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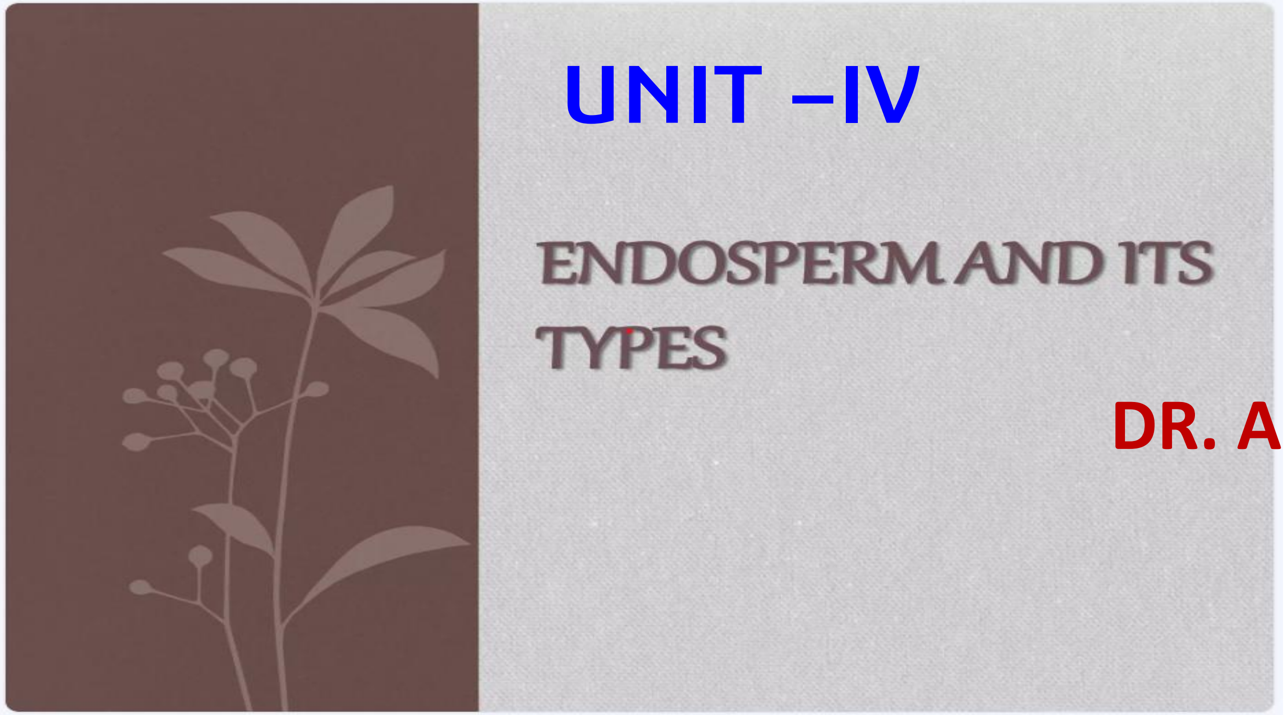
UNIT –IV



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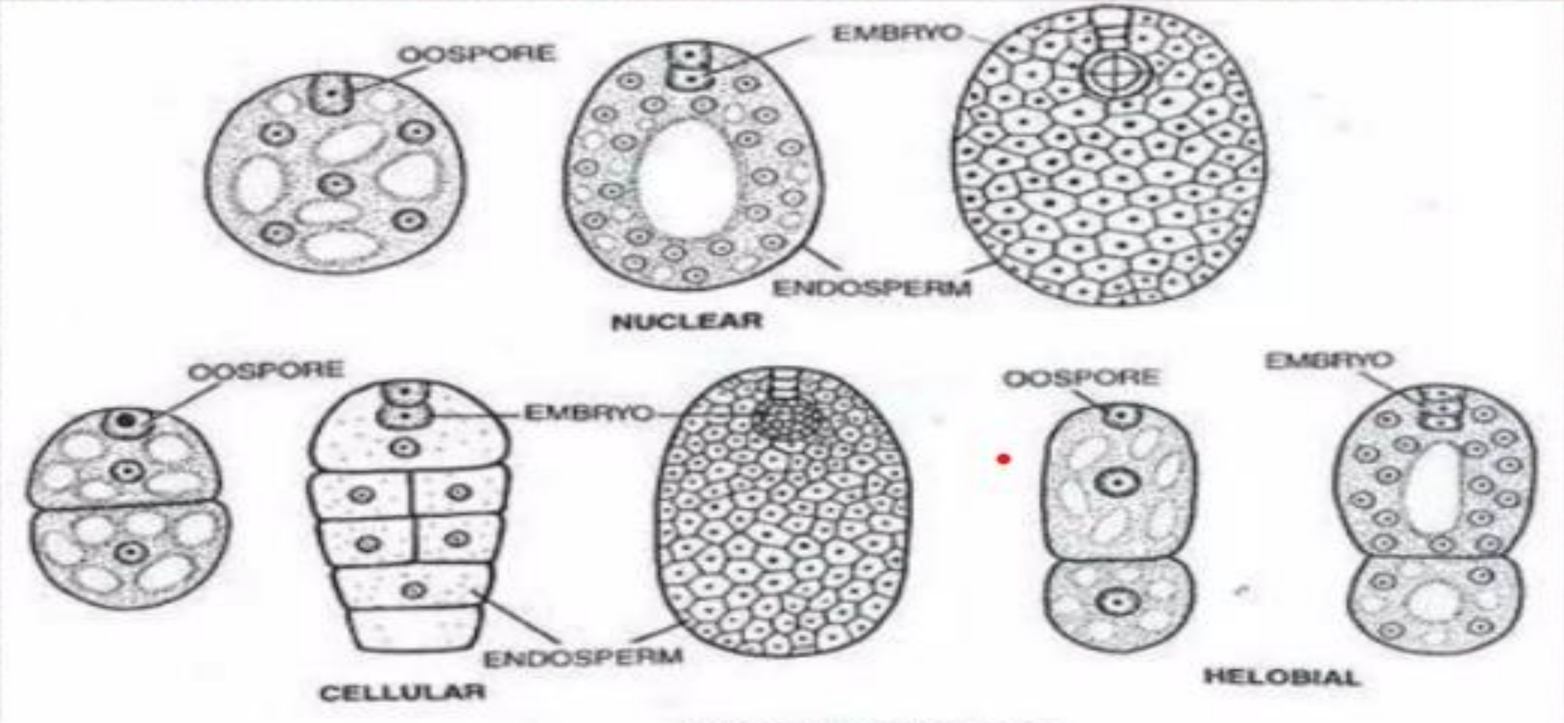
ENDOSPERM

- Endosperm is the most common nutritive tissue for the developing embryo in angiosperms.
- In gymnosperms, it represents the female gametophyte whereas the female gametophyte in angiosperms differentiates before fertilization and is haploid, 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 the second male gamete is termed Primary endosperm nucleus.
- The only angiosperms that do not form endosperm are the members of the families Orchidaceae, Podostemaceae and Trapaceae.

- Depending upon its mode of development , three types of endosperm have been recognized :-

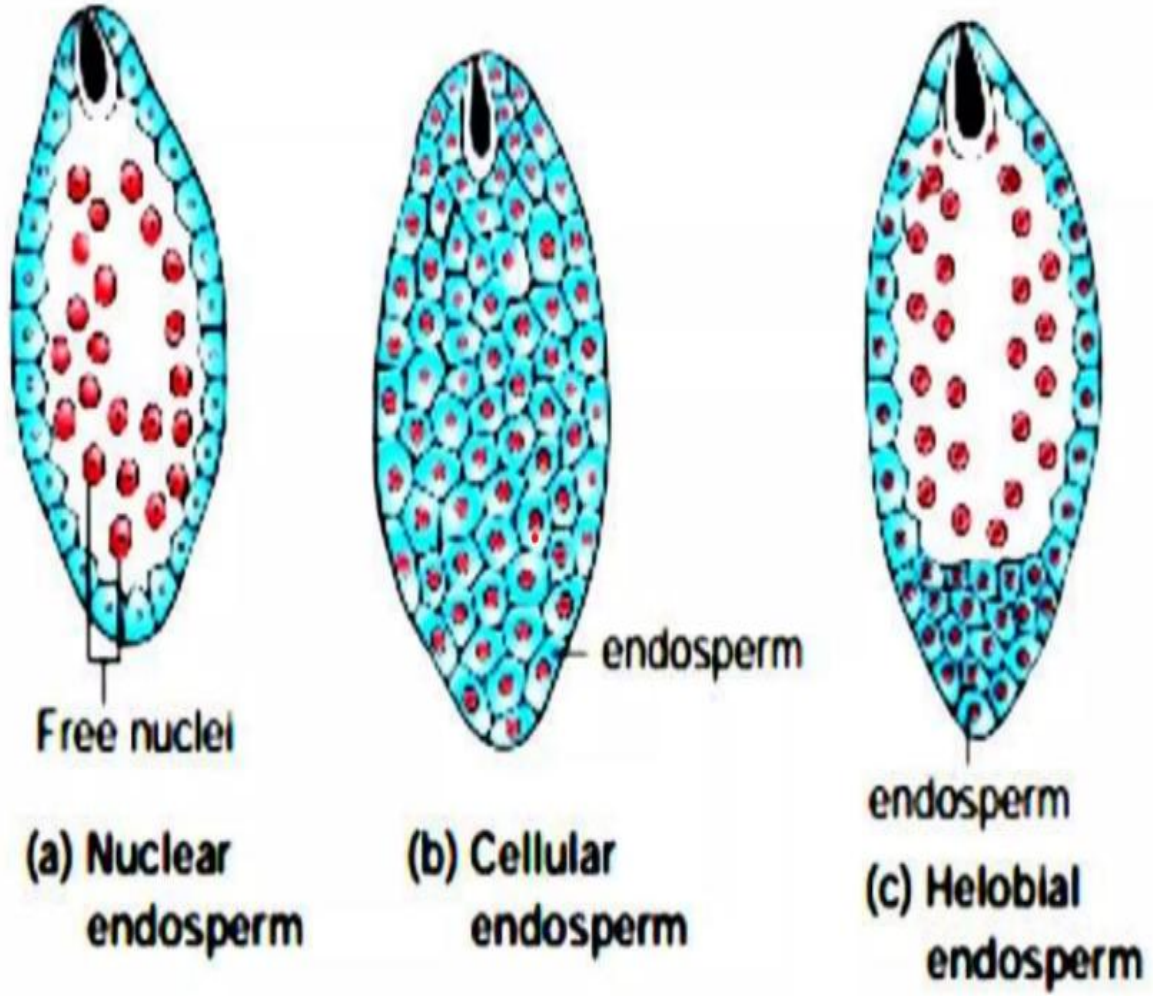
a) Nuclear Endosperm
b) Cellular Endosperm
c) Helobial Endosperm

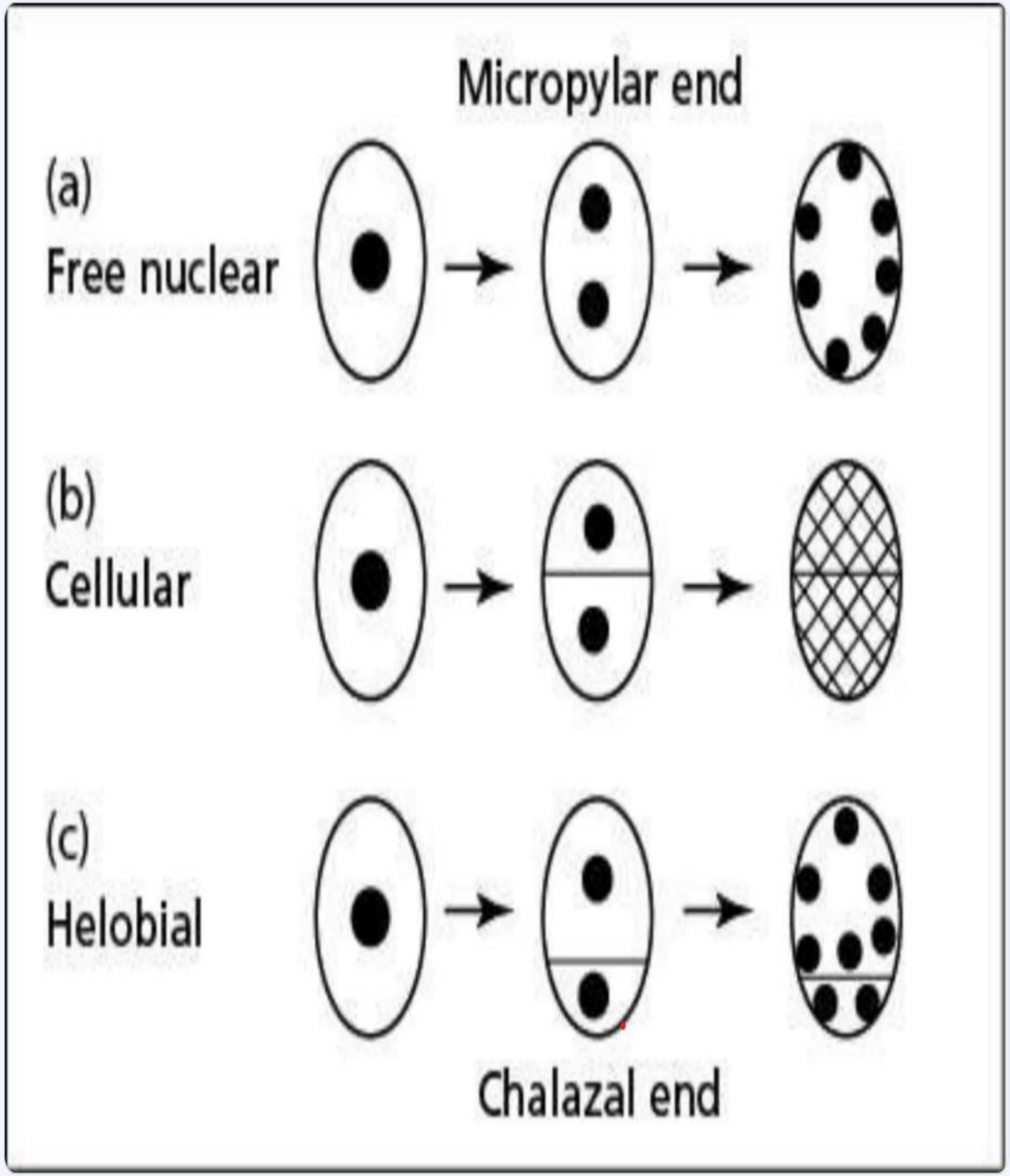
- Cellular endosperm is largely restricted to dicotyledonous families whereas helobial endosperm to monocotyledonous.

