~~Paper~~ - ~~I~~ B.Sc. secondyearse. Sem-III. 7 7 04

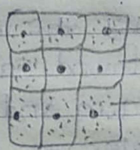
Plant anatomy

<u>meristem</u>:- The meristem is defined as localised region which consist of the cell having the ability of division.

It is also defined as the group of young cells that have campacity of active cell division.

The cells are living and thin walled the cells have large nucleus. and dense cytoplasm. usually the inter cellular spaces are not found. Each cell shows abuntant cytoplasm and one or more nuclei. The vacuoles in cells ~~are~~ may the small or completely absent. The cell have the constant capacity of division. The cells are immature. The presence of meristems differenciates the plant from animal. The meristem usually occur at the apices. of all main and lateral shoots and roots and thus they are quite large in number in a single plant. The secondery growth ~~increase~~ i.e. increase in thickness takes place by the vascular and cork cambia (i.e. lateral meristems). secondery meristems are generally lateral in position and give rise secondary tissues which increase

The vascular cambium in stems is partly a secondery meristem. The fasci-cular cambium is primary in origin while the inter fascicular cambium develops from cells of ground tissue and is secondery in origin. In roots the entire cambium ring is secondery in origin.



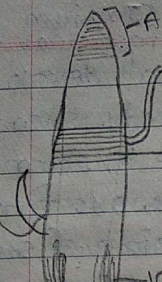
meristimatic cell or tissue

* classification of meristem on the basis of origin :- ① Primary meristems :- The meri-stems which are present from embryonic stage and persist throughout life of the plant are known as primary meristems.
  it forms primary or fundamental part of plant body. it is present in the apex of stem and root and the primo-rda of leaves and similar organs. Primary meristems builder the primary part of plant and consist the promeristem. Primary meristems are always present in the earliest stage of plant.

2) Secondery meristems :- These meristems appear later at a stage of development of an organ of a plant body. Secondary meristem always arise in permanant tissue and they are always form in the lateral position along the size of stem and root. Secondery meristems are also called beacuse they arise as new meristem in tissue which is not meristimatic. Cork cambium is the tipycal example of secondary meristem as it is developed from permnant tissue or cells i.e. mature cells of epidermis, cortex or pericycle. Secondary meristem increase the girth of plant organ. The vascular cambium is partly a secondery meristem. In the fascicular region the cambium develops from the procambium and is primary in origin while the inter fascicular region develops from the cells of ground tissue and is second-ery in origin. In roots the entire cambium ring is secondary in origin. The secondery meristem produ is resp-onsible for secondery growth i.e. secondery tissues.

ex of primary meristem - Fascicular cambium
Apical cambium
ex of secondery meristem - cork cambium
Inter fascicular cambium

* classification of meristem based position :- ① Apical meristem of cortex, endodermis and vascular cylinder



L.S. of shoot apex showing meristem

Apical meristems are present at the grow-ing points of stem and roots. These meristems are imp-ortant for to incre-ase the length of stem and roots. The stem of apical meristem devide and redevide con-stantly and growth takes place. Genrally apical meristem consist of many cells but in pteridophytes only one cell forms the apical meristem. it consist of Pro-meristem and get differenciated in to protoderm ground to meristem and procambium.

② Intercalery meristem:- it is the part of apical meristem which has been separated from the apex due to development of permanant tissues along with the gradual elongation of apical meristem. These meristems present betn the region of permanant tissues.

ex:- at the base of leaves in the internodes of equisetum, grasses etc.

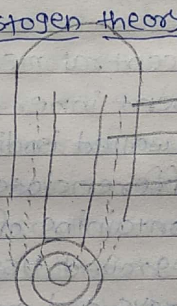
③ lateral meristems:- These meristems are present along the site of stem and root. The cells of this meristem devide mainly only in the periclinal plane and thus add girth of organ.

ex:- vascular cambium and cork cambium.

The lateral meristem become active only after the organ in which they are formed has attained certain length.

* Theories inrelation to structural development and differenciation of meristem:-

① Histogen theory:- According to histogen theory the primordial meristem i.e. primary meristem was separated in to three distinct zones called histogens.



L.S. of root apex demostrated Histogen theory.

The apical meristem or growing region of stem and root are composed of small mass of cells which are all alike i.e. called promeristem. The cells of promeristem get differenciated in to three regions i.e. dermatogen, periblem and plerome. Each zone consist of a group of initials called histogen or a tissue builder.

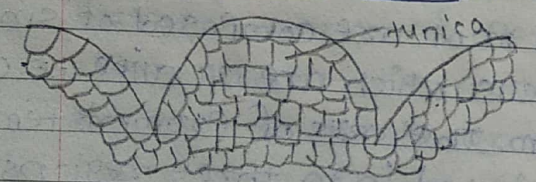
* Dermatogen → It is single one of ... and vascular cylinder.

most layer of cell which later give rise to the epidermis of stem. In the root it is also single layered but it also develops a small cell tissue called calyptrogen which also meristimatic and gives rise to root cap.

* **periblem**:- it is present inner to the dermatogen and is the middle region of apical meristem. it is single layered at the apex but in central part it becomes multilayered. it develops in to cortex of stem and also in the root.

* **plerome**:- it is the central meristimatic region and is present inner to periblem. it consist of thin walled isodimatric cells. it develops and differenciates in to central stele. which containing of primary vascular tissues and ground tissues i.e. pericycle, medullary rays and medulla.

(2) **Tunica corpus theory**:- Schmidt in 1924 proposed this theory for organisation of shoot apex. according to this theory the shoot apex is differenciated in to two region i.e. tunica and corpus.



L.S. of apical meristem show tunica corpus theory

A central core is called corpus which consist of large cells which devide irregularly to result in valume growth.

* **Tunica** → it is surrounding the corpus. tunica cells are smaller and devide mainly anticlinally. The tunica may be one to many layered. The tunica cells undergoing surface growth. The corpus cells are large, irregular in shape and the whole mass grows in valume.

Each layer of tunica arises from a group of separate initials and corpus has one layer of such initials. In tunica the number of cells of initials is equal to the number of cells of tunica i.e. each layer of tunica has its own layer of initials. The corpus arises from a single tier of initial which devide first periclinally and later which devides various planes resulting in formation of inner mass of cells.

* **Permanent tissues** → The tissues which have lost the capacity of division are called permanent tissues. The cells of these tissues may be living or dead and thin walled or thick walled. The thin walled tissues are generally living where as thick walled tissues may be living or dead.

The permanent tissues are of

two types ① simple tissues ② complex tissues or compound tissues.

① simple tissues :- simple tissue are made up of one type of cells and forming a uniform or homogeneous system of cells.

simple tissues has of three types.

① parenchyma :- It is type of simple tissue. it is composed of living cells which are variable in their morphology and physiology, but they are having thin walls and are concerned with vegetative activities of plant. The parenchyama is primitive tissue The parenchyma consist of isodimetric, thin walled cells. The parenchyma cells are oval, rounded or polygonal in shape. The cells are living and contain sufficient amount of cytoplasm and with one or more nuclei.

Parenchyma makes up large parts of various organs in many plant. pith (central part of stem), mesophyll of leaves, the pulp of fruit, endosperm of seed, cortex of stem and root and other organs of plant consist mainly parenchyma. The parenchyma also occur in xylem and phloem.

In the aquatic plants the parenchyma cells in the cortex show wel developed air spaces i.e. intercellular and the tissue is called aerenchyma.

(जा3) Parenchyma present in succulent and xerophytic plants is more speciilized and act as water storage tissue.

ex :- aloe, Agave.

when the parenchyma cells are expose to light they develop chloroplast ~~exposed~~ in them and is called chlorenchyma.

Commonly parenchyma cells have thin cell walls while storage parenchyma develop thick walls.

ex :- In the endosperm of Diospyros, Asparous the walls of such endosperm become thiner ~~become~~ during germination.

Function of parenchyma → The turgid parenchyma cells help in giving regidity to the plant body. The parenchyma also act as storage tissue to store food material in the form of starch grains, proteins, fats and oils. The parenchyma also help in the partial conduction of water. The parenchyma cells that contain chloroplast in them called chlorenchyma which are responsible for photosynthesis in green plants. In water plants the aerenchyma keep up the beloyancy of plants. The air spaces facialated exchange of gases. cortex, endodermis and vascular cylinder.

water storage tissue present in succ-
-ulent and xerophyte plants store
water. The parenchyma cells also import-
-ant for vegetative propogation takes
place by cuttings ie. buds and advant-
-acious roots.

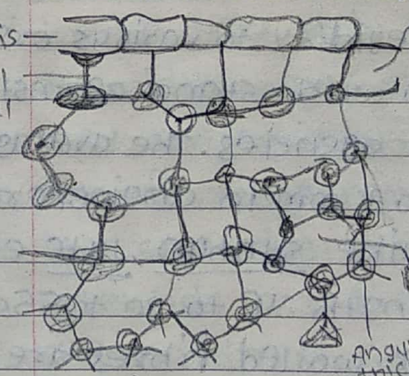
② chlorenchyma → it is a type of simple tissue and consist of one type of cells. chlorenchyma is a typical supporting tissue of growing organ and of those mature harbaceous organs. it is first supporting tissue in stems, leaves and chloral parts. it is main supporting tissue in many dicotyledon leaves and some green stems. it may occur in root cortex. it is not found in the leaves and stems of monocotyledons. It occurs in peripharal regions of stems and leaves. it is commonly found just beneath the epidermis. In stem and petioles with ridges, chlorenchyma is well developed in ridges. In leaves it is found on one or both sides of veins and along margin of leaf blade.

The chlorenchyma consist of elongeted cells with unevenly thicken walls, reactangular, oblic or tapering ends. The cell wall consist of cellulose and pectin. and also contain much water. In many plants chlorenchyma is a compact tissue lacking intercellular spaces.

The mature chlorenchyma cells are living and contain protoplast. chloroplast also occur chlorenchyma consisting of long narrow cells contains only a few small chloroplast.

(development) ontogenetically chlorenchyma develop from elongeted procambium cells. in the begining small intercellular spaces are present among the cells but later on they disappear.

* Function :- ① The chief primary function of chlorenchyma tissue is to support plant body. The peripharal position of chlorenchyma ion pulps of stem, petiol and leaf midribs etc. is very important for the support by tissue. ② The chlorenchyma containing chloroplast carry out the function of photosynthesis.



Angular (from stem of cucurbita)

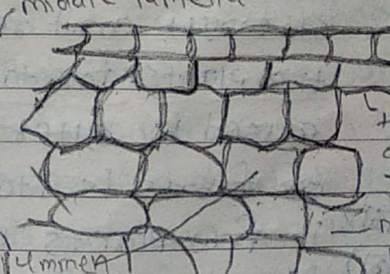


fig- Lamillar (from stem of Sambucus)

③ **Sclerenchyma:-** it is the type of simple tissue The sclerenchyma consist of thick walled-cells and often lignifyed and the main function is to give mechanical support. Scler-enchyma cells do not possess living protoplast at maturity. The walls of the cells are uniformly and strongly thickened. The sclerenchyma cells are grouped in to two fibres and sclereids.

① **Fibres:-** The fibres are elongate scleren-chyma cell and are with pointed ends. The wall lignified the cell cavity or lumen is very much reduced or absent. The pits of fibres are always small, round and oblic. ~~and are~~ The pits on the walls are numerous or few in number.

The sclerenchyma fibres are commonly found in many plants. They are dead and purely mechanically function. they provide strength and regidity to various organs of the plants. for to which stand against strains caused by outer agencies. The average length of fibres is 1 to 3 mm in angiosperms. but
(अंबाडी) in few plants like sunhun, Jute etc. The
(ताग) fibres are of length up to 20 to 550 mm. these long thick walled fibres are of commercial importance.

The fibres are grouped in to two xylem fibres and extraxylary fibres.

The xylem fibres develop from meristimatic tissue and form part of xylem. on the other hand the extraxylary fibres are related to phloem. The fibres that form continuous cylinders in monocote stem and present in the ground tissue inner to epidermis are called cortical fibres. The fibres also present in the peripharal region of vascular cylinder close to phloem are called pericyclic fibres.

The extraxylary fibres are also called blast fibres and are of different types

⊛ **Phloem fibres:-** These fibres originate in primary or secondary phloem.

⊛ **Cortical fibres:-** These fibres originate in cortex.

② **Sclereids:-** The sclereids are widely found in the plant body. They are not much longer than the width. they occurs singly or in groups. They are commonly found in cortex and pith of gymnosperms and dicotyledons. The sclereids also occurs in the leaves. Sclereids are found in fruit and seeds. The hardness and strength of seed coat is due to presence of abdent sclereids. i endodermis and vascular cylinder

The secondary sclereids are typically ligni-fied and vary in thickness. In sclereids the lumen is almost filled with massive wall deposits of secondary cell wall ma-terial along with pits.

The sclereids are of 4 types.

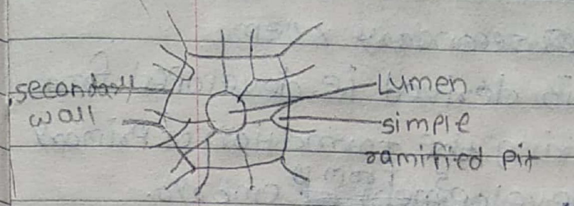
① **branchy sclereids** :- These are commonly called stone cells. These are short and more or less isodimatric. They are commonly pre-sent in cortex, phloem and pith of stem and in the pulp of fruits.

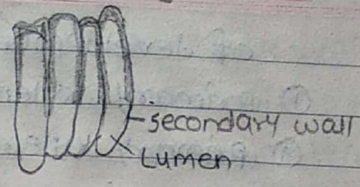
② **macro sclereids** :- They are rod like cells. and forming Paiiced like layer of many seeds and fruits. they are found in xerophytic leaves. and cortex of stem.

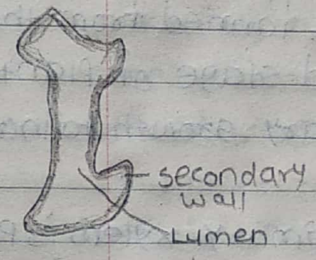
③ **ostteo sclereids** :- They are bone shaped sclereids. i.e. the cells are enlarge at their ends. These sclereids are commonly found in hypodermal ~~cells of~~ layer of many. They are also found in xerophytic leaves.

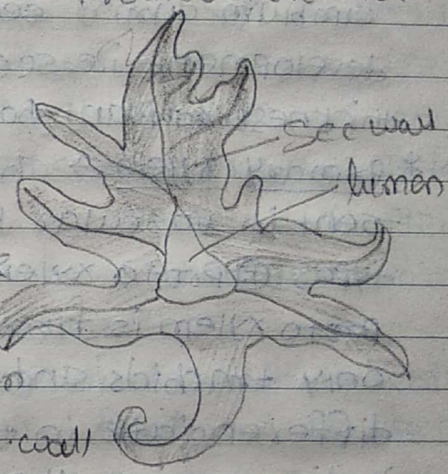
④ **Astro sclereids** :- They are star shaped sclereids. The sclereids are with lobs. which project out. They are commonly found in the inter cellular spaces. of the leaves and stems of hydrophytes.

