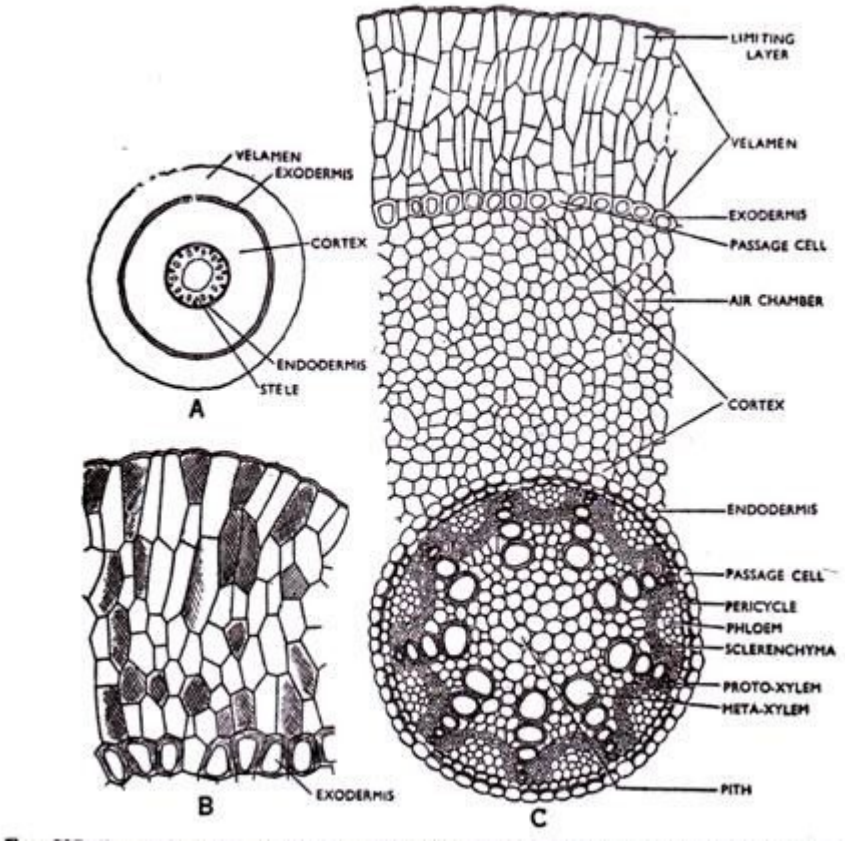

Fig. Root of orchid. A. Complete transverse section (Diagrammatic) B. Velame with exoderm. C. A portion of the root in transverse section

Cortex:

The outermost layer of cortex consists of a row of thick-walled cells forming what is known as exodermis. The thickenings due to deposition of suberin are more pronounced on the outer and lateral walls of the cells. Unthickened ones, called passage cells, occur here and there, which may serve as channels for flow of water absorbed by the velamen.

The main bulk of the cortex occurs internal to exodermis. It is composed of a few layers of parenchyma cells with intercellular spaces. Chloroplasts are present in these cells; this fact explains the greenness of the roots, particularly when wet. The last layer of cortex is the endodermis with suberised radial and inner walls. Passage cells occur in the endodermis, usually opposite the protoxylem vessels.

Stele:

Pericycle is uniseriate, made of thick-walled cells; only the cells just lying internal to passage cells of the endodermis are thin-walled. A good number of xylem and phloem groups occur alternating in the stele. Conjunctive tissues sin-rounding the phloem groups are sclerenchymatous. Central portion is occupied normally by the parenchymatous pith, but these cells may undergo sclerosis.

Breathing Roots (Pneumatophores):

These roots are found in the plants growing in situations with scanty oxygen. Unlike the normal roots, they come vertically upwards—thus becoming negatively geotropic and negatively hydrotropic. They absorb oxygen from the outer atmosphere through specially located lenticels at the tips. Thus strictly primary condition can hardly be noted. The anatomical structure resembles that of a stem in the nature and disposition of the vascular system in particular.

I. Cork:

A few layers of cork cells occur at the outermost portion with small lenticels which are really instrumental for absorption of oxygen.

II. Cortex:

It is quite massive, composed of a few layers of more or less rounded parenchyma cells with well-developed intercellular space system. The last layer of cortex is as usual the endodermis—a uniseriate zone made of small barrel-shaped cells.

III. Stele:

Just internal to endodermis occurs pericycle made of parenchyma and sclerenchyma. Usually the outer portion is parenchymatous and the inner sclerenchymatous. The vascular bundles actually resemble those of the dicotyledonous stems.

They are collateral and open. In fact, the bundles form a continuous cylinder with xylem and college botany phloem, the cambium occurring between them. The Xylem is endarch. Large pith composed of parenchyma cells occurs at the central portion.

चौधरी महादेव प्रसाद महाविद्यालय
आ नो भद्राः क्रतवो यन्तु विश्वतः
प्रयागराज विश्वविद्यालय