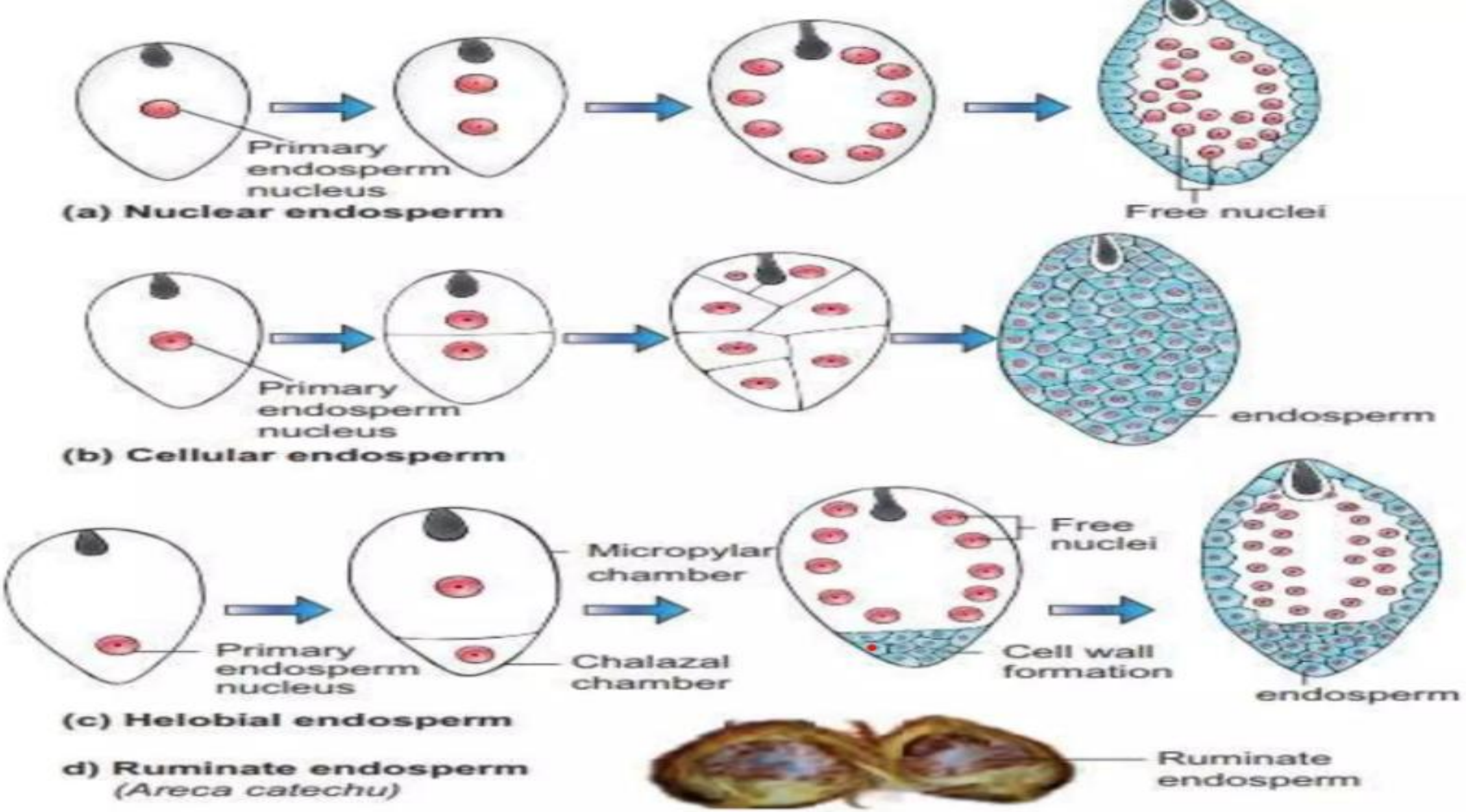


Types of endosperm.

Types of Endosperm







TYPES OF ENDOSPERM

Nuclear Endosperm

- Most common, found in about 56% families.
- No cell wall formation during initial few divisions of the primary endosperm nucleus and nuclei are remain free in the cytoplasm of the embryo sac
- The number of divisions depends on the size of embryo sac, larger size more division.
- The size of endospermic nuclei are not same. Usually the nuclei at the chalazal end are larger and at micropylar end are smaller.
- The wall formation occurs subsequently as in *Glycine max* and *Arachis hypogea* OR nuclei remains free indefinitely as in *Limanthes douglasii*, *Acer pseudoplantanus* and *Myricaria germanica* etc.
- Hundreds of free nuclei are found along the periphery in the embryo sac of *Primula, Malva, Mangifera, Citrus, Arachis*; indicating that wall formation takes place at later stage.
- Wall formation takes place only at 8 or 16 nucleate stage as in *Calotropis, Rafflesia* and *Xeranthenum.*
- The wall formation is usually centripetal. i.e. it begins at the periphery of the embryo sac and cell plates gradually extended inwards.

- In ***Cocus nucifera*** the milky or watery liquid endosperm, which fills the large embryo sac, contains numerous free nuclei. It is known as **liquid syncytium**. Besides free nuclei, syncytium also contains several multinucleate cell. These cells and the free nuclei gradually accumulate along the periphery towards the centre and formed **coconut meat**.

- **Endosperm haustoria**:
- The cellularization of endosperm is restricted to the micropylar end of the embryo sac.
- The nuclei at the chalazal end are free and embedded in a common cytoplasm.
- This chalazal coenocytic part of the embryo sac grows into a tubular haustorium.
- Tubular haustoria is found in families like Cucurbitaceae, Fabaceae and Proteaceae.

Cellular Endosperm

- Found in 25% families, generally in dicots
- No free nuclear phase at any stage.
- Wall formation begins with 1st division of primary endosperm nucleus.
- Cellular endosperm has been further divided based on the orientation of walls following the first two or three divisions-

1. Orientation of wall formed after the 1st nuclear division in vertical i.e. longitudinal to embryo sac. The second wall is also vertical but at right angles to the first. The subsequent wall formation is restricted to the micropylar end only. Example – *Adoxa, Cetranthus*
2. Orientation of the 1st wall is transverse and one or both cells then divided vertically. Example – *Scutellaria, Verbascum*
3. First 2-3 division are transverse. Example- *Ericaceae and Annonaceae*.
4. Orientation of the 1st wall is oblique, and the two cells thus formed may be of equal or unequal size. Example – *Myosytis arvensis*
5. Orientation of the first wall is indefinite. Example – *Senecia, Gunnera*

Endosperm Haustoria

- Characteristic feature of cellular endosperm.
- One or more cells becomes specialized to function as haustoria
- The haustoria are formed at micropylar or chalazal or at both the ends and penetrate the nucellar tissue to absorb nutrition.
- Some secondary haustoria are also formed in addition to micropylar and chalazal haustoria. Example- *Alectra*
- Multinucleated chalazal endosperm haustorium occurs in *Magnolia obovata*

Helobial Endosperm

- Found in the members of the order Helobiales and confined only on some monocot families..
- Intermediate between the nuclear and the cellular types.
- After triple fusion, the primary endosperm nucleus migrates to the chalazal end.
- The wall formation after 1st division of the endosperm nucleus results into large micropylar and a small chalazal endosperm chamber.
- The nuclear divisions takes place in the micropylar chamber, while the nucleus of the chalazal chamber remains undivided or may undergoes few divisions.
- In micropylar chamber regular wall formation takes place and it becomes multicellular but there is no wall formation in chalazal chamber.

Endosperm haustoria

- Haustoria develops from the micropylar tissue. They are tubular, unicellular and having extensive outgrowths which penetrate the nucellus at the chalazal end.

Mosaic Endosperm

- Endospermic tissue lack uniformity.
- For example endosperm of *Zea mays* shows two distinct colour regions which form a mosaic pattern, part of endospermic tissue is yellow and other are white.
- This may be due to failure of triple fusion, male gamete does not fuse with polar nuclei. The male gamete and polar nuclei divide independently providing nuclei of two distinct characters interspread during the free nuclear stage.
- At maturity when the endosperm has become cellular, it gives a mosaic or variegated appearance.

Ruminate Endosperm

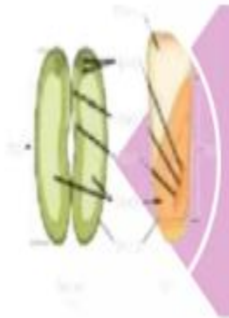
- The endosperm with uneven or irregularities on its surface is known as ruminate endosperm.
- Ruminate endosperm is found in Annonaceae, Myristicaceae, Araliaceae and Arecaceae family.
- The ruminate character reflects the activity of endosperm as well as seed coat.

Functions of Endosperms

- An important nutrient medium for the successful development of the embryo.
- Rich in fat, carbohydrates and proteins which are used in the establishment of the seedling during seed germination.
- At the time of fertilization little nutrition available in the embryo sac. But with the formation of endosperm enough food becomes available for the developing embryo.
- The division of zygote usually begins after the endosperm is sufficiently grown. Even if the zygote and primary endosperm nucleus divide simultaneously, the endosperm grows more rapidly.
- Juice of immature endosperm of a plant is used as nutrition for the developing embryo of the other plant. For example coconut milk is used as nutrient medium in in vitro embryo culture.

EMBRYO DEVEOLPMENT IN MONOCOT AND DICOT

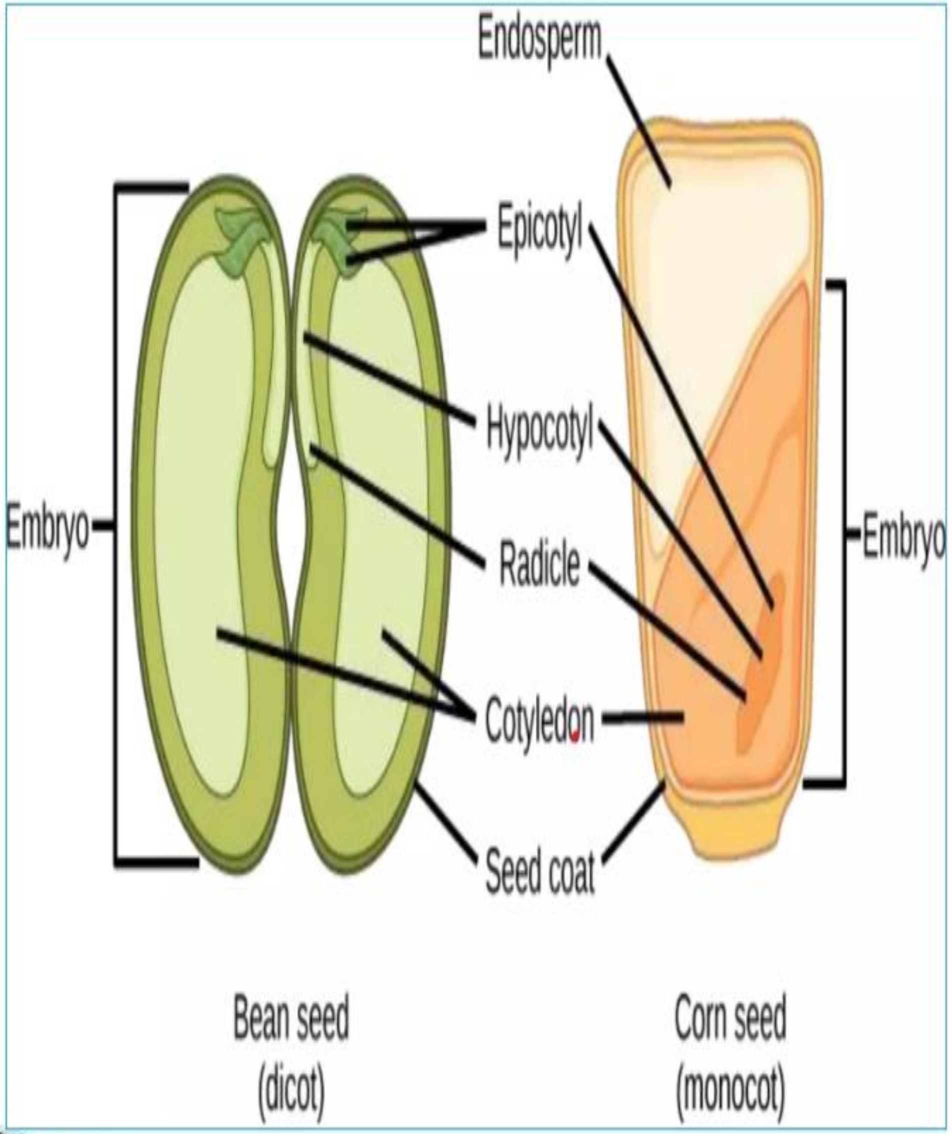
Zygote



Embryo

Plant

MONOCOT AND DICOT EMBRYO

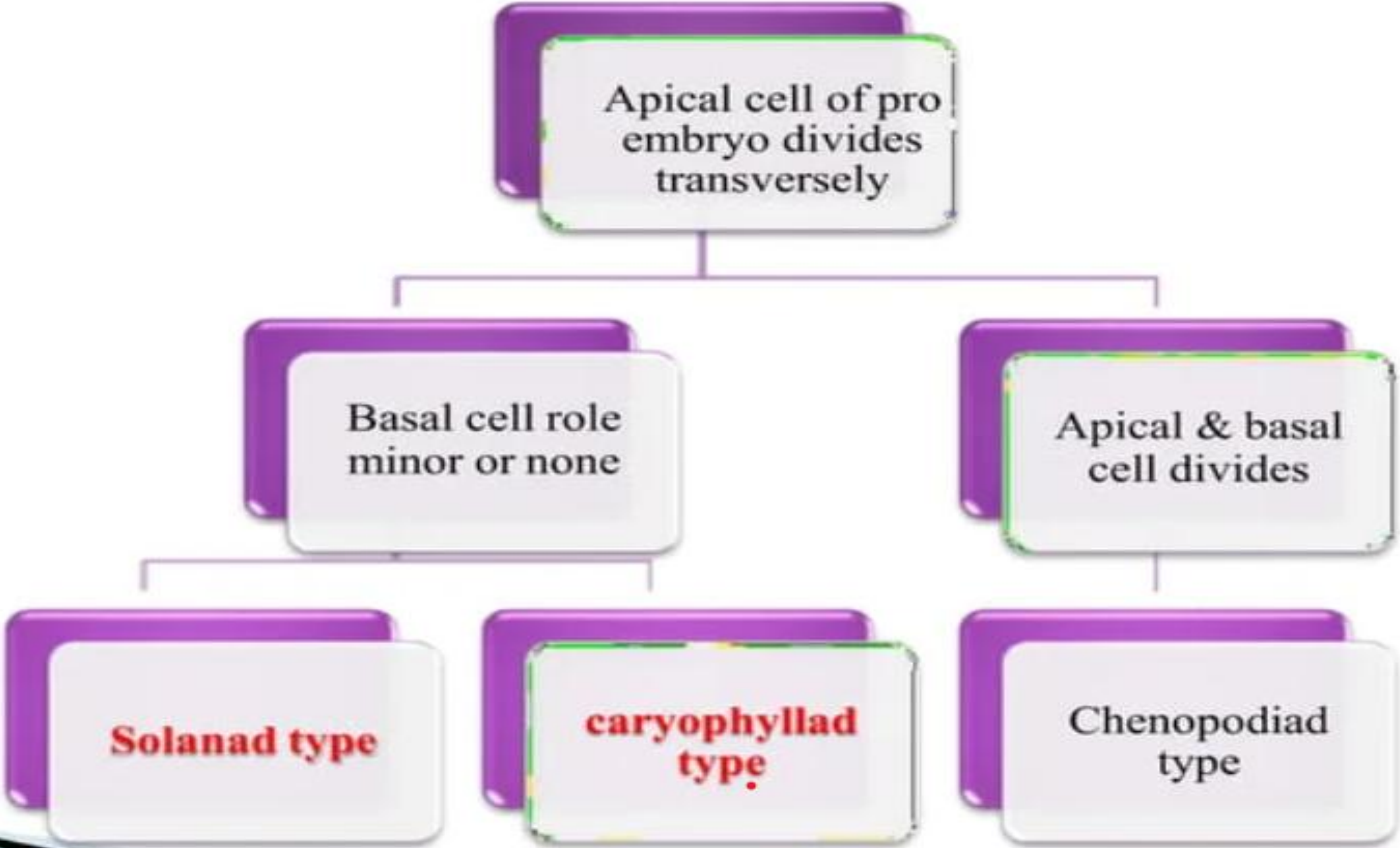


- Region of embryonal axis above cotyledons – epicotyl
- Epicotyl terminates in plumule (embryonic shoot), covered by coleorhiza
- Region below of embryonal axis below cotyledons hypocotyl
- Hypocotyl terminates in radicle (embryonal root), covered by coleoptile
- Monocot cotyledon is called scutellum