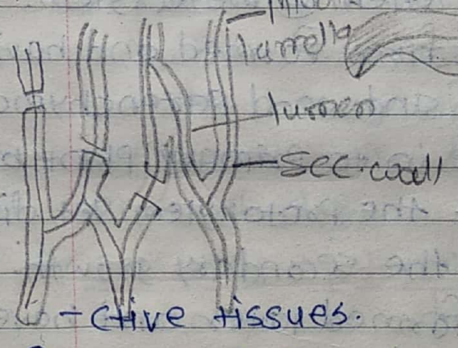
* **Comound tissue** :- ① xylem ② phloem.
These tissue also called vascular or condu-











-ctive tissues.

① **xylem** :- it is a permanant complex vascular tissue. it is a conductive tissue which con-ducts water and mineral nutrients up-word from root to leaves. The xylem is composed of 4 different kinds of ele-ments. They are trachids, vessels or tracheae, xylem parenchyma, xylem scle-renchyma.

The xylem is of two types on the basis

of development.

① primary xylem ② secondary xylem.

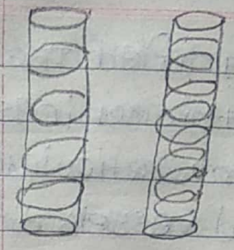
① primary xylem is derived i.e. developed from procambium during the formation of primary plant body i.e. developments from embryo.

② secondary xylem :- it is formed from the cambium during second stage of plant development i.e. secondary growth to increase thickness of plant body.

* primary xylem → The primary xylem is present in vascular bundle - and is of two types ① Proto xylem ② metaxylem.

Proto xylem is first formed and having only trachids and wood parenchyma. it differenciate in to primary plant body. the protoxylem get disorganise during the secondary growth. The meta xylem is formed later and have fibres, trachids and wood parenchyma. it becomes non functional after the formation of secondary xylem and is not destroyed. The protoxylem show annular thickening while the metaxylem element show scalery form, reticulated, pitted thickening.

* Elements of xylem :- ① xylem trachids :- xylem tracheids is an elongated cell with tapering ends. These are dead cells. and lack protoplast



at maturity thus look like an empty lumen. The walls are hard and usually lignified. In T.S. the trachied is seen angular or rounded. The thickening may be annular, spiral, scalery form in primary xylem. and pitted in secondary xylem. The size and number of pits is variable in each trachid. In Angiosperms the trachids are associated with vessels. but in pteridophytes and gymnosperms they form the main bulk of xylem.

The passage of water in trachid from cell to cell is also fascilated by the presence of pits.

* Function of trachids :- The trachid is structurally adapted for the conduction and storage of water and minerals

② thick and hard walls of trachids play an important role in supporting of an organ.

* xylem vessels :- or trancheas :- These are cylindrical tube like structeres found mainly in the wood of angiosperms. They are formed by the absorptions of end walls from a row of procambium cells placed end to end. the mature cells has no protoplasm

and the walls are lignified. The cell walls have various types of thickenings. i.e. Annular, spiral, scalery form, reticulate and pitted. The tracheids and vessels differ from each other that the tracheid is an imperforate cell i.e. without ~~pores~~ perforation, where as vessel has perporation one or more at each end. These perforations may also found on the side walls. In vessel the water moves from cell to cell through perforations. The perforated part of wall of vessel member is called the perforation plate. A plate may be simple i.e. with only one perforation or multiperforate with more than one perforation. The multiperforate plate may be scaleri form i.e. perforations are scattered or reticulate i.e. if perforations are in the form of network.

* ~~Functions of vessel:-~~

* Ontogeny (development) vessel:- A vessel originates from a longitudinal series of meristimatic cells. These cells may be procambial cell in the primary xylem or cambial derivatives in the secondary xylem. This process involves fusion of cell end to end, then gradual loss of end walls resulting in the formation of opening of cells in to one another

This freely opening looks like a long tube.

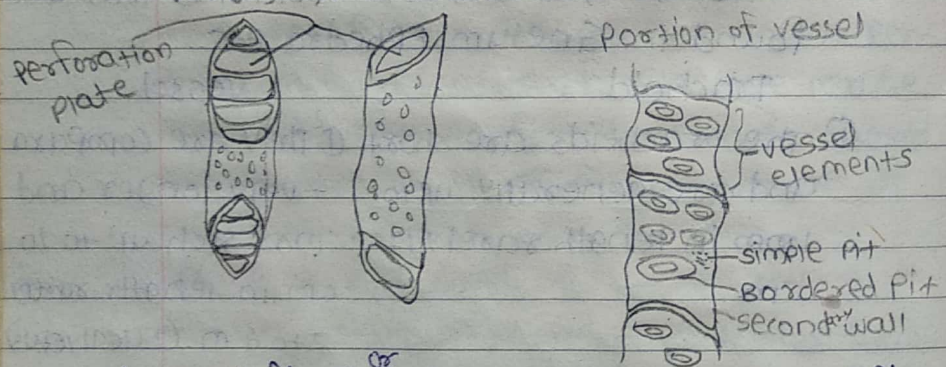
* Functions of vessel → There two main functions of vessel ① water conduction ② To give mechanical support.

The vessels are absent in some members of families winteraceae, trochodentaceae and tetracentraceae. vessels are poorly developed in some aquatic and paracytic plants. In many monocoteledons i.e. Draceana, Yucca etc. vessels are absent. vessels are found in some species of selaginella, in two species of pteridium from pteridophytes, among gymnosperms they are found in Gnetum, Ephedra etc.

Tracheid	Vessel
① The tracheids are short and are generally up to 1mm in length rarely 12 cm.	① They are comparatively longer and may rich up to 10 cm in length rarely 2 to 6 m. (Eucalyptus)
② It consist of single-elongeted cell	② The vessel consist of row of cells placed one above the other.
③ The end walls of cells are always tapering.	③ The end walls or intervening walls are absent.

Tracheids	Vessels
④ The tracheids are not tubular.	④ The vessels are tubular.
⑤ The tracheids found one above the other are separated by cross walls which bear bordered pits.	⑤ vessels are wel adapted for con-duction of water
⑥ trachids are not perfor-ated.	⑥ vessels are per-forated by small or large pores.
⑦ tracheids are present even in lower plants like gymno-sperm, pteridophytes etc	⑦ vessels are found in only angiosperm

various types of vessel elements



* wood fibres :- or xylem sclerenchyma :- xylem fibres constitute and intigrate part of the xylem which consist of long, cylinder, pointed, dead sclerenchymatous cells. wood fibres are usually very long and narrow cells with tapering or some times branched ends. The length of fibres varied greatly.

The extraxylary fibres are comparatively larger than the xylary fibres.

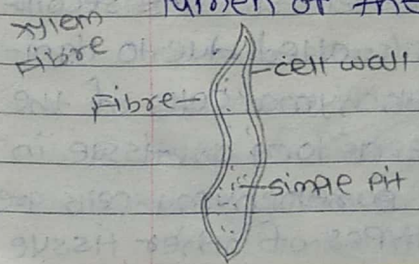
on the basis of wall thickness and amount of pits there are two main types of xyla-ry fibres.

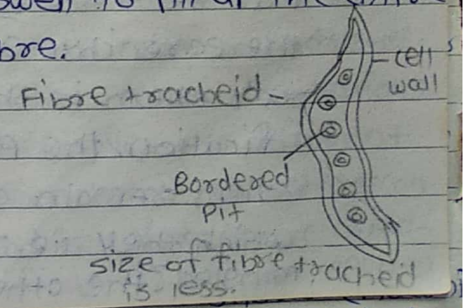
① Libriform fibres ② Fibre tracheids.

① Libriform fibres :- These fibres have extr-eme thick walls and simple pits. These fibre are commonly found within woody plants. mainly in family i.e. Leguminaceae.

② Fibre tracheids :- These are having walls of medium thickness i.e. not as thick as those of libriform fibres. but thicker than those of tracheids.

In the secondary xylem of dicoteledon another type of fibre is present which is called as gelatinous or mucilagenous fibre. The inner layer of secondary wall in these fibres contain a lot of α cellulose and is poor in ligning. This layer absorbe much water and may swell to fill up the entire lumen of the fibre.





cortex, endodermis and vascular cylinder

* Ontogeny of fibres:- ontogenetically it is assumed that the fibres have developed from tracheids. some evidences are infavour of this hypothesis are as follows.

① The wall becomes thicken thus causing a corresponding decrease of lumen. The number of pit and size of pit chember is reduced.

② The cell become shorten.

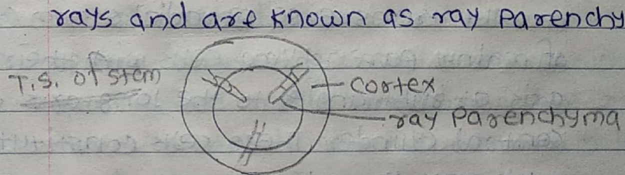
* Functions of xylem fibre:- ① In plant body xylem fibres give mechanical strength to specific parts. ② commercially fibres are extratected and used in following

① Textile industry ② cordage industry.

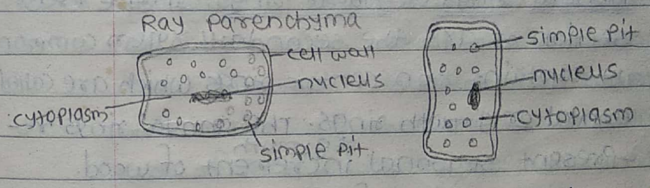
③ brush fibres ④ Filling fibres.

* Xylem parenchyma:- it is one of compon--ant of xylem. Parenchyma cells are — frequently found in the xylem tissue of most of the plants and are called wood parenchyma. These cells are more or less elongeted, placed end to end and may be thick or thin walled. usually the parenchyma present in the second--ary xylem is thick walled. due to ligni--fication. the parenchyma cells of the xylem remain alive. as long as tissue in which they lie. The parenchyma cells are mingled betn the other types of other tissue i.e. tracheids, vessels and fibres etc.

* Functions:- ① The conduction of water upwo--rd directly or indirectly with the help of tracheids and vessel ② The wood parench--yma also help in storage of food material like starch or fats etc. ③ Pannins, crystals and various other substances are also— common in xylem parenchyma cells. ④ The wood parenchyma present in the radial— transverse series of the cells form the wood rays and are known as ray parenchyma.



Xylem parenchyma



* Secondary xylem → The lateral meristem, the cam--bium produces secondary xylem towords the center. secondary xylem consist of various cell types i.e tracheids, vessels, different types of fibres, parenchyma cells. The secon--dary xylem or wood is a taxonomic crita--ria for the identification of the species cortex, endodermis and vascular cylinder

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* Basic structure of secondary xylem:- The secondary xylem show mainly two system of elements.

① longitudinal or vertical system:-
② Transverse or redial system.

The longitudinal system contains tracheids, vessels, fibres and longitudinal rows of parenchyma cells. All these cells have their long axis parallel with the long axis of the organ.

The transverse or radial system consist of mainly parenchyma cells with their long axis at right angles to the long axis of central cylinder. These cells constitute the xylem rays or medullary rays.

* Annual rings or growth rings:- In the cross section of axis the secondary xylem commonly contains non centric rings which are called annual or growth rings. The annual rings represent seasonal increment or growth of wood.

The width of ringth is variable due to (change) fluctuation of the atmosphere. The wider rings represent that they have got favorable growth conditions, while the narrow one rings represent that they have faced unfevorable conditions. The defoliation also causes the narrower growth rings.

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The spring or summer season is thought to be more favorable beacuse in this season the cambium is more active and forms greater number of vessels with wider cavities. In this season more leaves arise on the shoot thus more supply of food is wanted, while in winter lesser transport occurs due to comparatively lower number of leaves produced and decrease in metabolic activity.

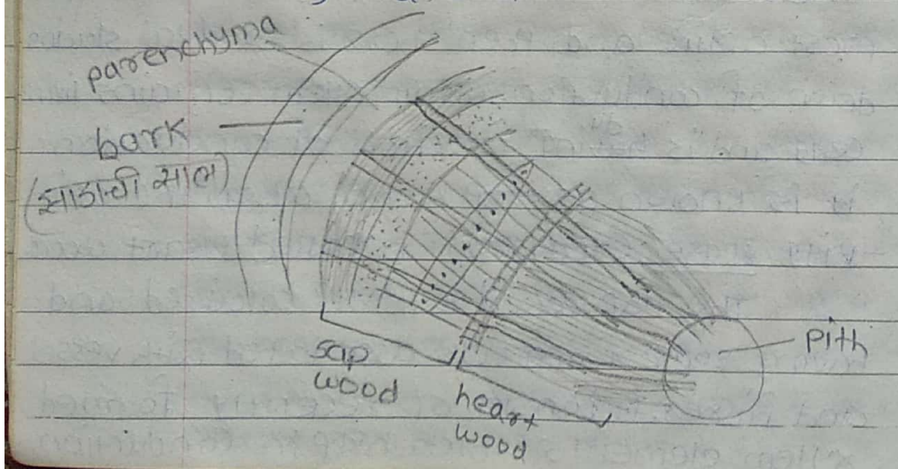
The wood developed in summer or spring season is known as spring wood or army wood and that formed in winter or autumm is called winter or outumm or late wood.

* Sap wood and heart wood:- The elements of secondary xylem are speciilised inrelation to their function. cells when first mature are most active and then there is gradual slowing down of conduction. untill xylem contains living cells and is doing function of conduction it is known as sap wood. when the activity ceases (reduces) it is called heart wood.

The sap wood is lightly coloured and having some living cells associated with vessel and fibres. it consist of recently formed xylem elements which help in conduction cortex, endodermis and vascular cylinder.

of water and nutrients and also store food.

The heart wood is the central region and is darker in colour and provides mechanical strength to plant body. Some chemical changes cause convertion of sap wood in to heart wood. The increase in the age of plant results in the loss of water and more storage of food. The wood also filled with various organic compounds oils, gums, resins, tanins and aromatic compounds etc. The various changes are responsible for strengthening, durability of wood and resistance against diseases than the sap wood. Thus heart wood is more economic than the sap wood. Heart wood is use for making articals of human use i.e. furniture and other wooden things. The sap wood is use for making pulp and packing material.



* **Phloem**:- The position of phloem:- The pheloem tissue occurs through out the plant body together the xylem. — The phleom in stem is usually external to the xylem but in some ferns and different species of dicote families i.e. Apocynaceae, cucurbitaceae etc. phloem is present on the inner side of xylem.

* **Types of phloem**:- ① Types of phloem on the basis of position:-

① **External phloem**:- it is of the normal type and present out side the xylem.

② **Internal phloem**:- or **intraxylary phloem**:- it is present inner to the xylem and called as internal or intraxylary phloem.

③ **Inter xylary or Included phloem**:- The phloem which is present within the secondary xylem is called Inter xylary or included phloem. it is found in the plants of families Amaranthaceae etc.