CHANGES HAPPENS ON ZYGOTE

Increased accumulation of cytoplasm , dictyosomes , ribosomes on the chalazal end where 1st division will takes place

Proembryo – from the 2 celled stage to untill the initiation of organs


Apical cell of pro embryo divides transversely
Basal cell role minor or none
Apical & basal cell divides
Solanad type
caryophyllad type
Chenopodiad type

- <u>Basal cell minor role</u>
- – basal become suspensor- solanad type

Solanaceae ,linaceae, theaceae

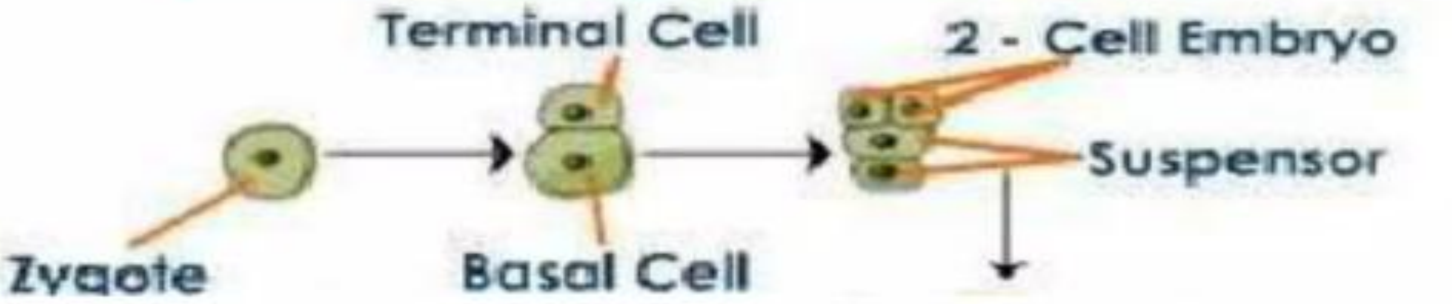
- Basal cell not contribute division & if suspensor present, is always derived fromapical cell caryophyllad type e.g. crassulaceae, caryophyllaceae
- Chenopodiad type – apical cell & basal cell contribute in embryo formation – chenopodiaceae

Johansen said 6th type – piperad type – loranthaceae , piperaceae , first division of zygote is vertical

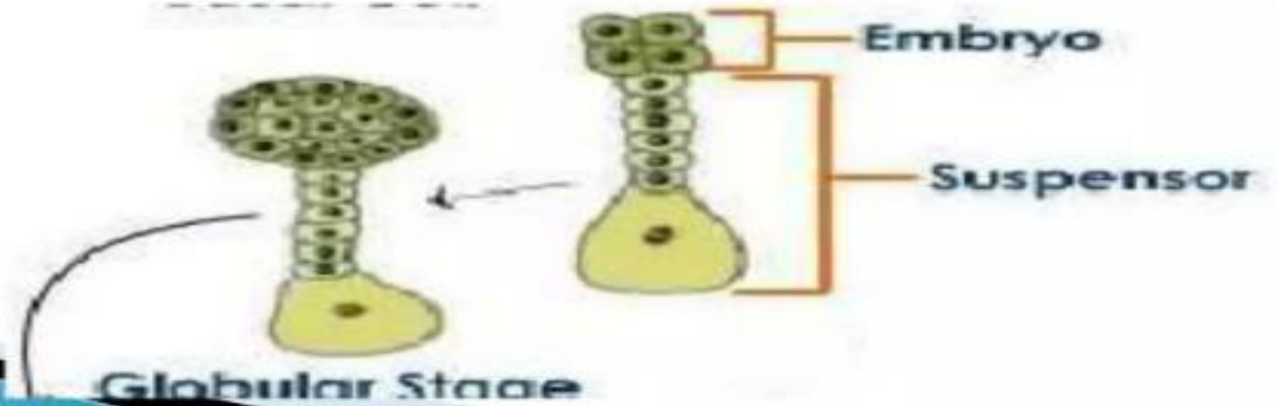
In dicots

_ONAGRAD TYPE – capsellabursa pastoris brassicaceae / cruciferaceae

Hanstein in 1870



4 celled quadrant stage



- 4 celled quadrant stage
- Terminal cells undergo vertical divisions & produce 4 cells → 8 cells in 2 tiers (transverse division)
- In octant

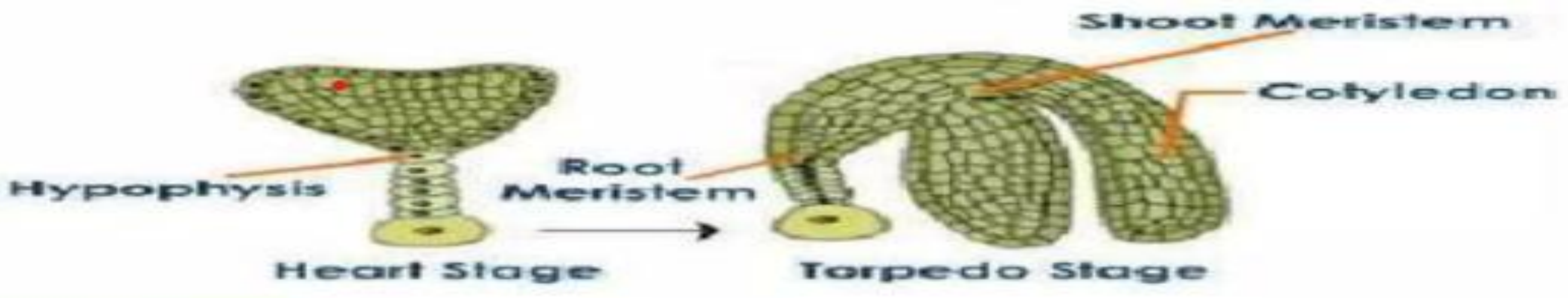
outer cell –periclinically divide dermatogen produced

inner cells divide vertically & transversally periblem & pleurome produced

anticlinically divide

Dermatogen → epidermis

- Periblem → cortex
- Pleurome → stele



Stages of Plant Embryo Development (Dicot)

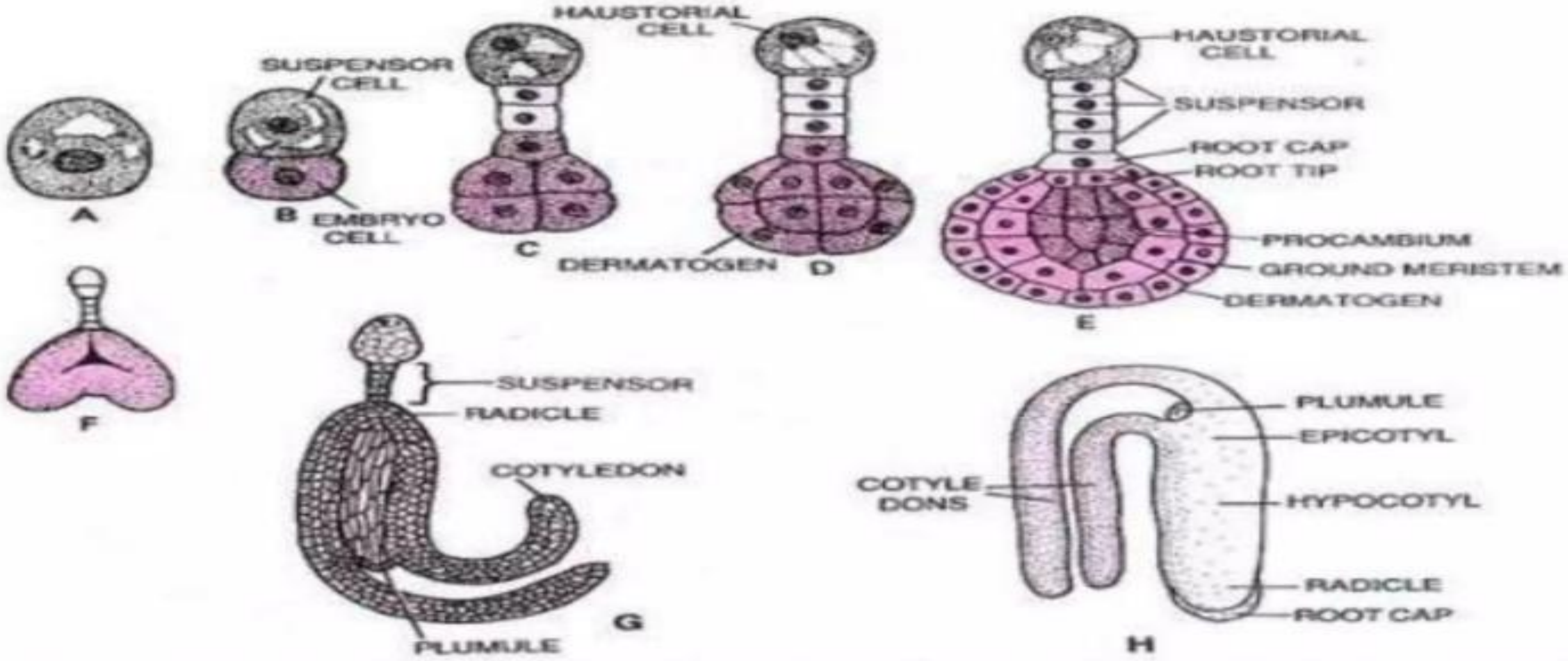
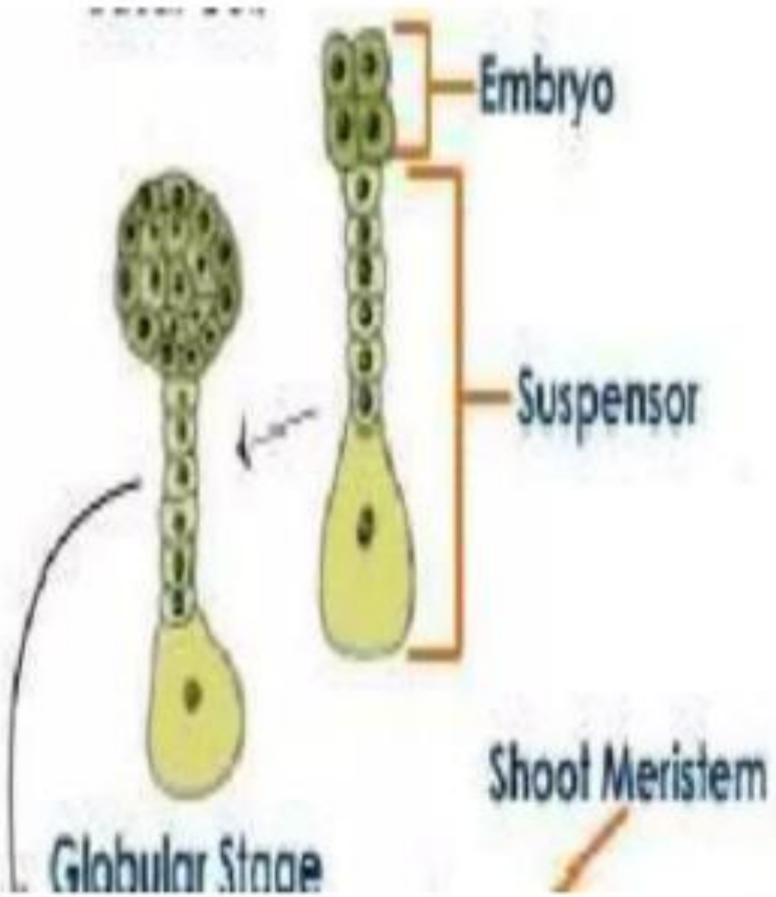


Fig. 2.30. Stages in the development of a dicot embryo. A, Zygote or oospore. B, Division of zygote into suspensor and embryo cells. C, Formation of suspensor and embryo octant. D, Periclinal divisions of embryo octants to form outer dermatogen. E, Globular embryo showing regions of radicle, procambium, ground meristem and dermatogen. F, Heart-shaped embryo. G, Mature dicotyledonous embryo. H, a typical dicot embryo.

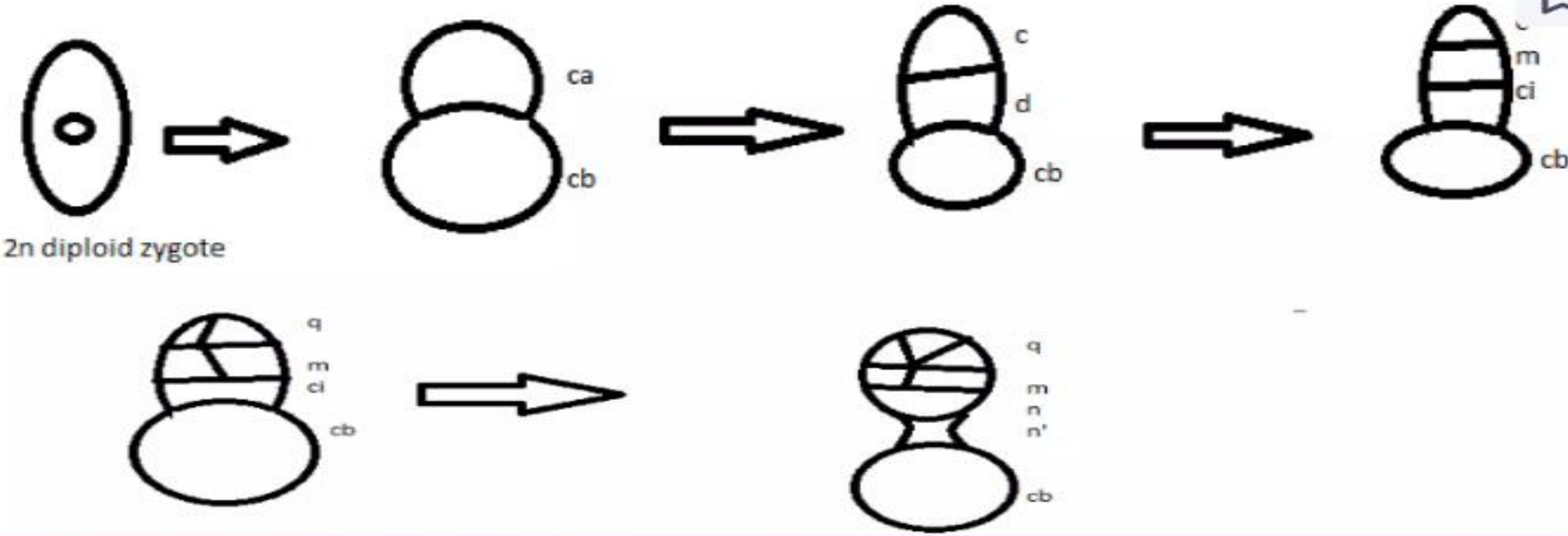
Suspensor

- Filament tube structure
- The basal cells divides transversly & produce 6- 10 cells
- The terminal cells of suspensor enlarges and form haustoria(help to get the nutrition for the developing embryo)
- The lower most cell in the suspensor called hypophysis
- The hypophysis undergo 2 vertical divisions & produce 8 cells in 2 tiers
- Then the upper tier produces root cap & root epidermis , the lower tier produces [illegible] cortex



Embryogeny in Najas (monocot)

- Najas is aquatic plant
- Illustrated by swami & lakshman in 1962
- Complete embryo from apical cell
- Basal cell to haustoria
- Apical cell divides transversally to form c and d
- D divides transversally form m and ci- linear proembryo form

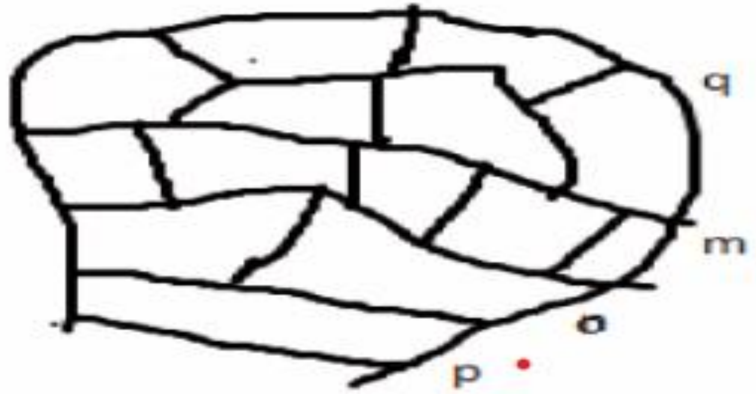


- 2 vertical divisions in the sense c and m lead to the formation of two tiers of 4 cells each q & m
- In the mean time ci divides transversly to give rise to n and n'

- Cell n divides vertically and n' undergoes transverse division giving rise to o and p

- The cell p under goes transverse division producing h and s

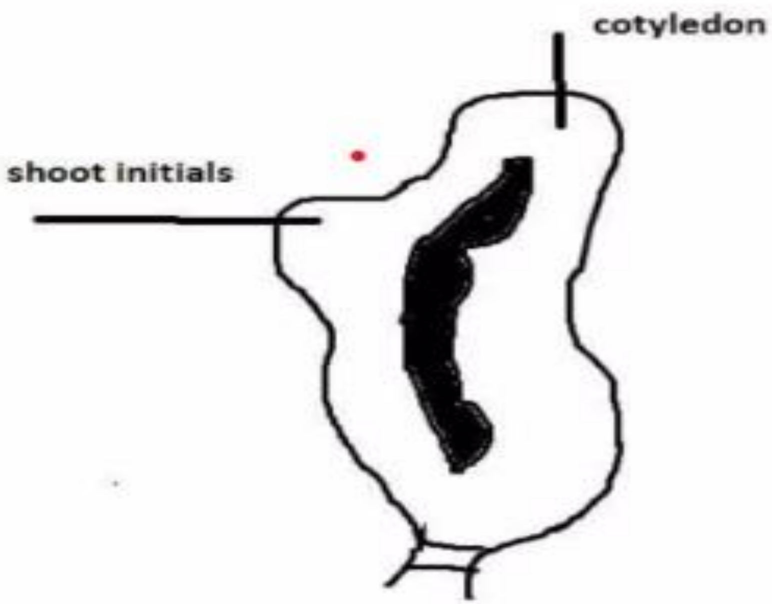
- Quadrant q divides periclinically cut down 4 celled dermatogen and 4 axial cells



The rapidly growing portion of the tier q forms the single cotyledons

- And the slow growing tissue derived from 4 th axial cells give rise to initials of epicotyl

- The radicle is organised from the derivatives of n



- The cells in the tier m divides by vertical & transverse division and become 2 tiered , at this stage proembryo is slightly spherical

- Transverse division of m and n tiers - makes proembryo elongated & become oval

- Central core of cells of q,m, &n become pleurome initials
- 3 of axial cells divide fastly than 4th one

- So symmetry changes and the embryo become notched

Stages of Plant Embryo Development (Monocot)

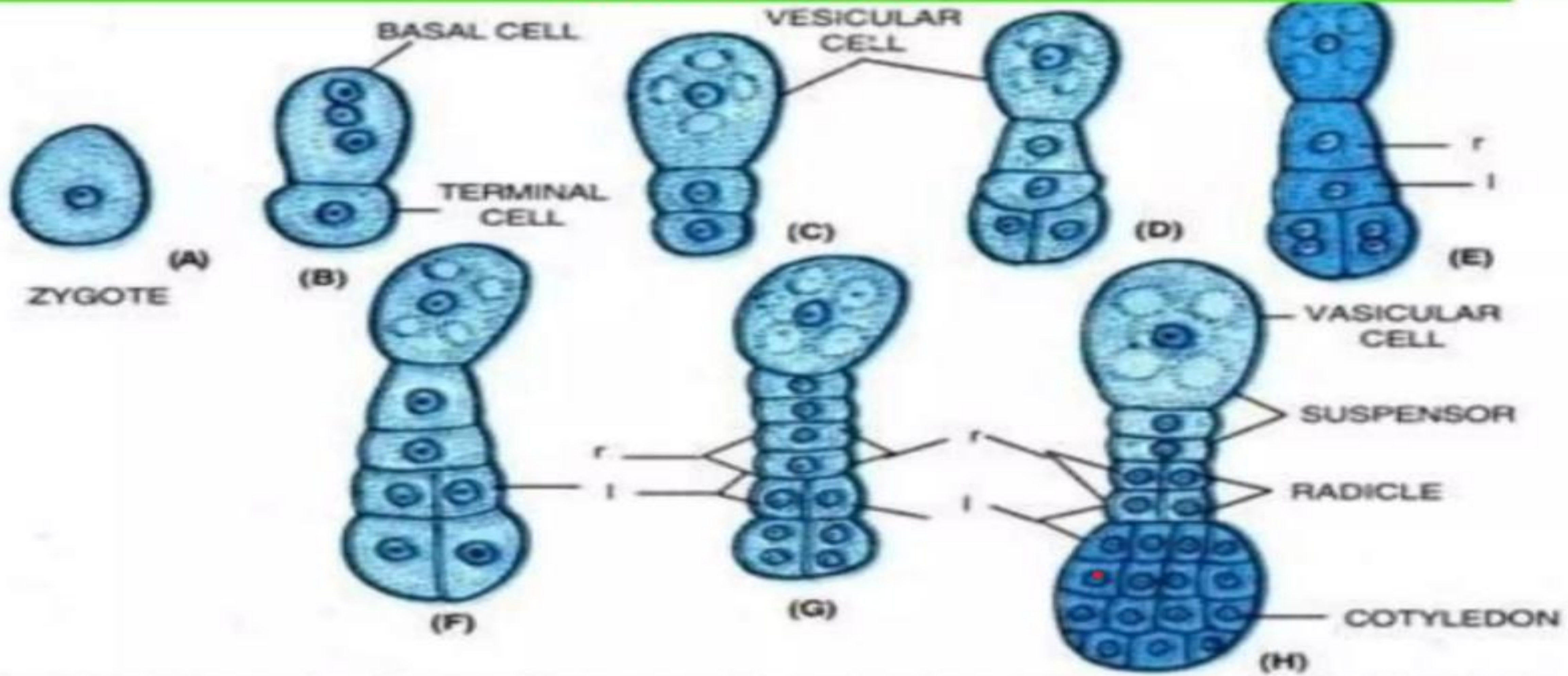


Fig. 2.33. Stages in the development of a typical monocot embryo in *Sagittaria*.

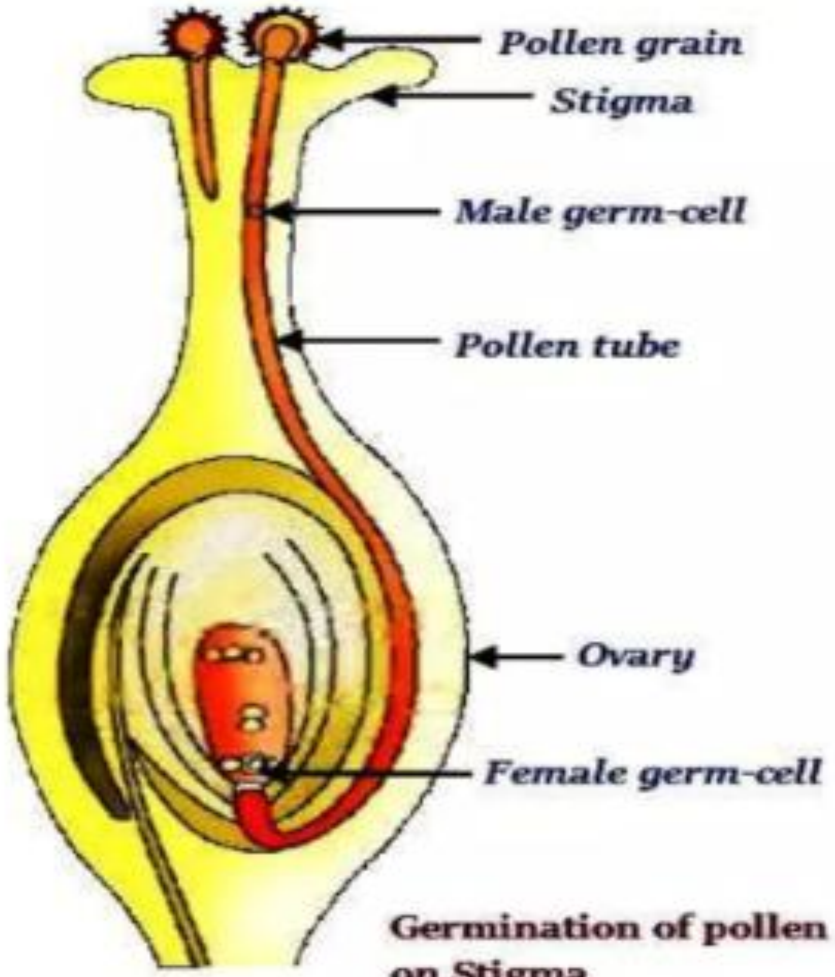
DOUBLE FERTILIZATION IN ANGIOSPERMS

- **Double fertilisation is a unique and the universal phenomenon in the life cycle of angiosperms.**
- **It involves two separate nuclear fusion events and is therefore called double fertilisation.**
- **First is the fusion between the female gamete or egg (found in the ovule) and one of the male gametes (found in the male gametophyte or pollen grain) to form a diploid zygote (Syngamy).**
- **The second fusion is between the other male gamete and the secondary nucleus, leading to the formation of a Primary Endosperm Nucleus (PEN) (Triple Fusion).**

- The zygote develops into the embryo and the PEN forms the endosperm

- This phenomenon was first reported by SG Nawaschin (1898) and Giugnard (1899) independently in *Lilium mortagon* and *Fritillaria tenella* of the family Liliaceae. However, the term Double Fertilization was coined by Thomas (1900).