② Types of phloem on the basis of its origin and development → ① **Primary phloem**:- The phloem which develops from procambium is called primary phloem. it does not have radial differenciation.

it is of two types.

Ⓐ **Proto phloem**:- it develops from procambium during an early stage of ontogeny.

(B) meta phloem :- it also develops from procambi-tum but at a later stage of development.

(2) secondary phloem :- The phloem develops from vascular cambium after secondary growth is called secondary phloem. It shows the radial differenciation i.e. the rays. etc.

* cell types or componants of phloem :- The phloem is a complex tissue and consist of a group of more than one type of cells performing same function. The different types of phloem are as following.

(1) sieve element (2) sclerenchyma cells.
(3) parenchyma cells.

(1) sieve element :- sieve elements are the most highly speciiised cells in the phloem. They are thin walled living cells. The sieve elements of cells having sieve areas in their walls and there is absence of nuclei in mature protoplast, sieve elements are studies as following.

(1) The walls :- The walls are highly variable in thickness in the plant of different families.

(2) sieve areas :- The sieve areas appear as dipressions in the wall in which group of pores are located. sieve areas with the larger pores usually occur on the end walls rairly on the side walls. The sieve areas are important for to collect protoplasts of adjoining cells.

(3) connecting strands :- These are the struct-ure resemble plasmodesmata but thicker than the plasmodesmata and pass through the pores to connect the protoplast of nei-ghbuoring sieve elements. The size of pores and thickness of strands are variable.

(4) sieve plates :- A sieve plate is a region of pores betn the two sieve tubes. sieve plates are of two types. (A) simple sieve plate :- it consist of only one region of pores.

(B) compound sieve plate :- it consist of seve-ral pore regions separated by bars of wall thickenings.

sieve plates are present on the end walls of elements.

(5) Callose :- Callose is a carbohydrate that stains blue with the aniline and gives glucose upon hydrolysis. The enzymes present in the plasmodesmata are invowed in the synthe-sis and break down of callose. it forms a sheath around the connecting strands. callose is important in the activity of cytoplasmic strands.

(6) Sieve cells and sieve tube members :- The sieve-elements on the basis of distribution of sieve areas on the walls are classified [illegible]

cortex, endodermis and vascular cylinder.

in to sieve cells and sieve tube.

① sieve cells :- it is sieve element cell in which sieve areas are not highly speci-lised and are not aggreegated in to sieve plates. sieve cells are present only in the Gymno-sperms and lower vascular plants.

② sieve tube members :- These are thin walled living cells. These contain highly differenciated sieve areas called sieve plates, which are usually present at the ends of the cells. The sieve tube members form verticle series of the inter connected through the sieve plates. The sieve tube are present only in Angiosperms.

* Function of sieve element :- ① conduction of food material in longitudinal direction is the main function of sieve element.

* Companion and albuminous cells :- sieve tube of angiosperm are accompanied by highly speciilised parenchyma cells called as companion cells. The companion cells usually can not be separated from sieve tube even by matceration. Companion cells have nucleus, richly granular cytoplasm and some vaculoes. They do not have starch and take more stain due to presence of slime bodies. Companion cells differ from sieve cells and sieve tube members in the following aspects.

① Companion cells have nucleus through out its life time and richly dense cytoplasm with some vacuoles. ② Companion cells having no sieve plates.

The companion cells and sieve tube both are related ontogehetically as they develop from the same meristimatic cell i.e. the mother meristimatic cell devides longitudinally, one of the daughter cell forms sieve tube members while the other becomes companion cell.

* Functions of companion cells :- ① conduction of the food material ② maintance of a pressure gradient in the sieve tube.

* Albuminous cells :- In the Pteridophytes and gymnosperms companion cells are absent while albuminous cells are present. These are developed either from phloem parenchyma or from cells of phloem rays.

* Sclerenchyma cells :- phloem fibres :- The phloem fibres or sclerenchyma cells are component of phloem i.e. they are present both in primary and secondary phloem. The fibres may be non septate or septate.

Cortex, endodermis and vascular cylinder.

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and may be living or non living. The phloem fibres are rerely found or absent in phloem of living pteridophytes. they are also not found in some gymnosperms and angiosperms. The walls may be lignified or non lignified. beacuse of strength of strands of phloem fibres, they have been used for a long time in the manufacture of cords, ropes, mats and cloth. The phloem fibres are known as blast fibres. The phloem fibres of Hibiscus cannavinus (Aambadi) etc. are long and with thick walls and are used commercially.

* <u>Sclereids</u>:- The sclereids are occagenally found in primary phloem. they may occur in combination with fibres or alone. These are found in the older parts of phloem and are formed due to sclerification of parenchyma cells. sclereids differ from that of fibres only as these are shorter in size or length than the fibres.

* <u>Function of sclarenchyma cells</u>:- ① The phloem fibres, similar to xylem fibres give support to the plant body ② some times the sclerenchyma cells also function as storage tissue.

* <u>Parenchyma cells</u>:- The phloem ~~parenchy~~

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also contains parenchyma cells that are concern with many activities characteristic of living parenchyma cells i.e. storage of starch, fat and other organic substance. The parenchyma cells also store tannins and resins. The parenchyma cells of primary phloem are elongeted like the sieve elements. There are two types of parenchyma present in secondary phloem i.e. horizontal and vertical. The parenchyma of vertical system is also known as phloem parenchyma or axial parenchyma cells. The horizontal parenchyma cells are called as ray parenchyma cells. The walls of both types of parenchyma cells have numerous primary pit fields. The phloem parenchyma is not found in ~~many~~ most of monocotiledons.

* <u>Function of phloem parenchyma cells</u>:- Parenchyma cells mainly perform function of storage and translocation of food substances ② some parenchyma cells contain starch, tannins and crystals, which are helpful in the physiology of the plant.

Proto Phloem	meta Phloem
① it is developed from procambium. in the early stage of ontog-eny.	① it is developed from procambium but at a later stage of ontogeny.
② The sieve elements get streched and become non functional.	② the sieve elements remain functional.
③ sieve elements of angio-sperms are usually narrow and inconstic-eous.	③ The sieve elements commonly have wider cavities.
④ They may or may not have companion cells.	④ companion cells are regulary present in the meta phloem of angiosperms.

* primary phloem:- The primary phloem develops from procambium in the early stage of de-velopment. The primary phloem is again of two types i.e. protophloem and metaphloem. The protophloem develops in the early stage of ontogeny while metaphloem develops at a later stage of ontogeny. basically the proto and meta phloem have same structural elements and function. but having some differences

⊛ secondary phloem:- The phloem which develops from vascular cambium. is called secondary phloem. The secondary phloem tissue are form-ed outside the sec. phloem. sec. phloem is less in amount than sec. xylem. The arrangment of elements of sec. phloem is parallel to that of sec. xylem.

In sec. phloem there are two systems.

① vertical sec. phloem system i.e. axial system.

② horizontal sec. phloem system i.e. radial system.

* componants of vertical sec. phloem:- Compo-nant of sec. phloem are sieve element, phlo-em parenchyma and fibre. In Gymnosperms however it has sieve cells, parenchyma and alb-uminous cells.

* componant of horizontal sec. phloem:- it consist of parenchyma of phloem rays. In many species of dicoteledon trees growth rings may also observe of the phloem which are formed due to differenciation in cells. produced in begining and at the end of season. The ray initial in the cambium produces cells both towords the xylem and phloem so that the xylem and phlo-em rays are continuous.

* Duration of accurity of sec. phloem:- In most of dicoteledon plants the function of phloem is due to mainly sec. phloem. i.e. pro-duced in last season and works like primary

phloem i.e. conduction of food.

* phloem cell types → In pteridophytes sieve cells and phloem parenchyma are present. In Gymnosperms sieve cells, parenchyma, phloem fibres and albuminous cells are present. In Angiosperms sieve cells, sieve tubes parenchyma, sclerenchyma, sclereids and companion cells are present.

* Anatomy of monocoteledon root (maize root):-

The distinct anatomical characters of monocot roots are as following.

① The xylem groups are neumrous i.e. polyarch — condition the number of xylem groups vary from 12 to 20. ② The pericycle gives rise to lateral roots. ③ The cambium is absent. ④ There is no secondary growth ⑤ The pith is large and weldeveloped.

* Anatomy of maize root or monocot root:-

→ Anatomy of maize root consist of epidermis, cortex, endodermis, pericycle and vascular tissue and pith.

* Epidermis:- or epiblema:- it is outermost layer of root and is commonly known as epiblema or rhizodermis or piliferous layer. it is uniseriate and consist of compactly arranged tubular cells without intercellular spaces and stomata. The tubular unicellular root hairs are present.

* Cortex:- it is present inner to the epidermis. The few layers of cortex just inner to epidermis forming the hypodermis. the cells of hypodermis are thick walled. it is a protective layer which protects internal tissues from injurious agencies.

The starch grains are abdently present in cortical cells.

* Endodermis:- The innermost layer of cortex is called endodermis. it is composed of barrel-shaped compact cells without intercellular-spaces. The endodermal cells possess casparian strits on their anticlinal walls. The casparian strits is the part of primary cell wall. the stripe is typically located close to inner tangential wall. Thus the wall of endodermal cell become thicker and thick walled passage cells are formed opposit the protoxylem poles. The passage cells are mean for diffusion and are called transfusion cells.

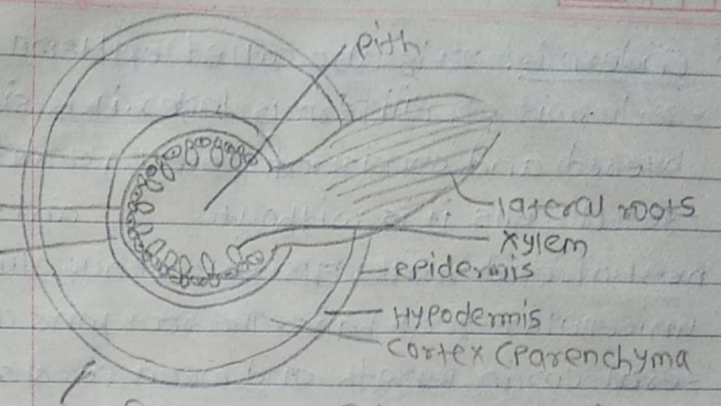
* Pericycle:- it is usually uniseriate and composed of thin walled parenchymatous cells. The pericycle gives rise to lateral roots.

* Vascular tissue:- The vascular tissue consist of alternate strands of xylem and phloem The phloem occurs in the form of strands

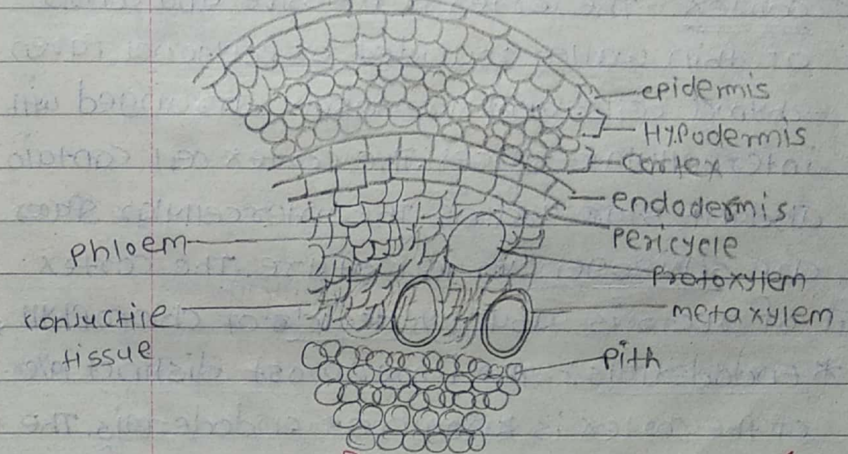
near periphary of vascular cylinder beneath the pericycle. The xylem forms discrete strands alternating with phloem strands the centre is accuping by large pith which is parenchymatous. The vascular bundles are numerous and are called polyarch. The large meta xylem vessel are arranged in a circle around the pith. The xylem is exarch i.e. protoxylem is present towords periphary and meta xylem towords center. The vessels of proto xylem are narrow and walls have annular and spiral thickening where as the meta xylem vessels are broad and have reticulate and pitted thickenings.

The phloem strands consist of sieve tubes, companion cells and phloem parenchyma. The phloem strands is also exarch i.e. protophloem is present towords the periphary and meta phloem towords the center. The parenchymatous or sclerenchymatous conjunctive tissue is found in betⁿ and around the xylem and phloem strands.

* pith :- The central part of stele is accupied by weldeveloped pith.



T.S. of maize root (diagramatically).



* Anatomy of dicotyledonous root (sun flower)

→ The important anatomical characteristic of dicoteledon roots are as following.

① xylem bundles vary from 2 to 6 in number i.e. diarch, tetrarch etc. The pericycle gives rise to lateral roots. The cambium appears as a secondary meristem. ② The pith is scanty or all together absent.

The anatomy of dicote root shows epidermis, cortex, endodermis and vascular cylinder.

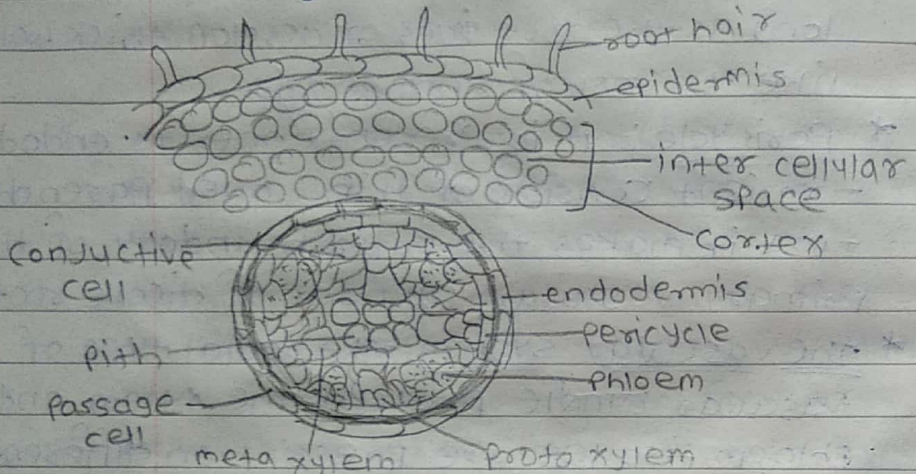
-chment controles the movement of the materials in the root and their passage in to xylem cells. The thin walled passage cells also found in the endodermal layer which lie against the protoxylem poles. The passage cells either remain unmodified as long as the root lives or develop thick walls like the rest of endodermis.

* Pericycle :- it is present next inner to endodermis. it consist of thin walled parenchyma. it makes the outer boundary of the primary vascular cylinder of dicote root.

* The vascular system :- The radial type of vascular bundle present. The xylem and phloem tissues are present on different radii and are alternate in position. the ~~proto~~ xylem is exarch i.e. the protoxylem is present towords the periphary of vascular cylinder and metaxylem is present towords center. The phloem is centripetally differenciated i.e. protophloem ~~occur~~ is present towords periphary and metaphloem towords center. The protoxylem consist of annular and spiral vessels where as metaxylem consist of reticulate and pitted vessels. phloem consist of sieve tube,

companion cell and phloem parenchyma parenchymatous conjunctive tissue. occurs in betn xylem and phloem—strands.