- Rudimentary Fertilization was also reported in *Ephedra* and *Gnetum* (Gymnosperms)



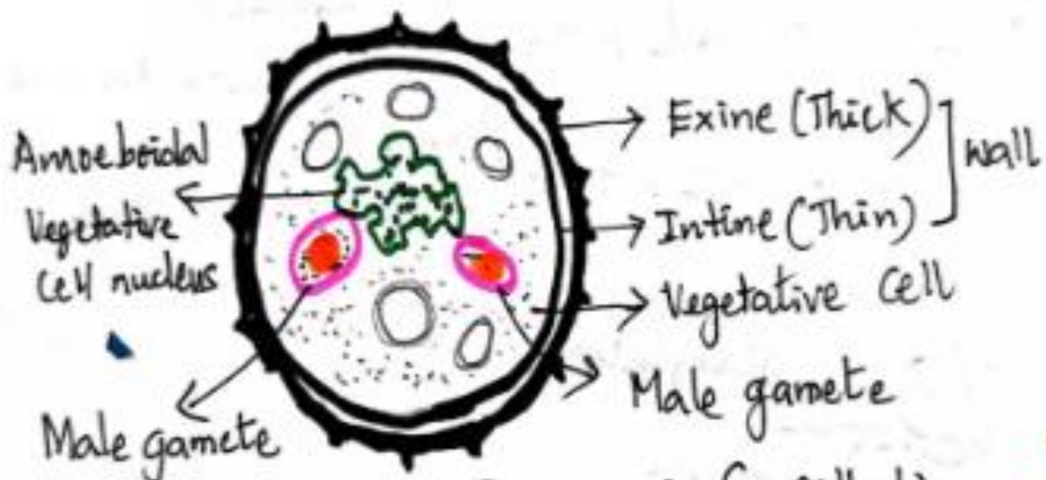
Germination of pollen on Stigma

Background:

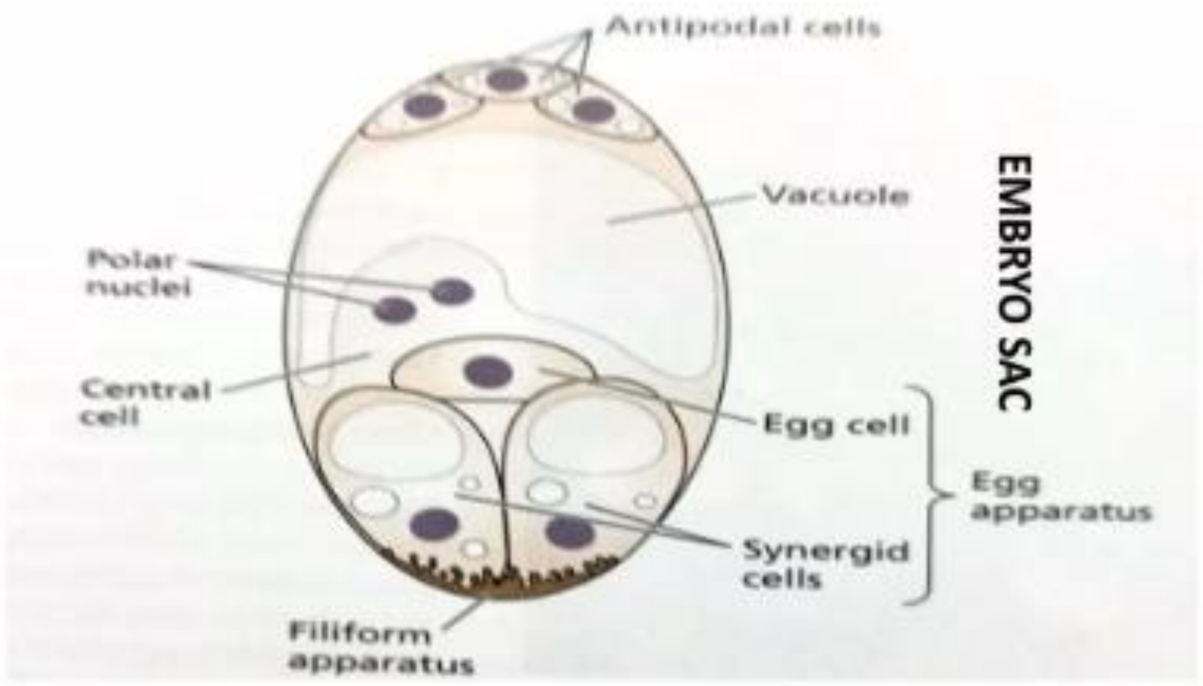
- The transfer of the pollen onto the stigma of the pistil is a prerequisite for the fertilization. This is known as Pollination, which is of two types namely Self-pollination and Cross pollination.
- Double fertilization is a complex process requiring coordinated action of the component cells of the female gametophyte in concert with the male gametes.
- Recently, the plant embryologists extensively studied these series events. With regard to this, there are two concepts are in prelude viz., the Male Germ Unit (MGU) and the Female Germ Unit (FGU) proposed by Dumas et al. (1984)

- **Pollen** : is the microscopic, 3-celled haploid male gametophyte. It mainly possess, the vegetative cell with two similar (homomorphic) or the different (dimorphic) male gametes. These are released by the anther and being received by the compatible pistil.

- **Embryosac:** is the 7-celled, 8 nucleate supercell or the female gametophyte is deeply seated in the ovule of the pistil or gonoecium.



A Functional Pollengrain (3-celled)



The process of fertilisation may be divided into the following steps:

- Pollen-Pistil Interactions & Germination of Pollen
- Entry of pollen into stigma
- Entry of pollen into style
- Entry of pollen into ovule
- Entry of pollen into embryo sac, and
- Double Fertilisation

Pollen-Pistl Interactions:

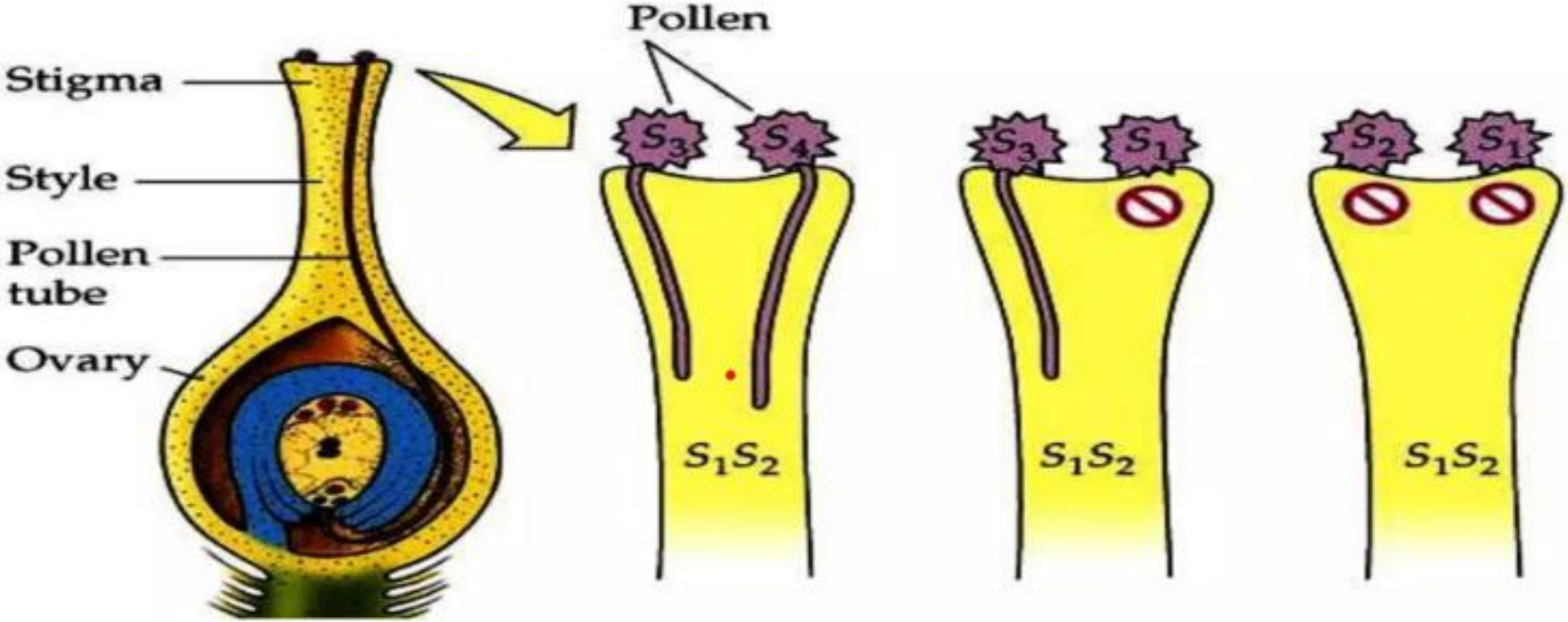


Figure 31 Compatible and Non-compatible reactions

Pollen grains are deposited on the stigmatic surface due to pollination. Such pollen grains interact with the sporophytic tissues of the pistil (stigma & Style) during fertilization. Important events during such interactions are

- **Pollen adhesion:** The liquid exudates produced by the stigma and the Papillae present on the stigmatic surface helps in attachment of the pollen grains to stigma.
- **Pollen hydration:** Stigma also provides the moisture required for the germination of pollen grains. Hydration is faster in wet stigmas and slower in dry stigmas, .
- **Pollen recognition:** Before allowing germination of pollens, the stigma recognizes whether the pollen is compatible (belongs to same species) or incompatible (belong to a different species). Only compatible pollen is allowed to germinate and incompatible pollen are not allowed to germinate or they are rejected. The proteins and other chemical factors produce by both pollen and stigma helps in this process.

- **Pollen Germination:** if the compatible pollen starts germinating by absorbing the nutrition and water produced by the stigma and develops the pollen tube.
- The pollen tube growth exhibits tip growth.
- The pollen also produces enzymes, which dissolves the outer pellicle and cuticle layers of stigmatic papillae through which pollen tube enters the stigma.
- Whereas, if the pollen is not compatible, it did not allow germination, and its further entry is blocked,.

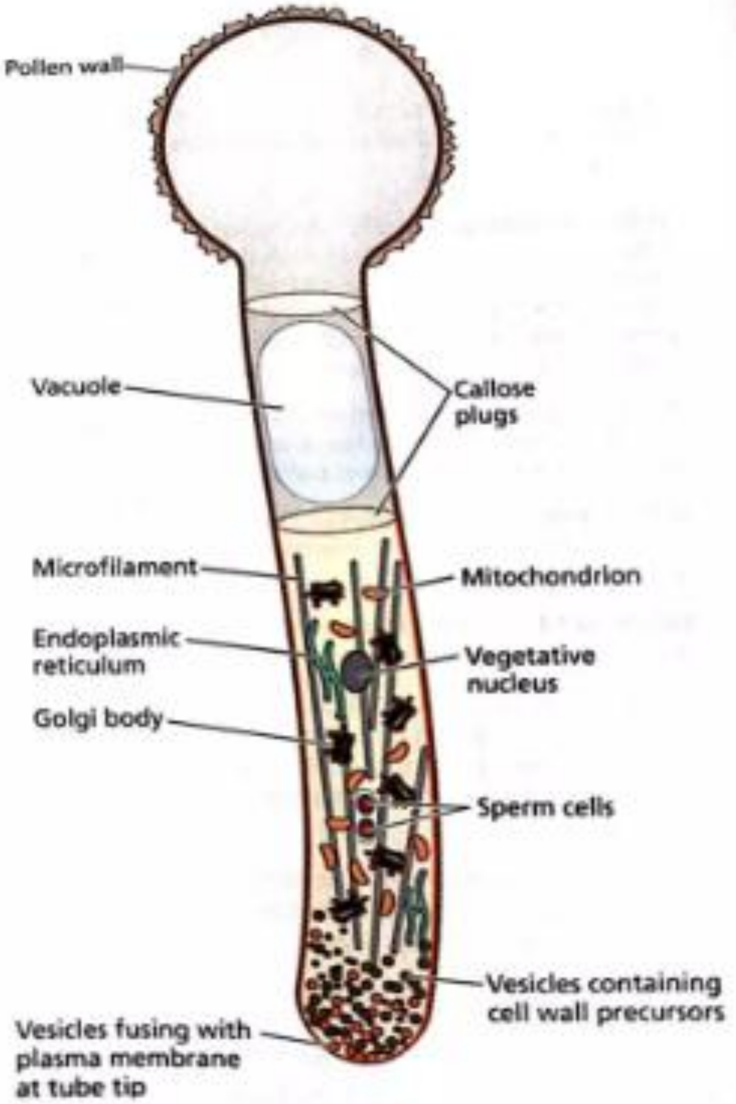
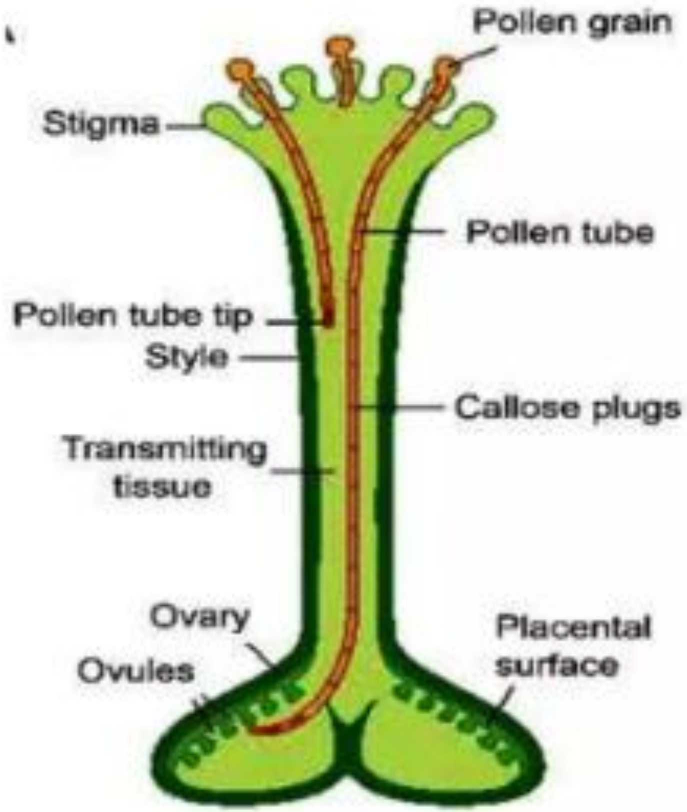


Figure 2 showing the ultrastructure of pollen tune

❖ Pollen tube entry into the stigma:

It depends on the nature of stigma.

- In wet stigmas, the cuticle of the papillae is already digested by the exudates. The pollen tube enters directly the stigma through the intercellular spaces of the stigmatic tissue. In dry stigmas, pollen tube releases cutinase enzyme, digests the cutin layer of papillae, enters the pecto-cellulosic layer and grows through it. After reaching the base of the papillae, it enters into the stigma through the intercellular spaces of the cells.



❖ Pollen tube entry and growth in the style:

It is also dependent on the nature of the styles.

- In solid type of styles, (more common in dicots) the pollen tube grows through the intercellular spaces of the central transmitting tissue, which is filled with matrix.
- In hollow type of styles (more common in monocots), the tube grows down on the surface of layer of canal cells which line the central canal.
- In semi-solid of styles occurs only a few plants (Cactaceae) where the hallow stles with the presence of transmitting tissue is confined to one side only.

Pollen tube entry into ovule: it is of three types

- **POROGAMY:** pollen tube enters to the ovule through the micropylar opening. it is common type (Brassica))
- **CHALAZOGAMY:** pollen tube enters to the integuments of ovule through the chalazal end (Casuarina)
- **MESOGAMY:** pollen tube enters to the ovule by piercing the integuments in the middle of the ovule between the chalaza and micropyle (Cucurbita) or through the funiculus(Pistacia).

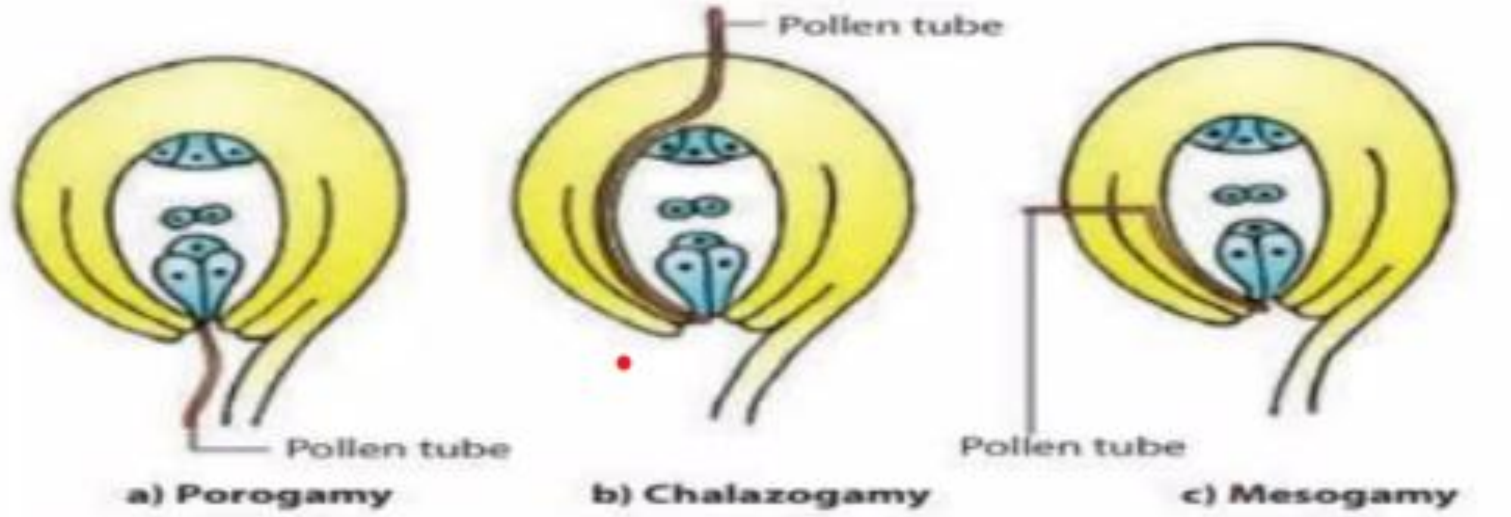


Figure 1.18 Path of pollen tube entry into the ovule

❖ Pollen tube entry to embryo sac :

- Pollen tube enters to the embryo sac always only through the micropylar pore. It enters into one of the synergids through its filiform apparatus (A finger like structure at the base of the synergids).The synergid to which pollen has entered starts degenerating. The contents of the pollen tube (2 Male gametes) and the nucleus and a little amount of cytoplasm of the vegetative cell) is released to the cytoplasm of this synergid through a pore .This is called **Pollen discharge.**

❖ Double Fertilisation:

The nuclear fusions or actual fertilization occurs after pollen discharge,

One of the released male gamete (N) moves into the egg cell and its nucleus fuses with the egg nucleus (N). This is called **Syngamy** and it results in formation of a diploid nucleus called Zygote (2N). The zygote then develops into the embryo. The second male gamete (N) moves to the central cell of the embryo sac. Its nucleus fuses with the secondary nucleus (N+N) (formed by the fusion of two polar nuclei), forming a triploid nucleus called primary endosperm nucleus (PEN). This is called **Triple Fusion**. The PEN develops into the endosperm. Recent studies has revealed that the movement of the

Recent studies has revealed that the movement of the male gametes towards the egg cell and the polar nuclei is being mediated by the involvement of the formation of the two Actin coronas due to the aggregation of the Actin protein rich microfilaments. These coronas will be appeared before the entry of pollen tube into the ovule and disappear soon after fertilisation

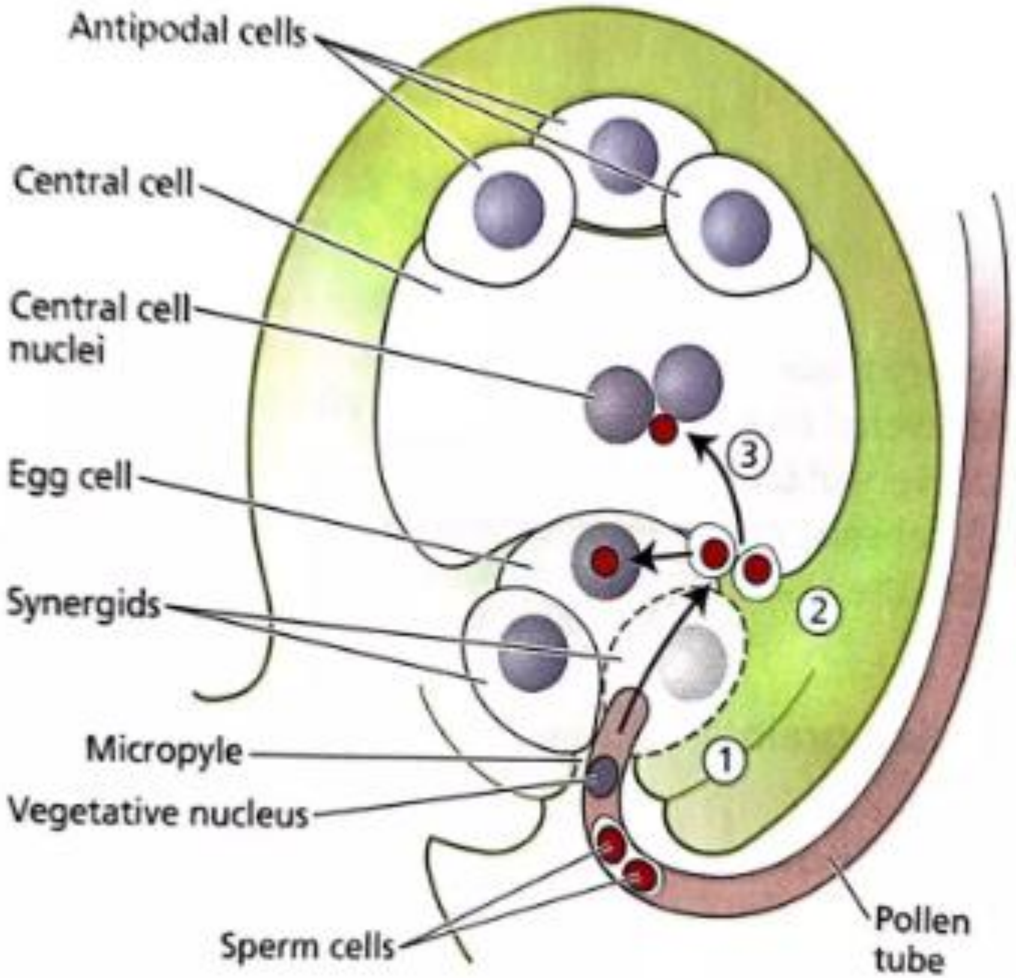
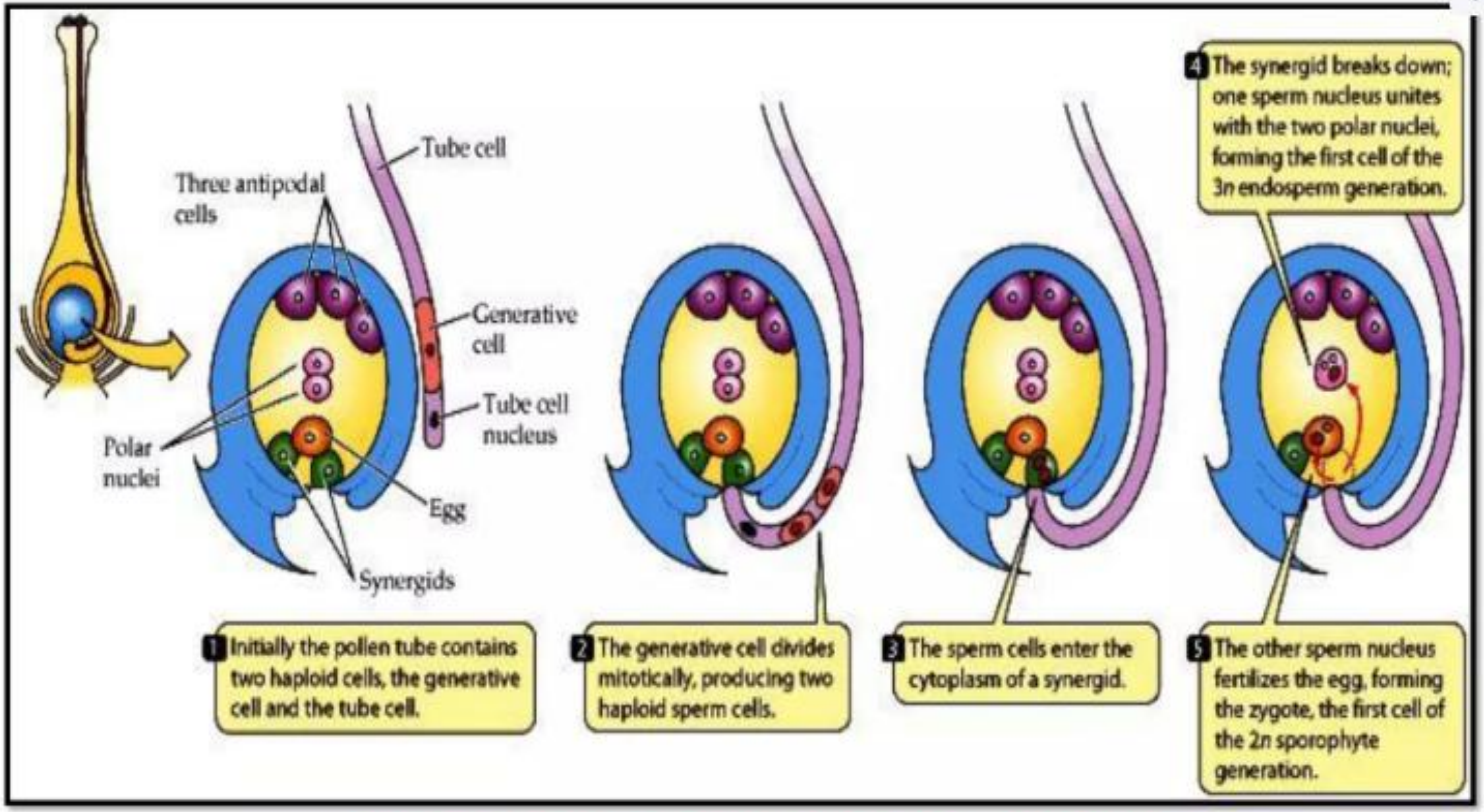


Figure 3: Showing the events of Double Fertilization



The pictorial over view of the Double Fertilization

Significance of Double fertilization: Since double fertilization is unique to Angiosperms, these are the most dominant vegetation on the earth today. Because they are producing the viable and most adaptive seeds as the propagules. Secondly, due to endospermic (albumen) the seeds are serving as the food to the human and his livestock.

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Note : **This document is prepared by Dr PB Mallikharjuna, Associate Professor & Head, Govt. First Grade College, Yelahanka , Bangalore -560 064 as a part of the e- learning on 19-4-2020**

POLYEMBRYONY

❖ Introduction :-

- The occurrence of more than one embryo in the seed is known as polyembryony.
- This phenomenon was initially discovered by Leeuwenhoek (1719).
- Polyembryony is quite common among conifers (Gymnosperms).but many species of both dicotyledons and monocotyledons exhibits this phenomenon.

❖ Classification :-

- *Ernst and schnarf classified the polyembryony into two types. :*

1. *True polyembryony*
2. *False polyembryony*

- *True polyembryony may be subdivided into two types. :*

a) *Cleavage polyembryony*
b) *Adventive polyembryony*

1. True polyembryony :-

- ***The production of embryos within or by projecting into a single embryo sac is termed true polyembryony.***

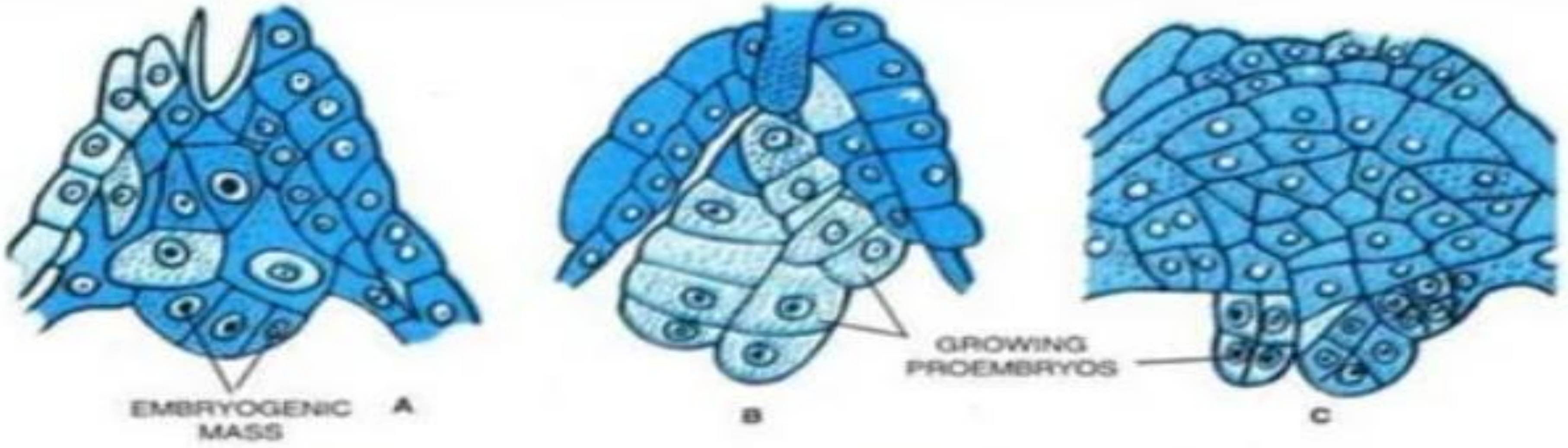
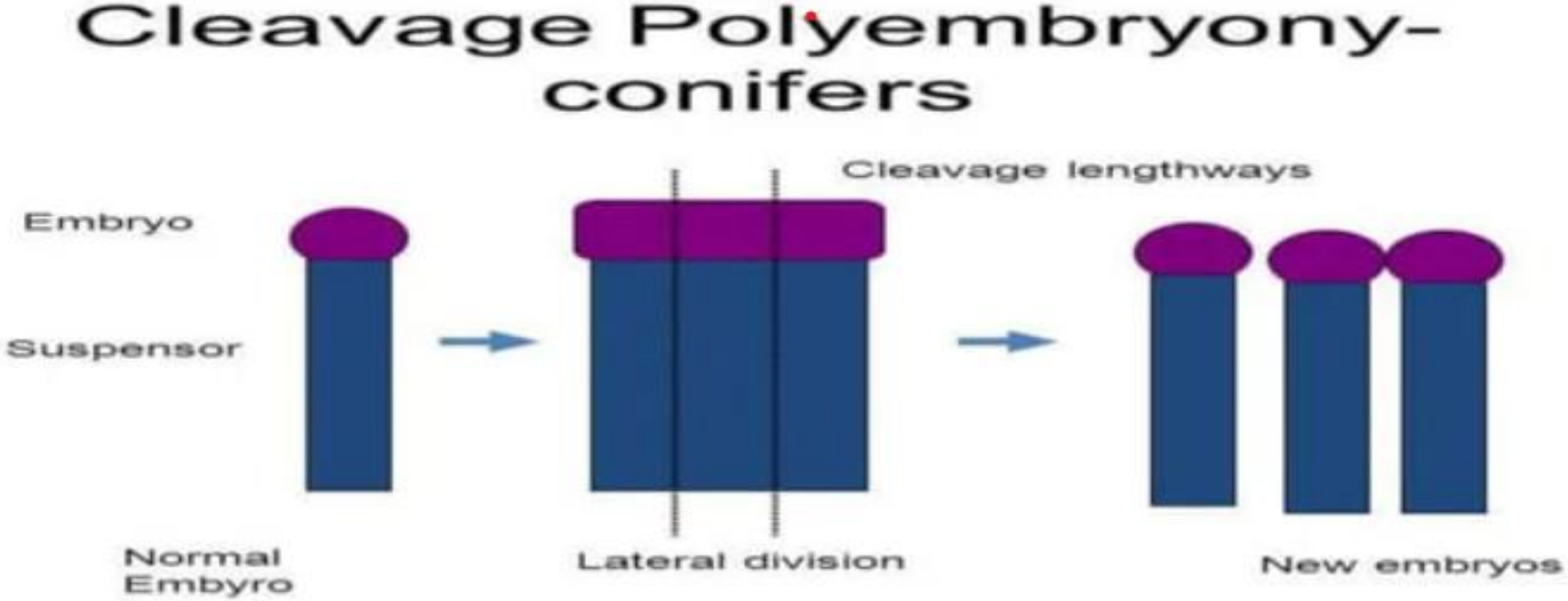