* pith ;- it is also called medulla. it is— scanty or all together absent.



* Anatomy of dicoteledon stem (sun flower stem) → The young stem of sunflo-wer shows following anatomical and internal structure it is almost circular in line it shows epidermis, hypodermis, cortex, Endodermis, pericycle, vascular tiss-uses and pith.

* Epidermis ;- it is the outermost layer of stem it consist of compactly arranged cells. The outer walls are cutinized. multicellular epidermal hairs are often present. Stomata are present here and there.

* Cortex ;- it is multilayered and present inte-rnal to epidermis. It is differenciated in to hypodermis, middle cortex and stele.

* hypodermis ;- it consist of 2 to 3 layers and present just below the epidermis. The cells are collanchymatous which are thic-kened at the corners. The cells are living and may contain chloroplasts. it helps in giving mechanical strength to young stem against bending forces.

* middle cortex ;- it is also few layered and consist of parenchymatous cells with inter cellular spaces. it also contain chloroplast oil ducts may be present.

* endodermis ;- it is single layered and is differenciated from the inner most layer of cortex. The cells are barral shaped and compactly arranged.

* stele ;- it is relatively larger than cortex it consist of pericycle, vascular bundles, pith and medullary rays.

* Pericycle ;- it is present in the form of sclerenchymatous patches just above each vascular bundle as a cap also called hard blast.

vascular bundles are few in number and are arranged in the form of ring

Each vascular bundle is conjoint, collateral and open type. It is wedge shaped. The phloem is made up of sieve tube, companion cell and phloem parenchyma.

* Cambium → it is present next to phloem and consist of small thin walled reactangular meristimatic cell.

Xylem is present inner to cambium. it is protoxylem towords pith which is with annular and spiral thickening. meta xylem is with reticulate and pitted thickening and present away from center. The development of xylem is centrifugal or endarch. wood fibres are irregular, polygonal, thick walled and lignified. xylem parenchyma consist of living, thin walled parenchyma cells.

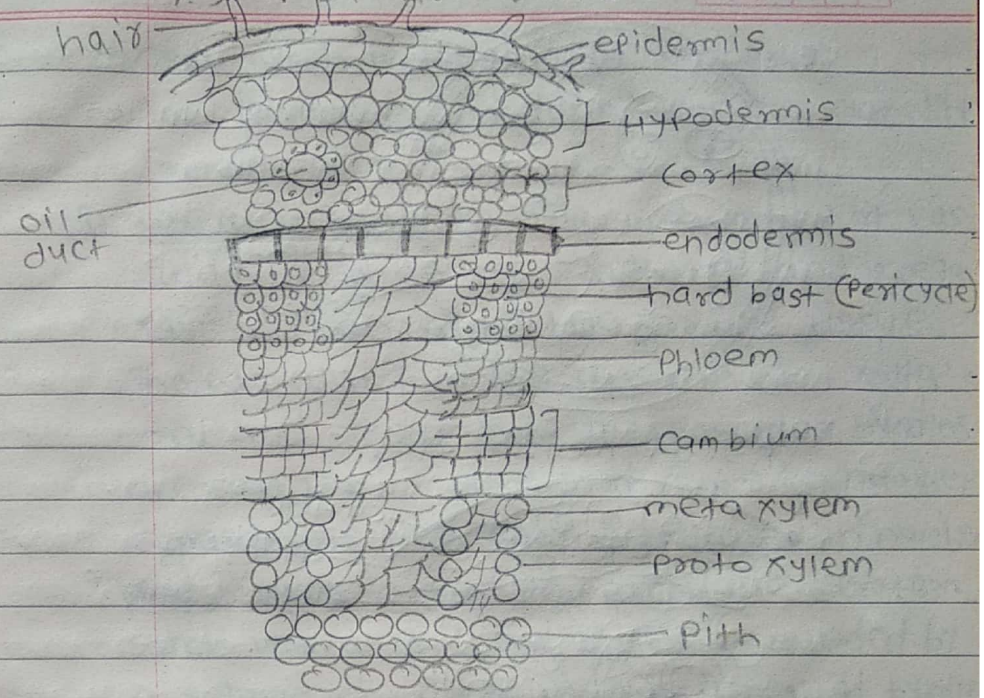
* Pith or medulla :- it is present in the center of stem and is parenchymatous. (Fig)

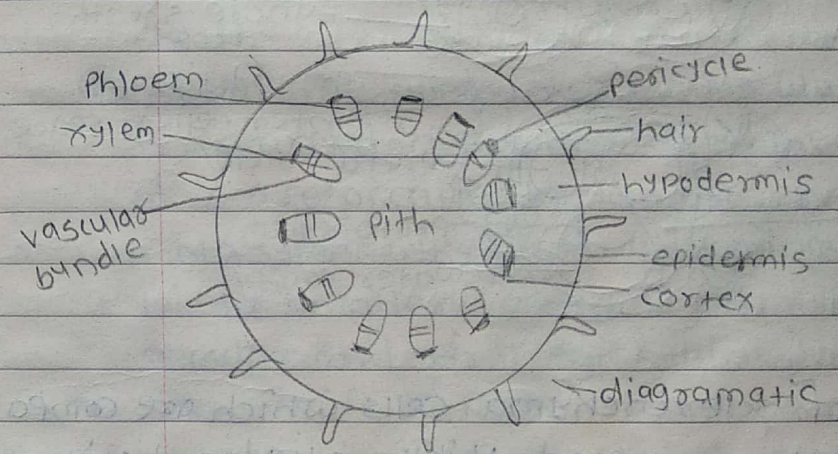
* Anatomy of monocotyledon stem :- (maize stem) :- The monocotes stems are monocotyledons stems are similar to dicoteledonous stems in having an epidermis, a cortex and stele.

Stem of maize is internally circular in out line and shows following internal structures :-

① epidermis → it is outermost layer of stem

T.S. of sunflower stem.



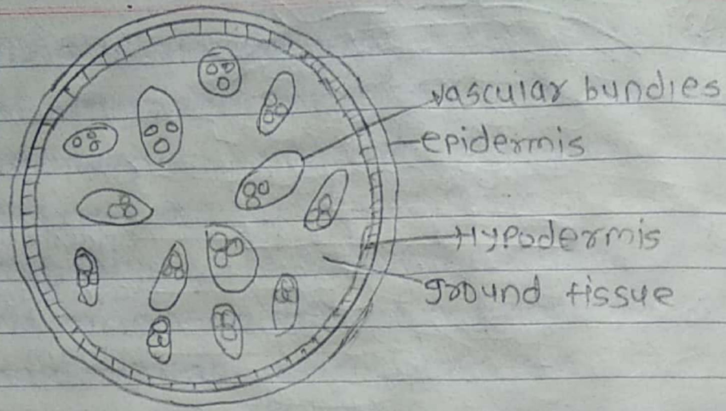


diagramatic fig :-

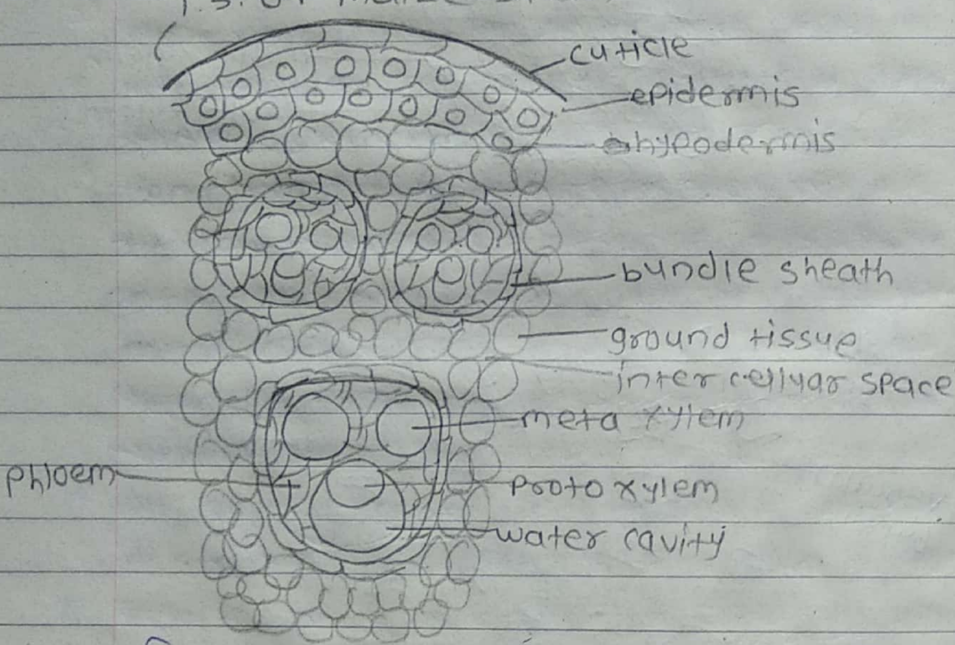
it is covered by thick cutical it is without epidermal outgrowths. Stomata are present in young stem.

② hypodermis :- it is present below the epidermis. it is 2 or 3 layered. it consist

T.S. of maize stem diagramatic



T.S. of maize stem



of sclerenchyma cells which are compa-ctly arranged thick walled and without stomata.

③ ground tissue:- it is present inner to hypodermis and occupy the entire region of stem. it is consist of thin walled paren-chymatous cells which are loosely arra-nged with intercellular spaces.

Pericycle, endodermis etc. are not diff-erenciated.

④ vascular bundles:- A large number of vas-cular bundles are scattered and irregu-larly arranged in the ground tissue. The vascular bundles are conjoint, collate-ral and closed type. The vascular bundles are smaller in size and more in number towards the periphary and lesser in numbe and bigger in size towards the center. Each vascular bundle is surrounded by a sclerenchymatous sheath called bundle sheath.

⑤ xylem:- The xylem in each vascular bundle is arranged in the form of Y. The two arms of Y are occupied by two big vessels i.e. meta xylem. with pitted thickenings and the tail by smaller vessels (Proto xylem with annular and spiral thickenings) on the inner side of Proto xylem a lysigenous water cavity is present. it is formed by the breaking of Proto xylem vessels. on the outer side of Proto xylem a few scle-renchyma cells are present.

⑥ phloem:- it is present above xylem. it consist of sieve tubes, and companion cells only. phloem Parenchyma is absent. The Protophloem is usually crushed aga-ins sclerenchyma. meta phloem is Present just below proto phloem and the arms of xylem.

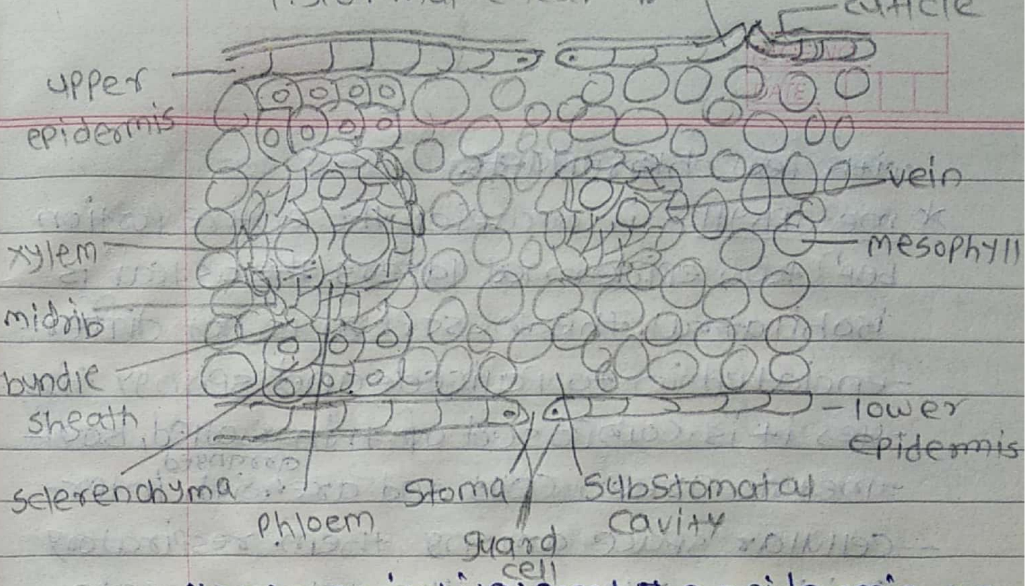
Thus most distinctive and characteristic annotomical feature of monocote stem following

1) vascular bundles are many in number
2) stele is broken up in to bundles.
3) vascular bundles are scattered in ground tissue ④ endodermis is not found ⑤ cortex, pericycle, pith are not differenciated beacuse of presence of scattered bundles ⑥ vascular bundles are collateral and closed. ⑦ sec. growth of normal type is absent. ⑧ each vascular bundle is surrounded by sclerenchymatous bundle sheath
9) vascular bundles are commonaly oval shaped
10) phloem consist of sieve tubes and companion cells only ⑪ The phloem parenchyma is absent
12) pith is absent. ⑬ hypodermis is usually sclerenchymatous ⑭ usually epidermal hairs are not present.

* Anatomy of monocote leaf :- (maize leaf)

→ The internal structure of monocoteledonous leaves is more or less similar in both the upper and lower halves and so it is

T.S. of maize leaf



known as isobilateral. The epidermis on either sides contain the stomata and mesophyll is usually not differenciate in to palicede and spongy tissue but consist only a parenchyma cells having chloroplasts with intercellular spaces. The leaf is also know as unifacial. The internal structure of monocot leaf shows epidermis, mesophyll and vascular bundles.

* Epidermis :- The epidermis is found on both upper and lower surfaces of leaf. The epidermal layers are uniseriate. and composed of more or less oval cells. The outer wall of epidermal cells is with cuticle. The upper epidermis is easily identified due to presence of xylem and dullyform cells toward it. stomata are present to both upper and lower epidermal layers. stomata are surrounded by kidney shaped guard cells

with few chloroplasts.

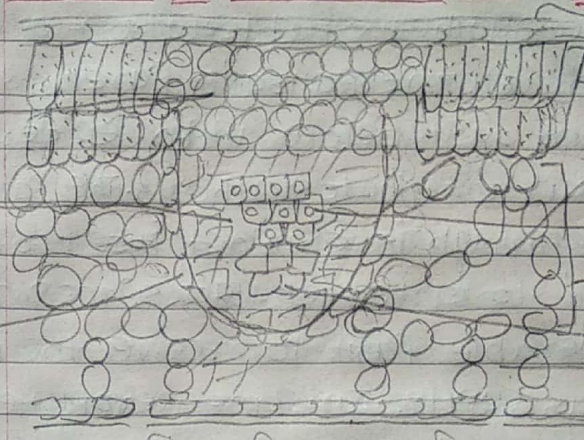
* mesophyll:- it occupies the entire portion betn two epidermal layers. ~~the~~ as leaf is isobilateral, the mesophyll is not differenciated in to palicede and spongy tissues it is composed of thin walled, isodimetric green cells and are arranged with intercellular space among them. respiratory cavities are present just below stomata.

* vascular bundles:- The vascular bundles are arranged in parallel manner and they may differ in size in some cases The vascular bundles are occur in the mesophyll tissue they have a common stry. and are enclosed by a bundle sheath. The vascular bundles are collateral and closed type. They occur at regular interval.

The xylem is found towards upper side and phloem towards lower side in bundles. The cells of bundle sheath genrally contain starch grain in them. xylem consist of vessels and phloem consist of sieve tube and companion cells. ~~and~~ sclerenchyma cells occur in patches on both ends of large vascular bundles which give mechanical support to the leaf.

* Anatomy of dicotyledon leaf:- (sunflower leaf)

→



T.S. of sunflower leaf.

* Anatomy of dorsiventral leaf:- it is also known as bificial leaf. it is differenciated internally in to a dorsal region and a ventral region. most of the dicoteledonous leaves are of this type. Genral out line of leaves shows prominant midrib in center with lamina on either side and differenciated in to following regions.

① upper epidermis:- it is single layered and consist of closely fitted cells. with outer thick walls. The chloroplast and stromata are usually not present. it also bears multi cellular hairs.

② mesophyll:- it forms the main bulk of leaf and consist of two regions i.e. palisade layer and spongy layer.

* palisade tissue:- it is composed of one

~~or~~ two layers of ~~cell~~ closely arranged columnar cell. A large number of chloroplast are present in each cell. The palisade parenchyma is present just below upper epidermis and is mean for photosynthesis. The palisade tissue though is compact itself but remain exposed to intercellular spaces for a considerable part to receive the proper gaseous supply. In some xerophytes palisade tissue may be present on both side of leaf. ex:- Eucalyptus.

* Spongy layer:- Spongy layer is present just below palisade layer. it consist of loosely arranged parenchyma cells. it looks like a net. The intercellular spaces are prominant and thus the name spongy parenchyma given. These cells contain less or no chloroplast. This layer helps in the exchange of gases betn the leaf and the atmosphere. respiratory cavities are seen just below stomata.

③ Vascular bundle:- it is irregularly distributed in spongy tissue. The structure of vascular bundles of midrib and other veins is similar to each other. A large number of vascular strands form an interconnected system in the median plane of blade. These vascular bundle in the leaves are called veins. A large number of these small veins arise from mid vein and form a network.

Each vascular bundle is conjoint, collateral, closed. The xylem is present towords upper epidermis and phloem towords lower epidermis. Xylem consists of annular or spiral vessel, tracheids, wood fibres and xylem parenchyma. Phloem consist of sieve tubes, companion cells and phloem parench. The entire vascular bundle is enclosed in paraenchmatous bundle sheath which is made up of a layer of compactly arranged cells.

* midrib region → in midrib region generally in place of palisade tissue there is present some parenchyma tissue on the lower side and also upper side.

④ lower epidermis — it is similar to upper epidermis in stru. it bears numerous stomata. Each stoma is surrounded by two guard cells. and is followed by substomatal cavity.

* Anamolous secondary growth in Dracaena stem:-
In monocoteledons normally, the vascular bundles are closed. The cambium is absent. so the sec. growth is absent. but in some plants like

Dracaena, Yucca etc. the sec. growth takes place and is known as anamalous or abnormal sec. growth.

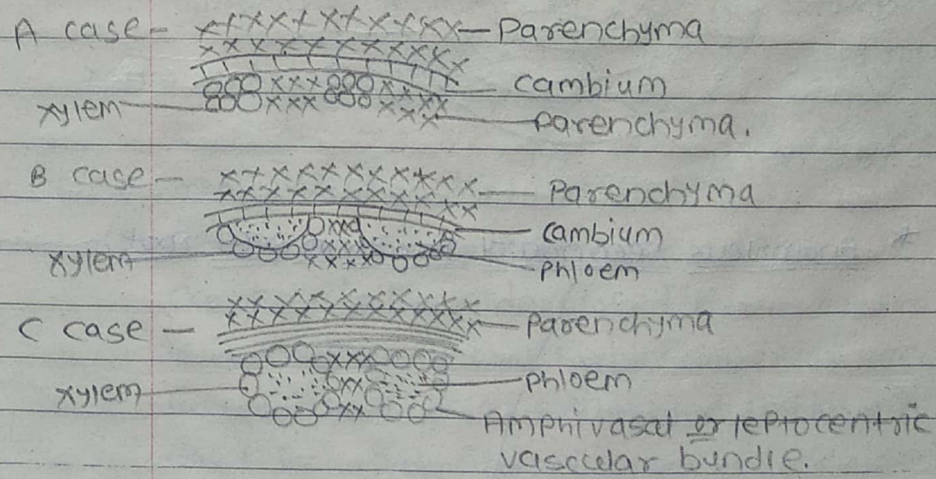
The abnormal sec. growth may be an adapt-ation. Dracaena is a common guarden plant and belongs to family Liliaceae the stem shows abnormal sec. growth. The pri. internal stru. of stem mainly resemble typical monocote stem of maize and it shows scattered, collateral and closed type of vascular bundles in the parenchymatous ground tissue. Endodermis and pericycle are absent.

sec. growth in stem takes place by the formation of cambium. one of the outer layer of ground tissue becomes meristimatic and functions as cambium. such sec. growth which is not common in monocotyledons is called anamalous secondary growth.

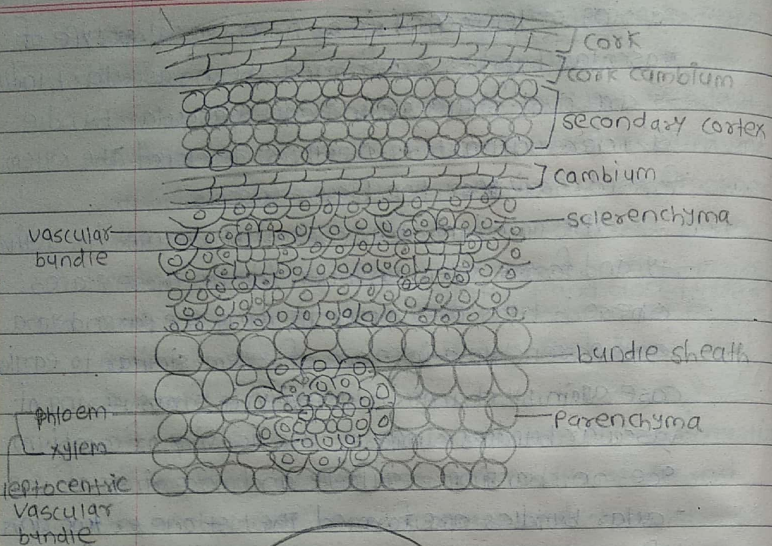
The activity or behavior of this cambium is also different. The activity of cambium ~~produces sec.~~ is more on the inner side and very little on the outer side where it forms only parenchyma. on the inner side it forms xylem and parenchyma in alternate patches. The inner parenchymatous cells are called conjunctive tissue.

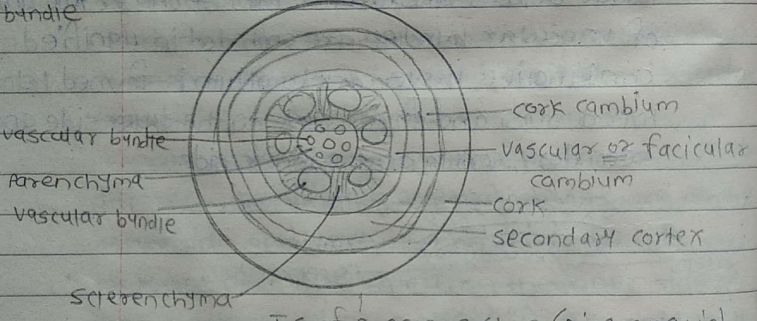
After a short while the activity of cambium on the inner side changes and above the xylem it starts forming phloem. and then again xylem thus phloem becomes encircled by xylem. and a ring of leptocentric or Amphivasal type of vascular bundles are formed. These vascular bundles are oval in shape. around each vascular bundle a sclerenchymatous sheath is developed. The xylem formed earli year has bigger vessels.

The cambium after some time changes its activity and forms xylem on inner side at those places where it was previously forming the parenchyma and parenchyma in place of xylem. similar to earlier case again by change in activity it forms a ring of vascular bundles similarly the activity of cambium goes on changing regularly and more rings of vascular bundles are formed. The last one or two rings of vascular bundles are embeded in lignified—conjunctive tissue. cork cambium is formed below hypodermis and forms cork on the outer side and secondary cortex on the inner side.



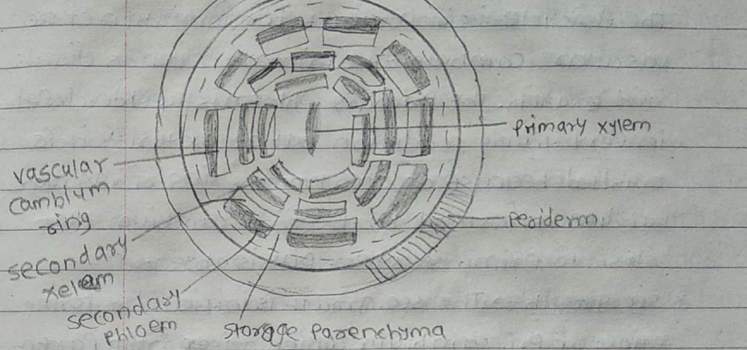
T.S. of Dracaena stem after secondary growth

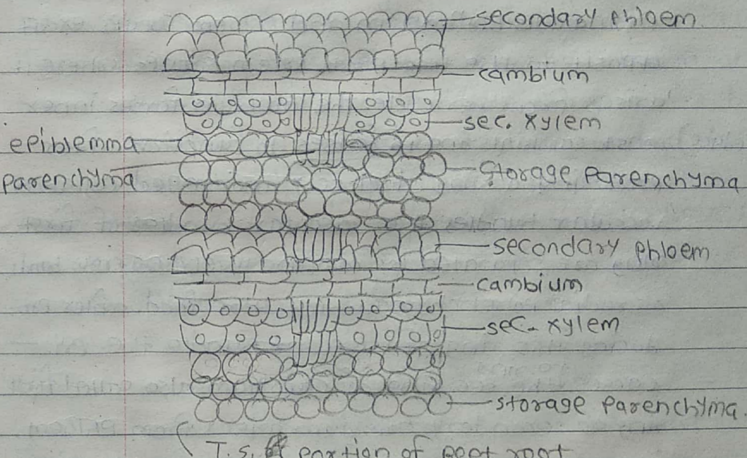




T.S. of Dracaena stem (Diagramatic)

T.S. of Beet root (diagramatic)





T.S. of portion of Beet root.

* Anamolous secondary growth in Beet root :- ——→ Epiblemma :- it is outermost layer of

Cortex :- it is weldeveloped but in mature roots it is completely crushed beacuse of sec. growth immediately below epiblemma Periderm is Present which is welldeveloped in young conditions. The endodermis is present but later on it is reptured

The pericycle is important for formation of sec. vascular cambium. The primary xylem is diarch and exarch. The primary phloem is weldeveloped in very young condition but at maturity it is crushed beacuse of sec. growth. ring of vascular bundles is formed by the first cambium just close to primary xylem. pith is absent.

* sec. growth → The sec. growth is initiated by formation of pri. cambium which arises from parenchyma cells betn xylem and phloem groups except opposit to the two protoxylem groups where it arises from pericycle. The cambium forms inner (reduce) most cambial ring it ceases to function after producing a ring of closely arranged collateral vascular bundles the vascular bundles of first ring are separated by comparatively narrow bands of radial parenchyma. which store food. after producing this ring of vascular bundle the pri. caeses to ring the sec. ring of cambium also called first ring of secondary cambium arises from phloem parenchyma outside first ring of pri. cambium. The sec. cambium ring produces a second ring of secondary vascular bundles outside the first. The bundles are conjoint and colateral i.e. phloem and xylem are present in the same radius. The phloem is present towords the outer side. This cambium ring also caeses

a third ring of cambium i.e. (second ring of sec. cambium) is fromed outside second ring it is derived from pericycle. it also forms a ring of sec. collateral vascular bundles. The cells of pericycle enclosed by cambium ring undergoes repeted divisions and form more pericyclic layers of parenchyma cells. These cells also store food material. The rings of pericycle appears dark red and those of vascular bundles are lighter in colour in transverse section. Thus root of Beta vulgaris increase in thickness by activity of concentric layers of cambium and by proliferation of pericycle. The Beet root is identified by presence of mainly cambial rings, proliferated pericycle and the storage parenchyma.

* Peridermi

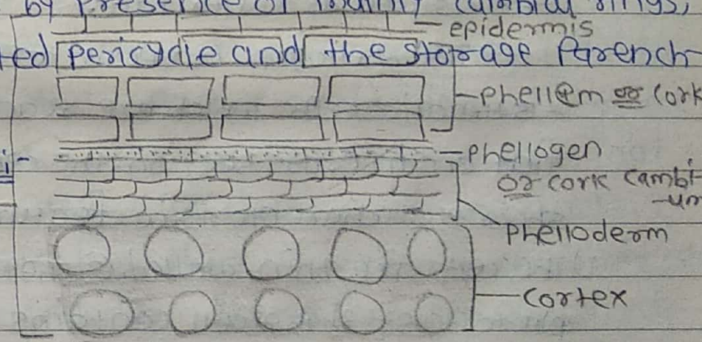


Fig – Peridem

The term periderm is applied to a protective secondary tissue that develops by the activity of secondary lateral meristem. and replaces the epidermis periderm genrally develops in gymnosperms and dicoteledon roots and stems. it is rairly formed in leaves or monocoteledons. it also develops as protective layer near injured parts and is called wound periderm.

The term periderm is more distinct than bark.

* **Structure of periderm:-** The periderm is made up of three layers i.e. phellogen or cork cambium, the phellem or cork and phelloderm or the living parenchyma tissue.

① **Phellogen:-** it is a secondary lateral meristem which arise from permnant living cells of epidermis, hypodermis, cortex and phloem cells. its activity adds to the diameter of stem or root beacuse itself devide into tangitial plane cutting off cells towards its inner as well as outer face.

The phellogen composed of single layer of meristimatic cells which are reactangular, radially flatten in cross section. the cells of phellogen show the characteristic features as following.

1) The cells are thin walled. ② They have vacuolate protoplast 3) The cell contains are granular.
4) The cells may contain chloroplast antanins
5) The cells are usually compactly arranged except in the lenti cells; 6) The cells are meristimatic and devide actively in tangitial plane.

• The phellogen originates at different depths outside the vascular cylinder.

ex:- In nerium the epidermal cells become meristimatic and give rise to phellogen. In varabilis the phellogen arise from cortical cells.