Fig. 2.35. A-C. Cleavage polyembryony : A. Embryonic mass formed by the basal cell of the zygote in *Erythronium americanum*, B-C. Differentiation of embryos from the cells of the embryonic mass.

a) Cleavage polyembryony :-

- ***Where the embryos arise within an embryo sac either by a cleavage of the egg or from the synergids antipodals or endosperms.***



b) *Adventives polyembryony :-*

- ***Where the embryos arise from the tissue lieing outside the embryos sac.***

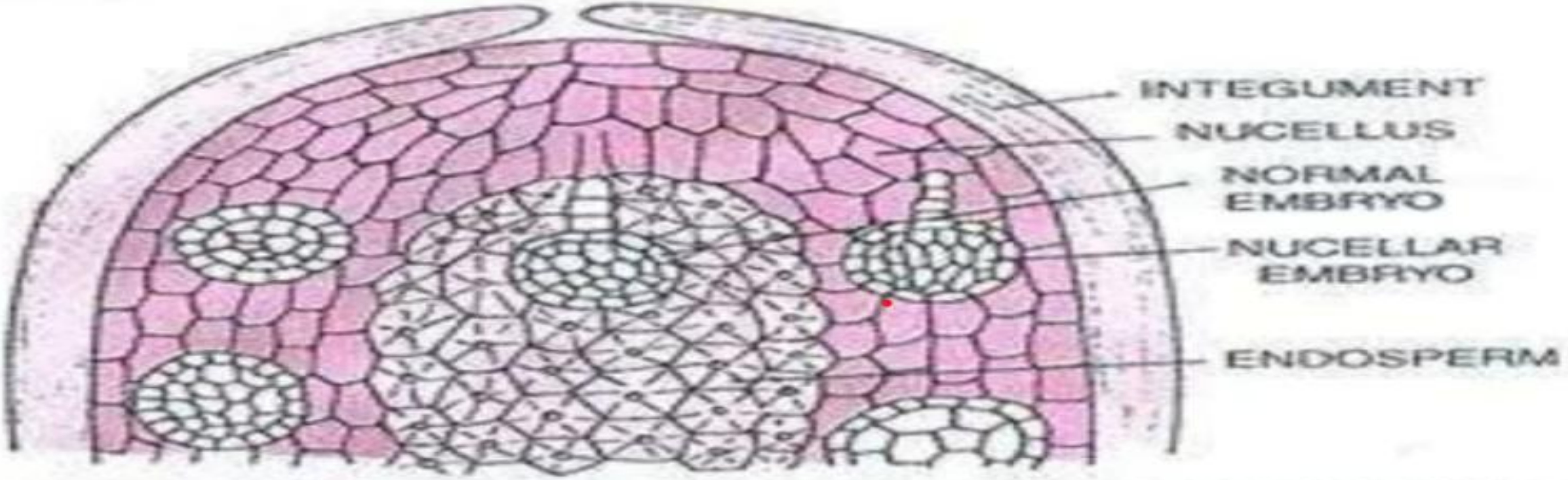


Fig. 2.33. *Citrus* ovule (Young seed) in section showing normal and nucellar (adventive) embryos.

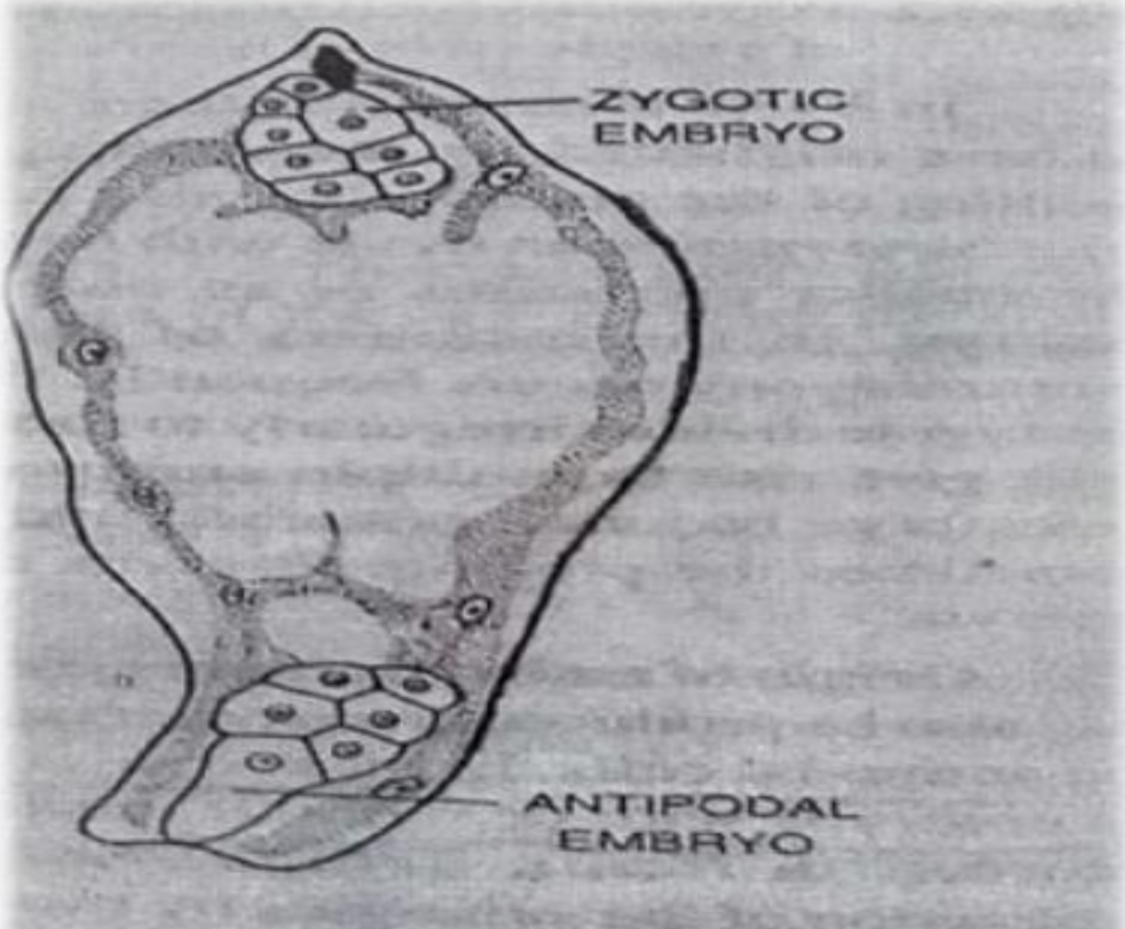
- *The cells of the nucellus or the integuments but generally they come to lie within the embryo sac.*

2. *False polyembryony :-*

- *This type includes the cases in which two or more embryos are formed as result of the development of the aposporic embryo sac.*

❖ *Origin of embryo from synergids or antipodal cells :-*

- ***The embryos may also be produced from other parts of the embryo sac such as synergids and antipodal cells.***



Polyembryony. Formation of embr
from antipodal cell

- In most cases the synergids become egg like to form the embryos with or without fertilization.
- Production of embryos from antipodal cell is rare.

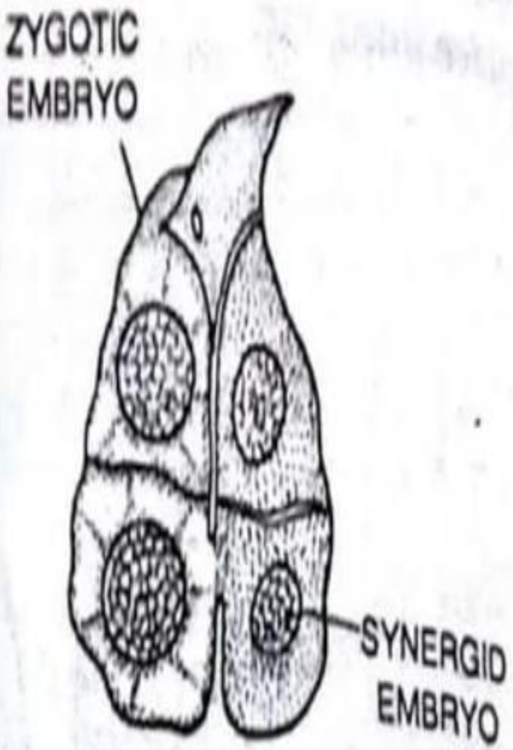


Fig. 61.4. Polyembryony. Formation of synergid embryo in *Lilium.*

❖ *Origin of embryos from endosperms :-*

- *Treub (1898) in balanophora, Woodworth in Alnus and others have reported the embryos developed from endosperm.*
- *Embryo develops normally from the egg.*

❖ *Origin of embryos from cell outside embryo sac :-*

- *The embryos also develop from the cells of the nucellus and integument.*
- *Ex – Citrus , Mangifera*

❖ Origin of embryos from other embryo sac in the ovule :-

- Sometimes the polyembryony occurs due to the presence of multiple embryo sac within the ovule.

- They may arise from :

1. The derivatives of the same megaspore mothercell.
2. From two or more megaspore mothercell.
3. From nucellar cells.

❖ Causes of polyembryony :-

- Many theories have been proposed to explain the occurence of polyembryony by different workers different times.
- Some of the important theories are as follows :

A) Necrohormone theory :

- This theory indicates that the degenerating cells of the nucellus act as source of stimulus for the adjacent cells to divide and form adventive embryos.

B) Hybridization theory :

- According to this theory the occurrence of multiple embryo is due to hybridization.
- The recombination of genes takes place during the process of hybridization, forming a single unit that gives rise to the multiple embryos.

❖ Importance of polyembryony :

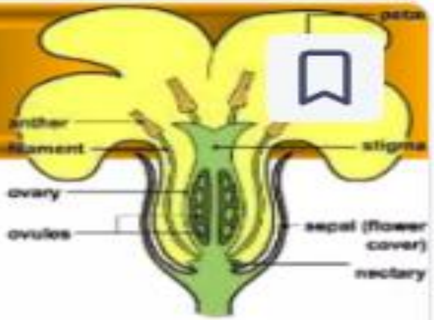
- Plant breeding and horticulture.
- Nucellar embryos are supposed to be free from disease.
- Propagation of the fruit tree, such as citrus and mango.
- The application of adventive embryos is also important for providing genetically uniform seedlings in fruit trees.
- Can be used for the development of homozygous diploid.
- Artificial production of these embryos from the eggs or synergids.


APOMIXIS

INTRODUCTION

- Apomixis, derived from two Greek word "APO" (away from) and "mixis" (act of mixing or mingling).
- APOMIXS is a type of reproduction in which sexual organs of related structures take part but seeds are formed without union of gametes.
- The first discovery of this phenomenon is credited to Leuwen hock as early as 1719 in *Citrus* seeds.
- The genotype of the embryo and resulting plant will be the same as the seed parent.
- This is clonal seed production.

Modes of reproduction



Modes of Reproduction

- **Sexual**
- **Asexual**
  - **Vegetative**
  - **Apomixis**
    - gametophytic
    - sporophytic

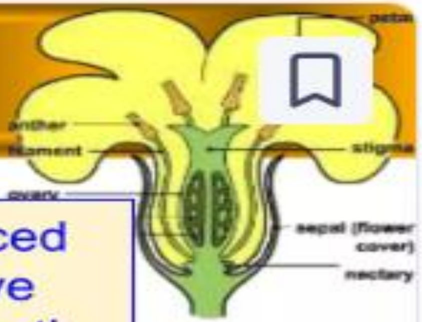
If the unreduced cells give rise to a megagametophyte, then gametophytic apomixis occurs. If the unreduced cells give rise directly to an embryo, then sporophytic apomixis occurs.

- Site of origin
- Developmental pattern

APOMIXIS

- Development of embryo without sexual fusion
- Sexual life cycle is "short-circuited"
- Genotypes of developed plants are identical to the parental plant.
- Discovered by Leuwenhock (1719) in citrus seed

Types of apomixis



- **Gametophytic** — unreduced cells give rise to a megagametophyte
  - diplospory — the embryo sac originates from the megaspore mother cell either directly by mitosis and/or after interrupted meiosis
  - apospory — the embryo sac originates from nucellar cells the most common mechanism of apomixis in higher plants characterized by the presence of multiple embryo sacs
  - Androgenesis
- **Sporophytic** — unreduced cells give rise directly to an embryo
  - adventitious embryony
  - Parthenogenesis
  - Apogamy

Semigamy

The haploid sperm nucleus enters the egg but does not fuse with the haploid egg nucleus. Each nucleus divides independently creating a haploid embryo that contains sectors of male and female origin.