Thus on the basis of origin and position the phellogen is of different types.

ex:- ① Epidermal phellogen - ex:- Nerium
② Hypodermal or subepidermal phellogen - ex:- Prunus
3) Cortical phellogen - ex:- Pinus
4) Phloic phellogen - ex:- tunica
5) Pericyclic phellogen - ex:- Vitis

The phellogen form a complete layer of meristimatic cells which encircle the axis or it may arise in patches. In ridged stems the phellogen below the ridges is slightly differ than that below the grooves.

Phellogen arises from permanant cells by regaining the capacity of division and become meristimatic. These cells undergo periclinal division cutting of outer and inner cells. If outer cells function as phellogen the inner cells become phelloderm layers. further periclinal division give rise to more layers of cork cells towards the outer side. the inner cells function as cork cambium or phellogen. In order to increase in circumference the cells of phellogen devide anticlinally. The number of cork layers formed during one year varies bet^n 2 to 20.

② **Phellem or cork layers:-** The phellem or cork arise as a result of tangitial or periclina division of phellogen cells. The cells cut off towards outer side, mature in to cork cells or phellem. These cells are compactly arranged have thin cellulose walls in begining but as they mature the cells become elongeted redially and there is gradual loss of living material. The cell walls become thick by deposition of suberin. The cork cells may also contain resin or tanin materials. The air present in cavity of cells also gives it thermal insulating qualities which act as protective layer of plant and also useful commercial product. In some cork cells sclereids and crystals present.

③ phelloderm:- it consist of the layers of thin-walled cells. The cells are living and possess cellulose cell walls along with pits. the cells are arranged in definate redial rows. In some cases cells may contain chloroplast and starch.

* **lentials**:- it is defined as small portion of the periderm where the activity of phellogen is more than else-where and the cork cells produced by it are loosely arranged and possess numerous intercellular spaces.

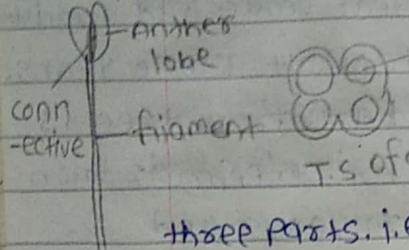
The loose arrangment of cells in the lential makes them the cheif aerating structure. the lentials are found in the periderm of both stems and roots. they are also found on the fruits small dots on the surface of fruit in apple lentials usually occurs as raised for corky spots on the surface of main axis and its branches they are present in most of plant undergoing secondary growth. the lentials genrally occure beneath old stomata or group of stomata and they may be appear in structure. They also occur in position opposite to muticellular vascular ray.

* **origin and structure of lenticals**:- Initiation of lential below stoma is marked by division of some all below stoma in different planes to form a mass of rounded cells. these cells grow bigger in size. loose their containts and become colourless. They form first layer of complimentory alls. beneath these cells the phellogen or a cork cambium appear its cells devide tangitially and out of more complimentry cells towords the outerside phellogen is lential region is characterised by presence of intercellular spaces between its cells. and their is addition of complimentory cells towords outerside. The epidermis repture ~~the outerside. thes~~ and expose underlying complementry cells. These cells are thin—

Unit – II

Embryology and reproduction

* **structure of anther :-** The stamens or microsporophylls are regarded as male organs of flower.



Each stemen consist of three parts. i.e. filament, anther and connective. The filament is cylinder stalk of stamen and anter is expanded head borne by filament at its filament.

Each anther consist of usually two lobes connected together by a midrib known as the connective. Each lobe of anther contains two pollen sacs. i.e. microsporangia. thus there are 4 chembers in each anther. But in many cases there are only two and sometimes only one chember is present. ~~within~~ each pollen sac contains ~~mass of~~ pollen mother cells or microspore mother cells. Each pollen mother cell after meiotic division produce a group of 4 microspores called pollen tetrad. Pollengrains are produced in large quantities in pollen sacs.

The wall of anther is two or three layered. The outermost layer is called epidermis. The cells of epidermis are greatly streched and flattened. and thus the cells lose contact with each other and at maturity get reptured. The layer next to epidermis is called endothecium or fibrous layer. The walls of cells of endothecium are readialy elongeted and bear fibrous bands. The fibrous bands of thickening of the cells is mainly responsible for dehiscence of mature anther due to hygroscopic in nature. The cells of endothecium are thin walled along the line of dehiscence of each anther lobe. The opening through which the pollengrains are discharged from pollen sac is called stomium. The inner most layer of anther wall is called tapetum. Tapetum is a single layered. The cells of tapetum layer have dense cytoplasm and conspicous nuclei. The tapetum layer is of great physiological significance since food material entering in to sporogenous tissue diffuses through this layer. usually tapetum is single layered but in some cases it is 2 to 3 layered. Thus tapetum is nutritive layer for development of microspores.

* **sporogenous tissue :-** The sporogenous tissue are called microspore mother cell or pollen mother cell. Initially microspore mother cells remain closely packed but later on they get loosely arranged —

The microspore mother cells after meiotic division produce 4 microspores or pollengrains the phenomenon is called microsporogenesis. The deploid nucleus of each pollen mother cell devides twice to form 4 nuclei, The first division is reduction division i.e. meiosis first and second division is meiosis second. At the end of meiotic division ~~these~~ 4 nuclei which are formed possess half (n) of usual number of (2n) chromosomes.

Depending up on the manner of wall formation during cytokinesis pollengrains are developed by 2 types i.e. successive types and simultaneous type. In successive type a cell wall is formed betⁿ two daughter nuclei. immediately after meiosis I. the second meiotic division takes place forming two haploid nuclei and then again a wall is formed thus there is formation of tetrad of cells. This step of development is found in monocote plant.

Symultaneous type:- This type is commonly found in dicote plants. In this type nucleus of microspore mother cell devides twice forming 4 haploid nuclei. in the common mass of cytoplasm of mother cell. The walls are laid down betⁿ 4 nuclei. Thus 4 nuclei arranged in tetrahedral manner. and 4 daughter cells are also ~~formed~~ forming a tetrahedral tetrad.

T.S. of an anther showing tetrads of Pollen grain

* <u>Development of male gametophyte</u> or <u>microgametophyte</u>:- The development of male gametophyte or microgametophyte in angiosperm is uniform. The microspore or pollengrain after germination develops in to male gametophyte it consist of only two divisions. The first division results in to formation of two cells i.e. a large vegetative cell and a small genrative cell. The second division is present only in the genrative cell.

The germination of microspore starts while it is still within microsporangium or pollen sac.

* <u>Formation of vegatative and genrative cells</u>→ The first division of microspore gives rise to the vegetative and genrative cells. The first formed periferal cell which is walled is the genrative cell

while the larger, necked. central cell is the vegetative or tube cell. The nuclei of genrative and vegetative cells differ in size, structure and in staining qualities. The nucleus of vegetative cell possesses a prominant nucleolus, of genrative cell cytoplasm is hyaline and is without RNA. whereas that of vegetative cell is rich in RNA. The nucleus of genrative cell contain a small nucleolus. The DNA containts of both nuclei are same in the begining but later on they increase in the genrative nucleus. The starch and fat are most conspicuous in the vegetative cell.

The genrative cell looses contact with microspore wall and it becomes oval or spindle shaped. Thus microspore becomes two celled. genrally pollengrains are shade from pollen sac in two celled stage for polination. In some cases both 2 and 3 celled pollengrains have been reported in the same plant.

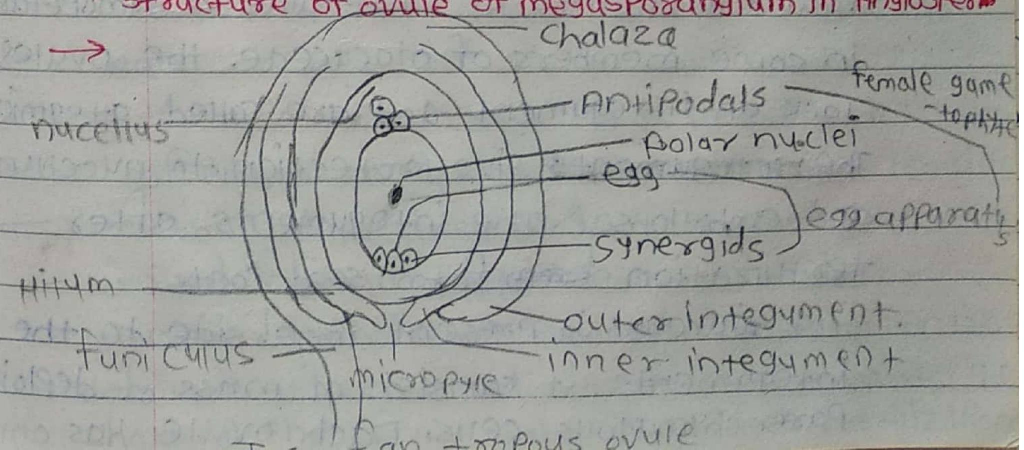
In most of angiosperms the pollengrains shadding from anther take place at 2 celled stage or binucleated or two celled stage. one of these is the genrative nucleus which later on devides and form two male nuclei.

* **male cells or male nuclei** :- The genrative cells devides in the pollengrain and sperms cells are formed. which are called male gamets.

* **vegetative or tube nucleus** :- The vegetative or tube nucleus play an important role in directing growth of pollen tube. The tube nucleus commonly present behinds male gamets.

* **Pollen tube** :- The pollengrain swells up and the exine reptures at germ pore. when pollengrain get deposit on the stigma after pollination. The intine along with contents come out in the form of a pollen tube. The pollen tube grows through the style and riches the ovule in the ovary. The pollen tube enter to micropyle or chalaza or side ways. It carries tube nucleus and two male gamets. at its tip. After discharging its contents in embryo sac the pollen tube collapses. The pollen tube contains some enzyme like amylase, pectinase, liypase etc. which have role during the entry of pollen tube in embryo sac.

* Structure of ovule of megasporangium in Angiosperm



The megasporangium of ovule in angiosperm show integument, nucellus, female gametophyte etc. stalk of the funicle which is variable in length. the ovule with funicle is called funiculate or stalked ovule and without funicle ovule is called sessile ovule. The point of attachment of funicle with the ovule. The point of attachment of funicle with the body of ovule is called Hilum. The funicle give support to the body of ovule. it also supplied nutrition to body or ovule from placental tissue. The body of ovule is devided in to two main parts such as integuments and nucellus. The body of ovule is covered by two layers called integuments and the ovule is called bitegmic. the bitegmic type of ovule is present in most of plants. The ovules with one integument are called unitegmic. bitegmic ovules occurs in plants of polypetaly and monocotes while the unitegmic ovule are found in plants of sympetalae or gamopetalae in some members of olacaceae. the ovules lack an integument and are called ategmic. The integuments give protection to nucellus and embryo sac. The integuments after fertilization ~~from~~ form seed coat.

Nucellus is present innerside to the integuments, it consists of mass of deploid parenchymatous cells. Each ovule has only one nucellus. The portion of nucellus present towards the micropyle is called micropylar end and the portion present at basal end are called chalaza. end. In nucellus towards the micropylar end, an embryosac or female gametophyte is ~~called~~ present nucellus present integument from its chalaza end. it also produces embryosac or female gametophytes. it acts as a nutritive tissue.

* **Embryosac or Female gametophyte** – it is present towards micropylar end. it is group of 3 cells. middle cell is called egg or female gamet and two lateral cells are called synergids. all cells are haploid after fertilization egg is converted in to deploid zygote which by mitosis produces an embryo of the seed. one of synergid helps to give entry of male gamets in to embryo sac.

* **secondary nucleus** → it is present in center of embryo sac which is deploid after fertilization deploid secondary nucleus is converted in to a triploid primary endosperm nucleus [3 PEN] which produces endosperm. Antipodals are three haploid cells present towards the chalazal end of the embryosac. after fertilization

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Antipodals get disorganised and surve as nutritive tissue. micropyle is genrally formed by either both two integuments or only the inner integument in bitegmic ovules. The micropyle allows the pollen tube to enter the ovule during the process of fertilization.

* Development of female gametophyte in Angiosperms → During development of gametophyte the megaspore enlarges considerabally and undergoes three successive mitotic divisions. resulting in the formation of genrally 8 nucleated embryo sac. However their are many variation from typical manner of development of megaspore and embryo sac has been observed — maheshwari 1950 classified different type of development of embryo sac in Angiosperm based on the different features like ① The number of megaspore or megaspore nuclei that take part in the formation of the embryo sac.

② Total number of division that occur during the formation of megaspore and gametophyte

③ Number and arrangment of nuclei and their chromosome number in mature embryo sac.

Based on number of megaspore nuclei involved in development. female gametophite of Angiosperm may be classified in to monosporic, bisporic and tetrasporic

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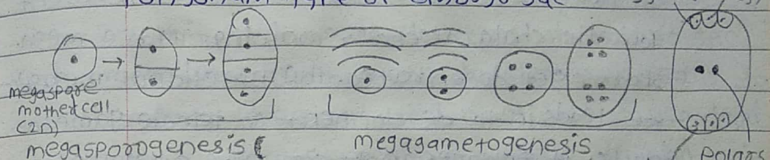
1) monosporic embryo sac → This type of embryo sacs are derived from only one of megaspore all nuclei in the monosporic embryo sac are genetically identical beacuse they are derived through mitosis of a single nucleus.

Polygonum type of embryo sac –



This type of embryosac is the most common type of development of embryosac. it was first discovered by stras burger 1879 in Polygonum div-ariation catum in this type out of four megaspore usually chalazal one functions and rest three megaspore degenrate functional megaspore enlarges and its nucleus undergoes three successive mitotic division and their is formation of 8 nucleated and 7 celled female gametophyte which consist of an egg apparatus two polar nuclei and three antipodal cells.

The development of female gametophyte mainly consist of two phases i.e. megasporogenesis and megagametogenesis. megasporogenesis is the phenomenon which consist of the meiotic or reductional division of deploid megaspore mother cell to form a group of

Four haploid megaspores. The megaspores are haploid ~~megaspores. The megaspores are hapl-~~ having n number of chromosome.

megagametogenesis consist of development of embryo sac or female gametophyte from a single functional megaspore which is present towards chalazal end remaining three megaspores get degenrated. The functional megaspore leads in to development of female gametophyte. it enlarges in ~~to~~ size. The nucleus of megaspore devides and redevides for three times to form 8 nuclei. The 8 nuclei are arranged in to 3 celled egg apparatus, secondary nucleus and 3 antipodals out of 8 nuclei four are migrated towards the micropylar end and other four towards chalazal end. one nucleus from each pole is then migrated in the center of the gametophyte.

The upper three nuclei are organised to form an egg apparatus the middle cell of the apparatus is called as an egg or female gamet and two lateral cells are called synergids.

Two haploid nuclei present in center of female gametophyte are called polars which later on get fused to form deploid secondary nucleus the group of three haploid nuclei present towards chalazal end are organised to form a group of 3 cells called antipodal.

In Angiosperm development of female gametophyte completes within megaspore such type of development of female gametophyte is called endosporic development.

*** Development of Bisporic embryo sac (Allium type)**

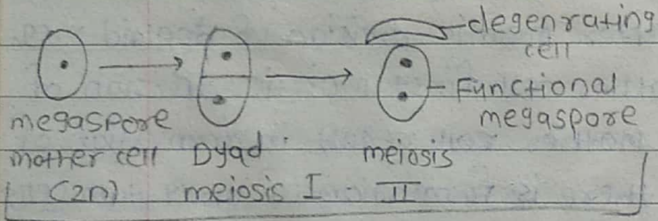
- In this type of development of embryo sac megaspore mother cell devides meiotically to produce two dyad cells. only one of the dyad cell undergoes second meiotic division while the remaining one degenrates.

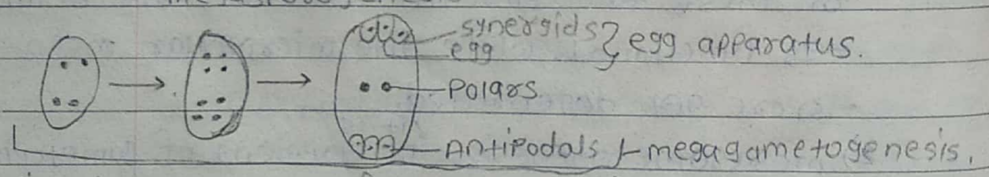
<u>Allium type</u> — This type of embryo sac was first discribed in Allium fistulism by ~~tra~~ s burger in 1879 the development of embryo sac consist of two parts megasporogenesis and megagametogenesis.

1) megasporogenesis is the formation of haploid megaspore after meiotic division of deploid megaspore mother cell first meiotic division of megaspore mother cell result in formation of dyad. Thus there is formation of only two cells of these two cells the chalazal one becomes functional. while the micropylar megaspore get degenrated.

2) megagametogenesis — it is Development of gametophyte or formation of female gamets from functional megaspore. The nucleus of functional megaspore devides to form two, four and finally

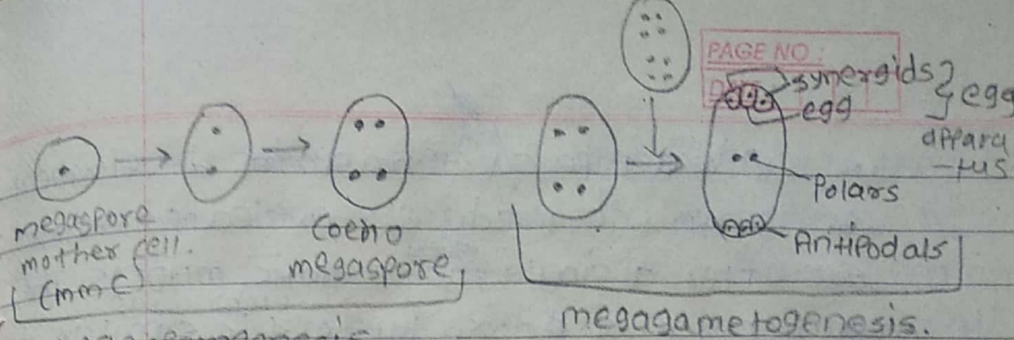
8 nucleated embryo sac. These 8 nuclei get orga-nised in to an egg apparatus, two polar nuclei and three antipodal cells. A group of four nuclei present towards each pole. Then one nucleus from each pole migrate to the center of embryo sac and are called polar nuclei. Three nuclei present towards micropylar end get organised in to an egg apparatus. Egg apparatus consist of an egg cell in the middle position which act as female gamet and the two lateral cells are called synergids. The three nuclei present towards chalazal end get organised in to three anti-podal cells. which are nutritive in function and lastly get disorganised thus final organ-isation of bisporic embryo sac is similar to the monosporic polygonum type.





Bisporic Allium type of development of embryo sac in Angiosperm

* Tetrasporic development of embryo sac:-
(Adoxa type):-



The tetrasporic development of embryo sac (Adoxa type) mainly consist of two phases.

① megasporogenesis:
② megagametogenesis.

megasporogenesis is the process in which deploid megaspore mother cell after meiotic division produce four haploid megaspores. The megagametogenesis is the phenomenon in which there is development of female gametophyte or embryo sac from haploid me-gaspores.

The tetrasporic development of female gametophyte consist of all the 4 haploid nuclei remain in a common cytoplasm which is called a coeno megaspore. A tetrasporic embryo sac is more heterogenous i.e. it shows variation than a bisporic embryo sac beacuse the four products or nuclei of meiosis are invol-ved in the formation of embryo sac and these four nuclei are genetically different. the nuclear behavior in tetrasporic embryo sac is quite variable.

Adoxa type of tetrasporic development of embryo sac produce 8 nucleated embryo sac after a single post meiotic mitosis. The organisation of Adoxa type of embryo sac is similar to polygonum type of embryo sac.

The embryo sac is 8 nucleated and 7 celled. one nucleus from each pole migrate to centre of embryo sac which are called polars. The polar nuclei later on get fused and form a diploid secondary nucleus which acts as female gamete and fuses with one of the male gamet to form triploid primary endosperm nucleus (3PEN) the process is called triple fusion. The three nuclei present towards micropylar end get organised in to an egg apparatus which consist of central egg cell and two side cells called synergids. The egg cell act as female gamete and which get fuse with male gamete the process is called syngamy which results in formation of diploid zygote. and later on in to the embryo. The two synergids are called supporting cells. which later on get disorganised. Three cells present towards chalazal end are called antipodal cells. which are nutritive in function and lastly get disorganised. Thus the Adoxa type of tetrasporic embryo sac or female gametophyte consist of an egg apparatus, antipodal cells and the central diploid secondary cell. so it is called 7 celled and 8 nucleated.

* Double fertilization and its significance:-

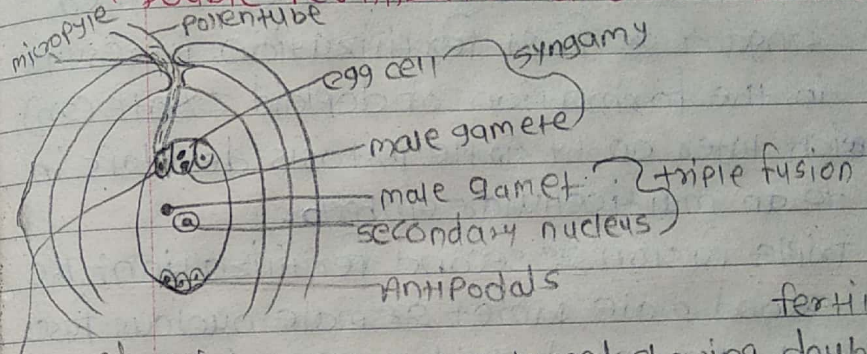


Fig- Embryo sac enlarged showing double fertilization ↓

Fertilization is the union of an egg and male gamet to produce deploid zygote (2n).

* Double fertilization:- it is defined as the phenomenon which involve two fertilizations i.e. syngamy and triple fusion the pollen tube entering the ovule through micropyle and is called the porogamy. The pollen tube passess through the nucellus and then enters in to embryo sac through one of the synergid. as a result the synergid as well as the tip of pollen tube get reptured. The two haploid male gamets are released inside the embryo sac near the egg The non motile male gamets or male nuclei

are brought up to female gametes with the help of pollen tube. And is called siphonogamy.

The two fertilizations which are involved in double fertilization are as following.

* **Syngamy :- or First fertilization :-** Out of two male gamets, one male gamet fuses with the egg or female gamet and is called syngamy or first fertilization. It results in the formation of deploid zygote (2n), which later on by simple mitosis develops in to an multicellular embryo.

* **Triple fusion or second fertilization :-** The second male gamet or male nucleus fuses with the sec. deploid nucleus. The process is called triple fusion or second ferti.n Triple fusion results in the formation of triploid primary endosperm nucleus (3PEN) which later on develops in to an endosperm. Thus double fertilization is present only in the angiospermic plants and it is characteristic of angiosperm.

* **Significance of double fertilization :-**
① The process of double fertilization is present only in Angiosperms. ② In double fertilization both male gamets are utilised. ③ Syngamy or first fertilization results in the formation of deploid zygote which later on forms embryo of seed ④ Syngamy also restores the deploid condition of plant. ⑤ Triploid endosperm is formed as a result of triple fusion in the seed. The endosperm supplies nurishment to the developing embryo. ⑥ In Angiosperm the seed is formed from ovule only after double fertilization ⑦ double ferti.n retain deploid number of chromosomes in the life cycle. ⑧ Due to double fertilization angiospermic seeds are more viable. So that percentage of seed germination is high. ⑨ Fertilization also brings about recombination of characters resulting in variation among the offsprings.

* **Post fertilization changes in Angiosperms :-**
The process of fertilization stimulates fertilized ovule as well as ovary. So, after fertilization many changes occur in ovule, ovary and in different ~~plants~~ parts of flower. All these changes are called post fertilization changes. These changes lead to the formation of seed from ovule and fruit from ovary. The fully developed embryo consist of radicle, plumule, one or two cotyledons. The embryo with two cotyledons is called dicotyledon embryo. The cotyledons of dicote embryo are thick, fleshy with abudent

reserve food material. embryo with only one cotyledon is described as monocotembryo. The monocotyledon embryo is thin and is called sculatum it does not store food material. in monocoteledon embryo radical is covered by colliorhiza and plumule is covered by coleoptile.

The different post fertilization changes are as following.

① Formation of seed – The ovule is transformed in to seed. The micropyle present in ovule remains as small opening of seed. which is important for to imerge out the plumule and radicle during seed germination.

After fertilization the integuments become dry and form seed coat. The outer integument get develop in to testa and the inner integument is converted in to tegman. The testa and tegman together is called seed coat.

② Formation of fruit :- After fertilization the ovary is converted in to fruit. The ovary becomes hard, rigid etc. as a result of fertilization. The wall of ovary changes in to wall of fruit. known as pericarp. After fertilization the floral parts like sepals, petals, stamen, style, stigma etc becomes

slowely dry and get wither – and lastly fall down.

3) Disorganisation of nucellus :- In most of the seed nucellus is completely absorbed by primary endosperm nucleus to form endosperm. Hence, in mature seed nucellus is absent however in some seeds it remains in the form of thin layer which is called perisperm.

4) Disorganisation of antipodals and synergids :- After fertilization synergids and antipodal cells get disorganised. which surve as nutritive tissue.

5) formation of endosperm :- endosperm develop from the triploid primary endosperm nucleus. treploid endo. nucleus by division and redivision develops in to multicellular endosperm. Endosperm grow faster than embryo. and it surround around the embryo. it is a nutritive tissue and provide food material to developing embryo.

In some plants endosperm is completely utilised for development of embryo so there is absence of endosperm in mature seed. The seeds without endosperm is called non endospermic or exalbuminous seed. exalbuminous seeds are commonly present in dicotyledon plant ex :- Sunflower, Groundn-

In some plant endosperm is partially utilised for development of embryo. so the endosperm is present in the mature seed, even after development of embryo. Thus the seeds with endosperm are called endospermic or Albu-minous seeds. it is the common feature of monocotyledon plants. ex:- Jowar, Bajra.

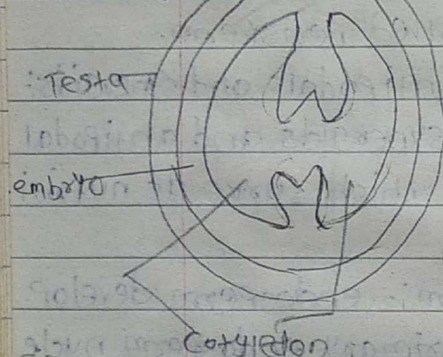


Fig
non endospermic seed
ex:- pea

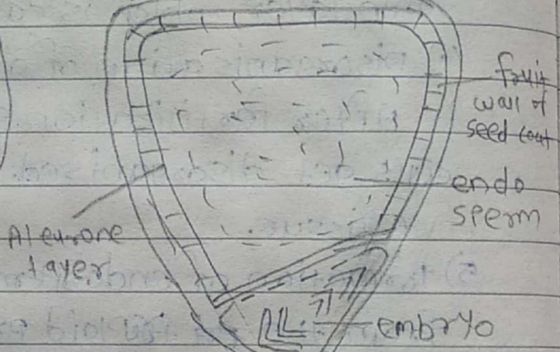


Fig - endospermic seed
ex:- maize

*** Endosperm:-** Endosperm is the most common nut-ritive tissue for developing embryoses in Angiosperms. The endosperm is the product of fertilization and is usually triploid. After double fertilization the egg is called zygote and the fusion product of polars and second male gamet is called Pri-mary endosperm nucleus.(3PEN) The seeds with endosperm are called endospermic seeds.

Common examples of endospermous seeds are cereals, coconut etc. Endosperm form the edible part of cereals and coconut and it is source of commercial caster oil in castor.

*** Development of endosperm:-** The primary endosperm nucleus is normally located directly below egg cell and undergoes division immediately after its formation. During triple fusion only the sperm nucleus fuses with polar nuclei while the male cytoplasm does not take part in this process. The membrane of primary endosperm nucleus is for-med by both the secondary nucleus and male nucleus.

After fertilization several changes occur in the centrale cell which indicate the increased metabolic activity and organization of protein synthesis machenary for differenciation of primary endosperm ~~nuc~~ cell. Depending upon its mode of development there are three types of development of endosperm.

① Nuclear type ② cellular type ③ Helobial type.

① Nuclear endosperm type - About 161 families of angiosperm show nuclear type of development of endosperm. In this type of development of endosperm the division of primary endosperm nucleus (PEN) and a few subsequent nuclear divisions are not acc-ompnied by wall formation. this results in a condition where central cell of embryosac has formed a few to several thousand nuclei freely suspended in its sap. this condition of endosperm

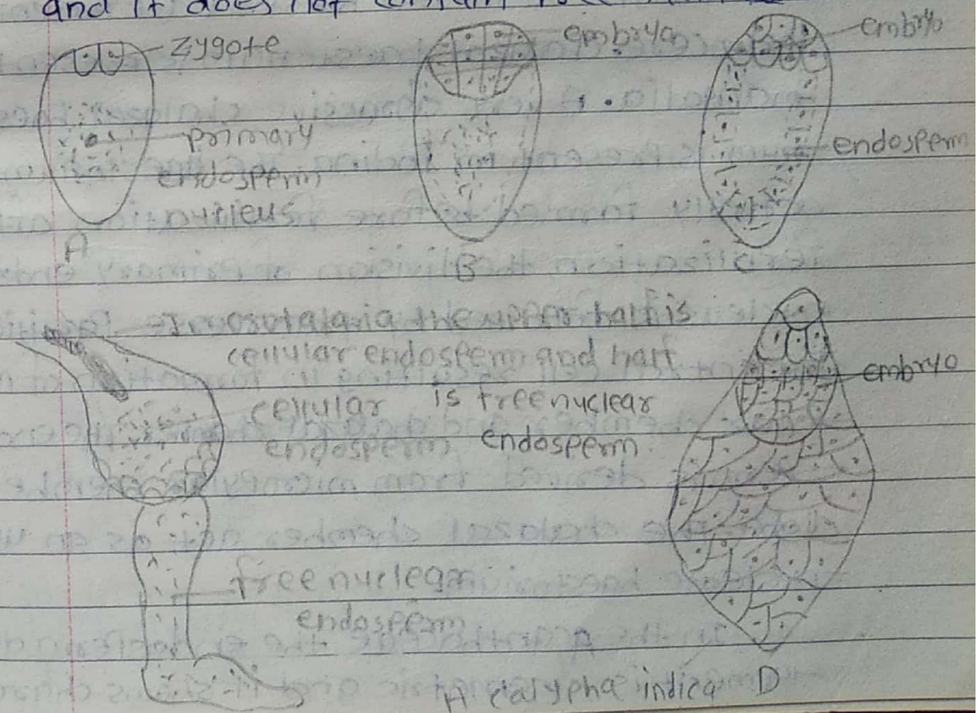
may persist untill it is consumed by the develop-
-ing embryo ~~or~~ it may become cellular at a later stage.

During cellular development the wall formation is mostly centripetal i.e. from peripharal to to-wards center. The degree of cellularization va-ries mostly the endosperm becomes completely cellular but in phasiolose cellularization occurs only around the embryo. In crotolaria the wall formation is present towards upper region of embryo sac while chalazal region remains free nuclei and is often elongates and act like an haestorium.

The endosperm haestorium have been reported in sereral plants of ~~endosperm hastorium~~ cucurbitaceae, Fabaceae. The chalazal endo-sperm haestorium remains free nuclei ~~with~~ throughout in Grevillea. The longest endosperm haestorium is reported in echinocystis lobata of family cucurbitaceae which mesures up to 16 mm in length.

In lomatia besides the main chalazal haesto-rium numerous single celled, finger shaped projections are present all over the endo-sperm which increase absorbing surface of endosperm. Both micropylar and chalazal endo-sperm haestoria have reported in scleria foliosa. a member of cyperaceae.

Development of endosperm in coconut is very specific. The primary endosperm nucleus under-goes a number of free nuclear divisions. when fruit is about 50mm long the embryo sac get filled with a clear fluid in which float numerous nuclei of various sizes. At a later stage the suspe-nsion show the addition of free nuclei and sev-eral cells each inclosing a variable number of nuclei. Gradually these cells ~~and~~ are free nuclei start settling at periphary of cavity and layers of cellular endosperm are formed. In mature coconuts the liquid endosperm becomes milk and it does not contain free nuclei ~~or~~ cells.



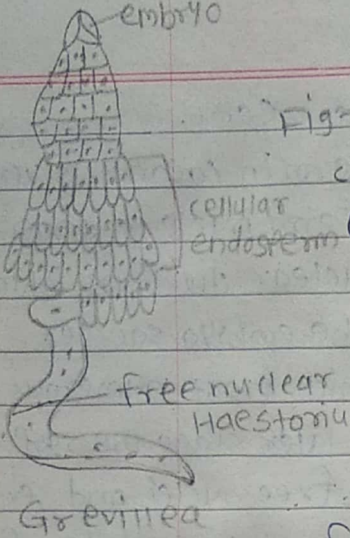
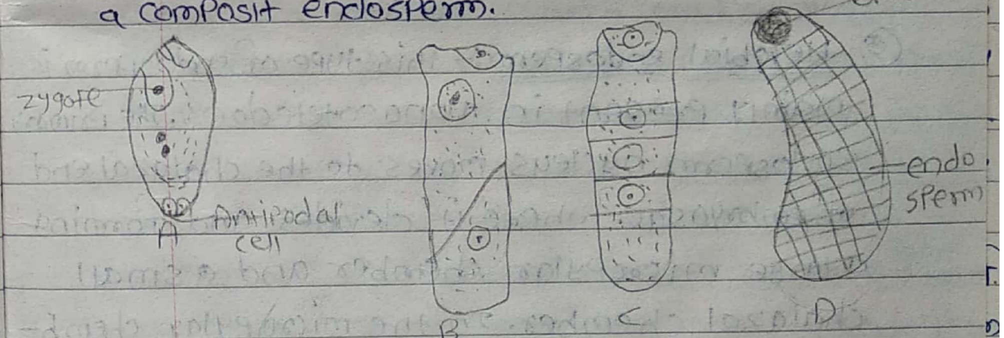


Fig- Free nuclear haestoria at the chalazal end of cellular endosperm

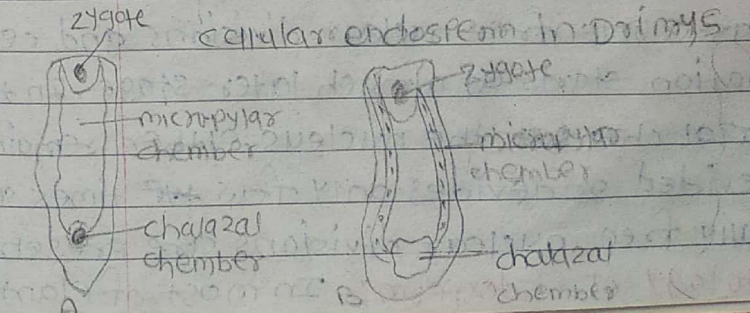
② Cellular endosperm:- The cellular endosperm is characterized by the absence of free nuclear stage. The division of primary endosperm nucleus and a few subsequent nuclear divisions are followed by wall formation.

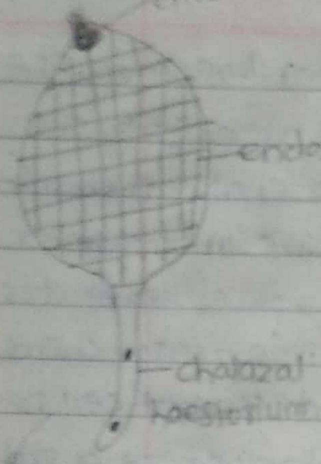
The occurence of haestoria is a common feature of this type of endosperm. The haestoria may be micropylar or chalazal. rearly both types of haestoria are present in the same plant. micropylar haestoria are present in Hydrocere. Chalazal haestorium is present in mangolia. A very aggressive chalazal haestorium is present in Iodina. The haestorium is actually formed before fertilization after fertilization, the division of primary endosperm nucleus is followed by transverse partitioning of central cell resulting in formation of micropylar chember and chalazal chember. The endosperm is derived from micropylar chember alone. The chalazal chember act as an uninucleate haestorium.

In the Acanthaceae the endosperm development is acemetric and it shows characteristic micropylar and chalazal haestoria. The PEN moves to the chalazal end of embryo sac and devides forming a smaller chalazal chember and a larger upper chember. The upper chember again devides and form a linear row of three cells. The chalazal chember and the micropylar chember develop in to haestoria and central cell form the endosperm proper. The development of endosperm in Loranthaceae is unique. There is no true ovule, all the embryo sacs in an ovary lie close to each other. After fertilization the PEN moves the basal part of embryosac where it devides. During their development, the endosperms of all the embryo sacs in an ovary fuse to form a composit endosperm.

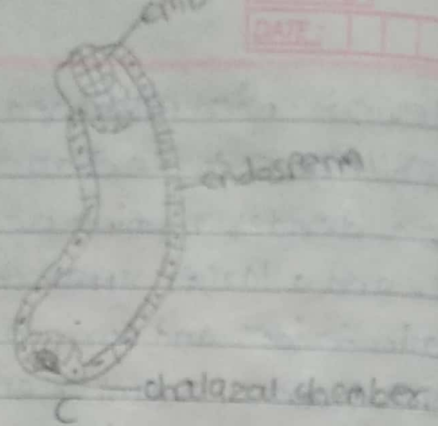


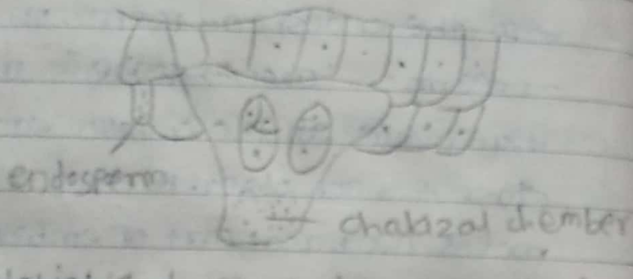
Cellular endosperm in Drimys





cellular endosperm
in magnolia





Halobial endosperm development in Asphodelus.

③ <u>Helobial</u> <u>endosperm</u>:- This type of endosperm is mainly present in monocoteledons. The Primary endosperm nucleus moves to the chalazal end of embryosac. where it devides and forming a large micropylar chember and a small chalazal chember. In the micropylar chemb-er as a role free nuclear divisions and cell formation starts at a much later stage. In the chalazal chember the nucleus either remains undevided or devides only few ~~the~~ times and usually free nuclear divisions are present.

* Cytology of endosperm:- In most of plants the endosperm is triploid (3n) beacuse it is — derived from fusion product of three harloid nuclei i.e one from male gametophyte and two from the female gametophyte. The number of nuclei contributed by the male gametophyte in the formation of the endosperm is const-ant throughout the angiosperms. the num-ber of nuclei contributed by female gametophy-te varies with the type of embryo sac.

ex:- In oenothera it is just one and endosperm is deploid, where as in Pepromia it is eight and endosperm is 9n.

The endosperm tissue is welknown for a high degree of Polyploidization of its cells during deve-lopment. Erbrich in 1965 studied endosperm cytology in many flowering plants. The Ploidy of nucleus of endosperm haestorium in the-sium sp. is up to 384 n the highest Ploidy has been reported in Arum sp. i.e. 24576 n.

Endomitosis and nuclear fusion are some of the methods of Polyploidization of endosperm cells the ocurence of various mitotic irre-gularities such as chromosome bridzes, laten-e chromosome, spontaneous brekage of chromosomes and fragmentation of nuclei is quite common in the endosperm tissue. size of nuclei and the number of nucleoli.

per nucleus also show great variation.

The endosperm is usually non chlorophillous. chlorophillous endosperm is also present in Raphanus.

* Functions of endosperm:- ① In plants with albuminous seeds the endosperm store enough food to ensure an adequate supply for the developing embryo. ② In most of angiosperms the zygote devides only after the endosperm has reached a reasonable stage of development even though the embryo surpasses the growth of endosperm. ③ In the absence of the endosperm (orchidaceae etc) special provision present to ensure the nutrition of developing embryo ④ During its growth embryo depelets the surrounding cells of endosperm of their containts (legumes and cucubits) the embryo consume the endosperm completely before the seed attain maturity. ⑤ The liquid endosperm or endosperm extract from immature fruit does not only support the growth of its own embry but can also nurish the embryos of other angiosperms. Coconut milk collected from green fruits has been successifully employed for growing embryos of many plants ⑥ Immature endosperm is also potent induing divisions in highly differenciated and mature cells.

ex:- The cells of secondary phloem in Carrot.

coconut milk also induces the differenciation of embryos from various plant tissues older endosperm lacks these stimulatery properties and it may even true inhibitory thus it prove that the yonge endosperm is rich in various growth harmones such as auxins, cytokinins and gibberellins whose concentration decreases after certain age of tissue. ⑥ Zatin a very potent cytokinin is extracted from yonge endosperm of maize

⑦ Apart from being a nutritive tissue, endosperm also regulates the mode of embryo development.

* Development of crucifer type of embryo in Dicotyledons :- The first division of zygote is transverse resulting in a basal cell and a terminal cell. The basal cell devides transversly and the terminal cell devides longitudenally resulting in a inverted ⊥ shaped proembryo composed of 4 cells. each of the two terminal cells. now devides by a vertical wall lying at right angle to first so as a result in a quadrant stage the quadrant cells intern become partioned

by a transverse wall so as to form octant of these the lower floor are meant for gives rise to the stem tip and cotyledons and upper floor to the hypocotyle. all the egg cells devide periclinally. The outer derivatives or cells which are newly formed develop in to dermatogen, while inner once undergo further division to give rise to periblem and plurom initials.

mean while two upper cells of the four-celled proembryo devide to form a row of 6 to 10 suspensar cells of which the uppermost cell becomes swllen and vesicular and act as haestoria. The lowest cell functions as hypophysis. Although at first the cells are similar in shape to the other cells of suspensor. it soon become some what rounded at the lower end and devides transversly to form two daughter cells each of which undergo two divisions by walls. which are oriented at right angle to one another of the resulting egg cell. The lower 4 form initials of root cortex and upper 4 give rise to root cap and root epider mis at the same time further divisions

takes place in embryo proper especially at two points in lower tier. which meant to form the cotyledons. At this stage embryo appear more or less chordate in longitudenal section. The hypocotyle as well as cotyledons soon elongates in size. mostly by transverse division of their cells. During further development the ovule become curve like a horse shoe and growing cotyledons also takes shape.

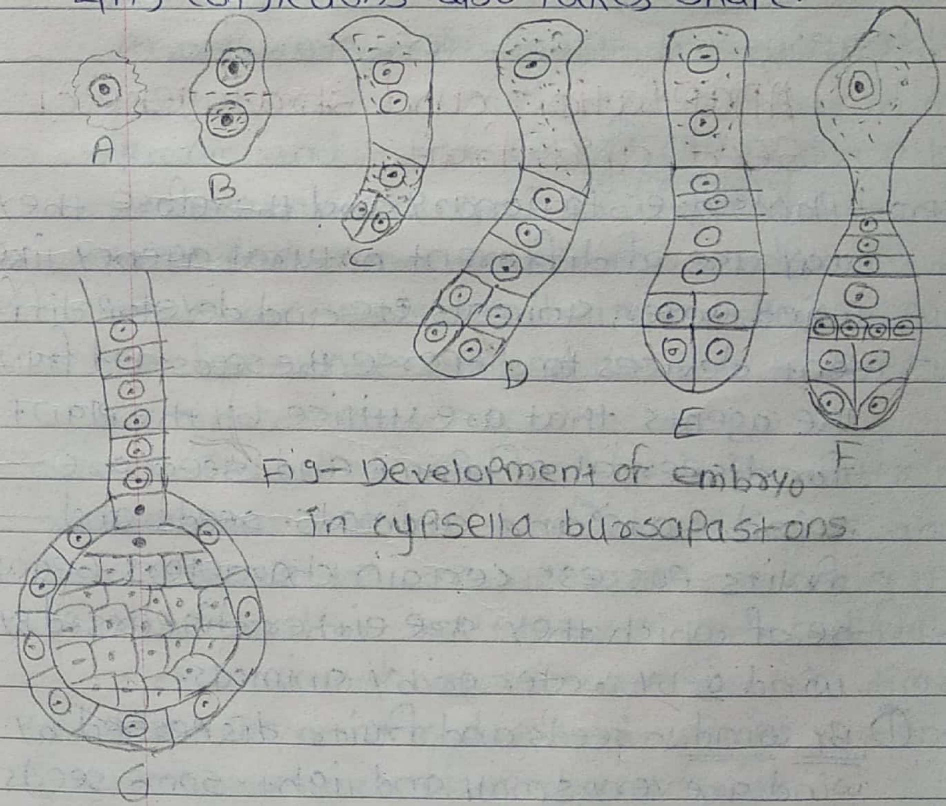


Fig- Development of embryo in cypsella bursapastons