Gametophytic apomixis

If the unfertilized cells give rise to a mega gametophyte

- ❑ Diplospory – MMC cells give rise to a megagametophyte

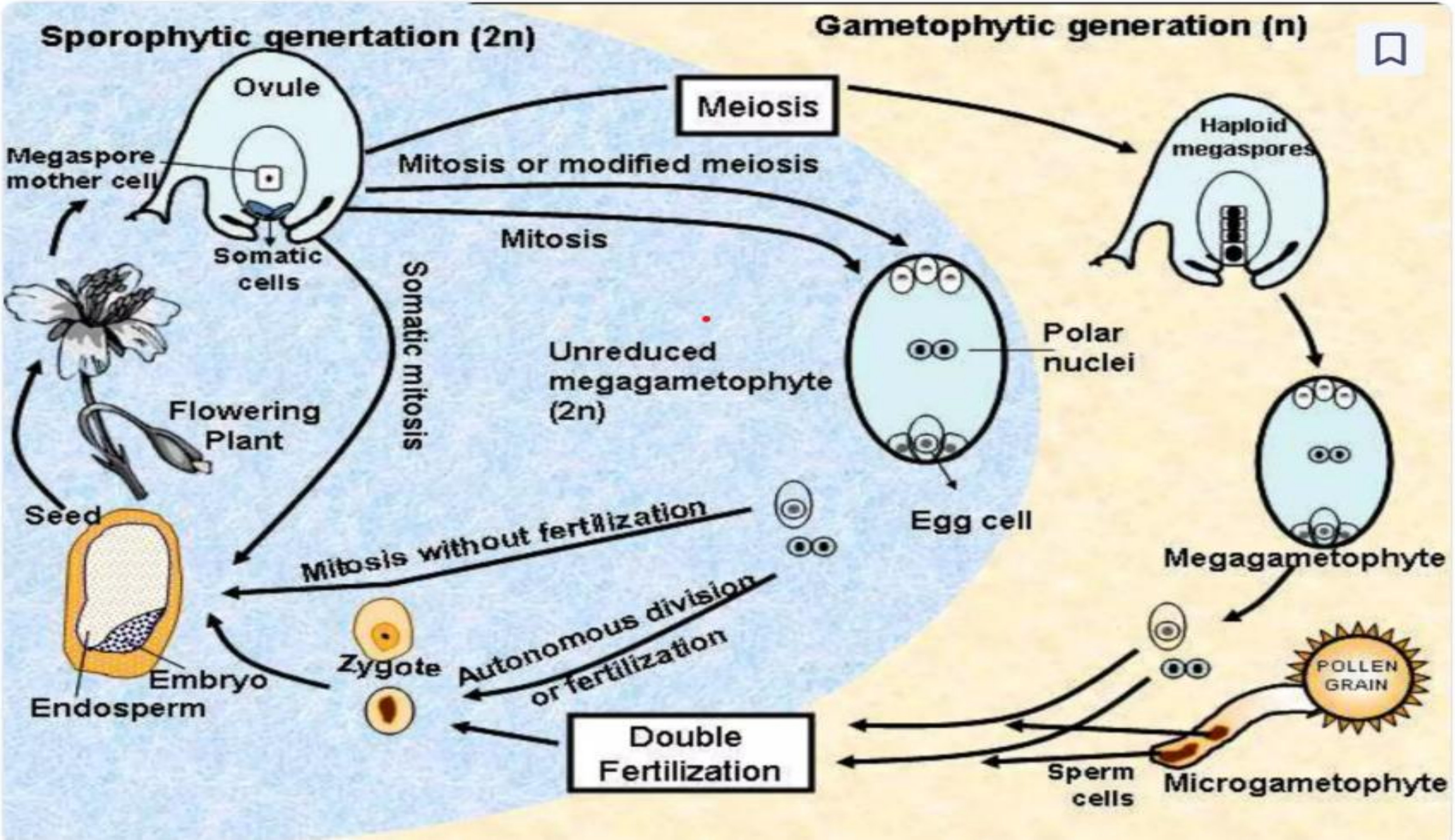
- ❑ Apospory - the embryo sac originates from the any diploid cell except megaspore mother cell either directly by mitosis and/or after interrupted meiosis

- ❑ Androgenesis - the embryo sac originates from generative nuleus of pollen tube cells the most common mechanism of apomixis in higher plants characterized by the presence of multiple embryo sacs

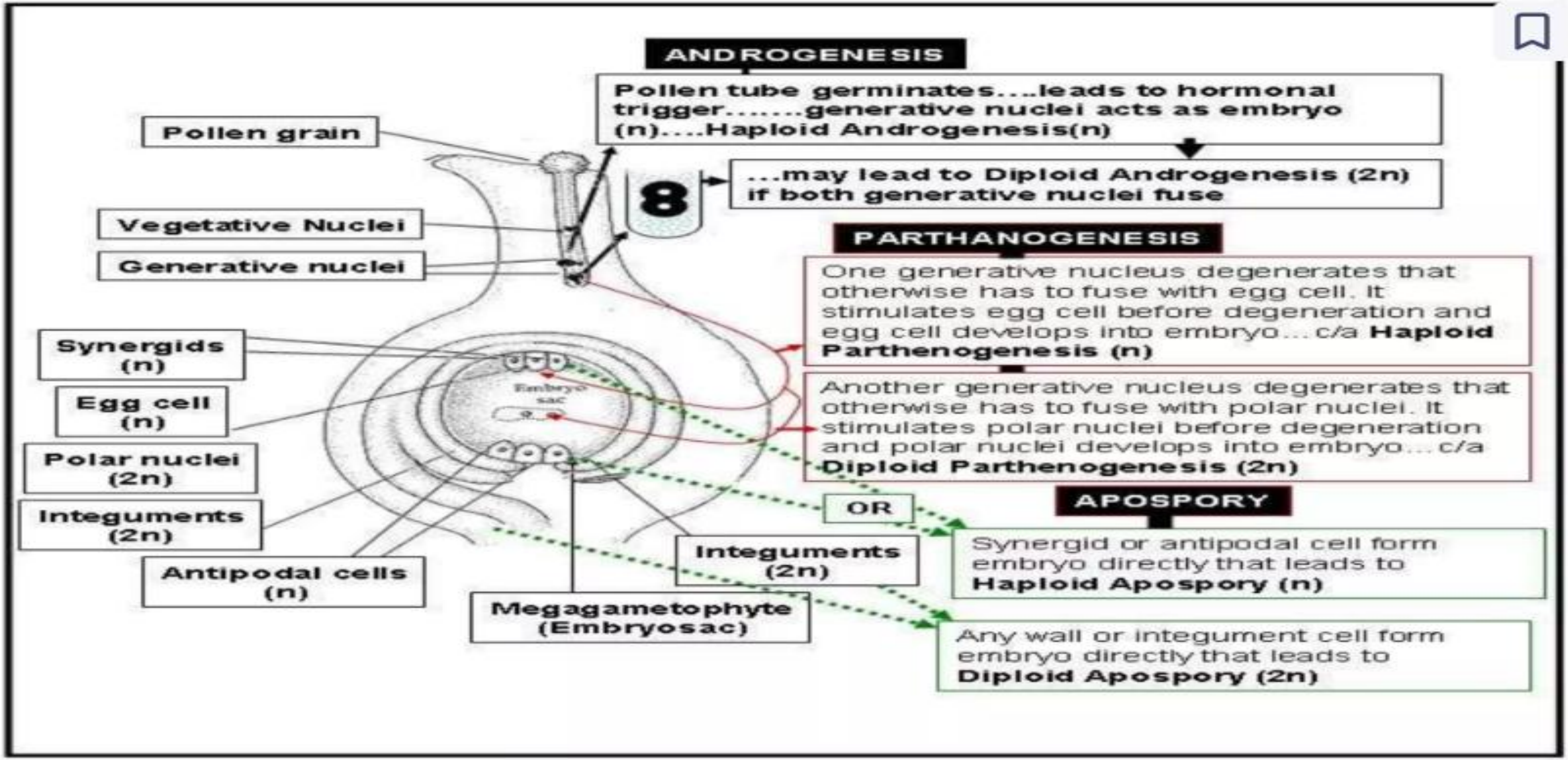
Sporophytic apomixis

If the unfertilized cells give rise directly to an embryo

- ❑ Haploid parthenogenesis : embryo developed from egg cell
- ❑ Haploid apogamy (pseudogamy) : embryo developed from synergids or antipodal cells
- ❑ Adventitious embrony (sporophytic budding) : embryo directly develop from nucellus or integuments (no production of embryosac) e.g. mango , citrus

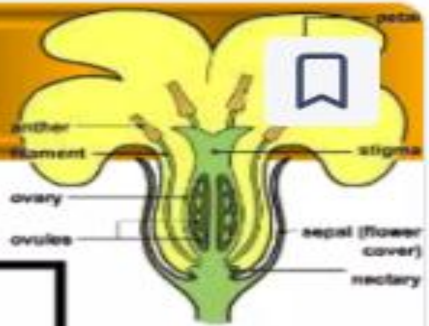


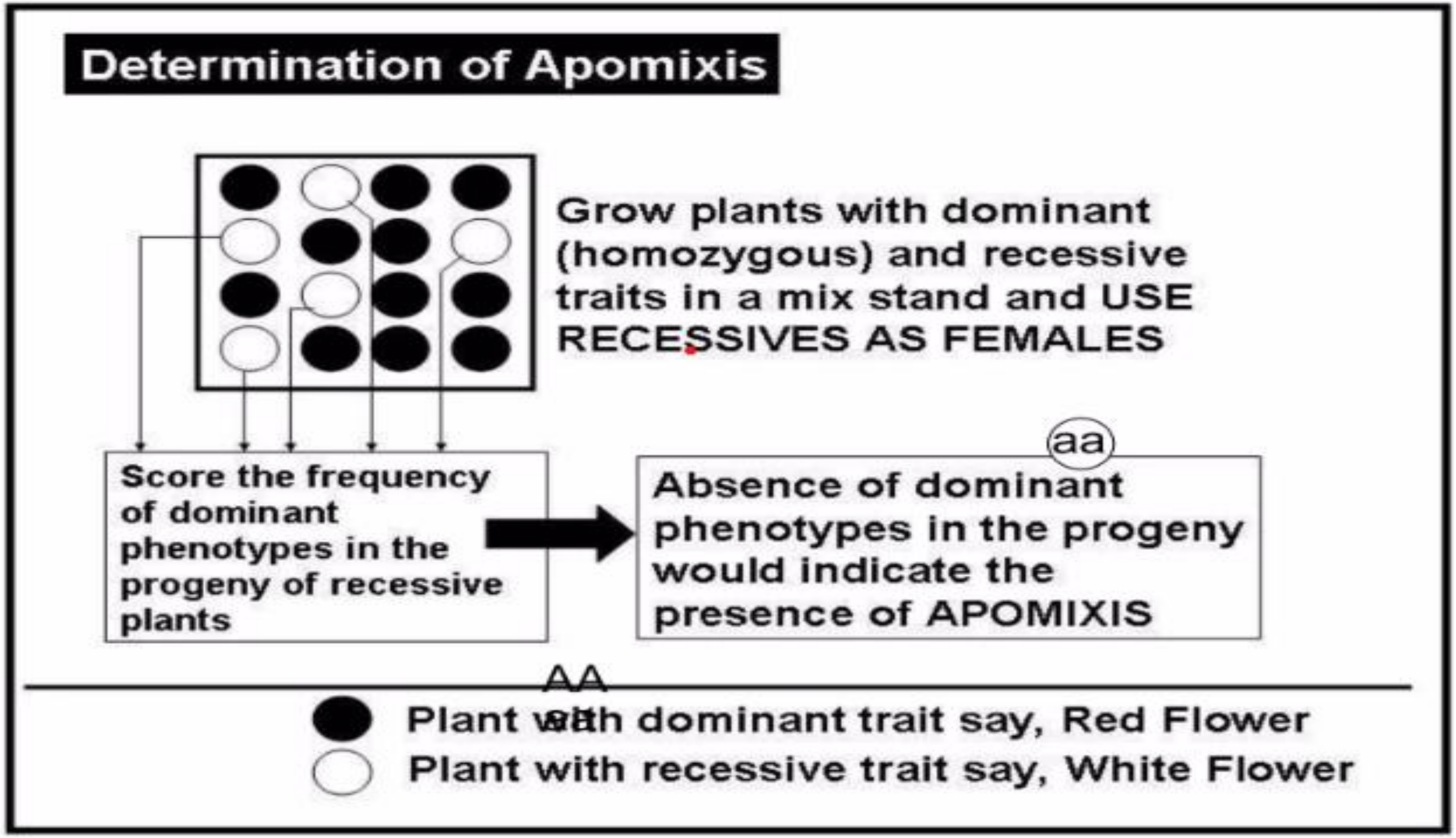
Sporophytic genertation (2n)
Gametophytic generation (n)
Ovule
Meiosis
Haploid megaspores
Megaspore mother cell
Mitosis or modified meiosis
Mitosis
Somatic cells
Somatic mitosis
Polar nuclei
Unreduced megagametophyte (2n)
Flowering Plant
Egg cell
Seed
Megagametophyte
Mitosis without fertilization
Autonomous division or fertilization
Zygote
Embryo
Endosperm
POLLEN GRAIN
Double Fertilization
Sperm cells
Microgametophyte



VARIOUS PATH WAYS FOLLOWED BY DIFFERENT CELLS OF EMBRYOSAC LEADING TO DIFFERENT FORMS OF APOMIXIS

Determination of apomixis





Types of apomixis based on occurrence :

1. ***Non reccurent*** :- embryo develop from any cell of embryosec (haploid cell)

- ***Haploid parthenogenesis*** : embryo developed from egg cell
- ***Haploid apogamy (pseudogamy)*** : embryo developed from synergids or antipodal cells

2. ***Recurrent apomixes*** : embryosec develop without meiosis from diploid cell

- ***Diplospory*** : embryo sec develop from MMC
- ***Apospory*** : embryo sec develop from any vegetative cell of ovule ,than embyo is developed from diploid egg cell.

3. ***Adventitious embrony (sporophytic budding)*** : embryo directly develop from nucellus or integuments (no production of embryosac) e.g. mango , citrus

The Ideal Apomictic System

1. All the progeny of plants should be apomictic so that progeny have the same genotype as the maternal parent.
2. The apomictic genotype should preferably be fully male fertile and self-incompatible, and reproduce via pseudogamy.
3. In case of diplospory, chromosomes should not pair or recombine during first meiotic division. which may give rise to variation among the progeny.
4. Apomixis should be dominant over sexual reproduction. Usually, apomixis is governed by two or more genes.
5. Expression of apomixis should be little affected by the environment.

Development of Apomictic Lines

Apomictic lines can be developed by the following three different approaches:

1. **Gene Transfer from wild species**:
   Genes controlling apomixis can be transferred into a crop species from a related wild species, *e.g.*, from *Tripsacum dactyloides* into maize, from *Pennisetum orientate* into pearlmillet.
2. **Induced Mutations:**
   This approach aims at developing apomictic forms in normally sexually reproducing species by utilising induced or even spontaneous mutations.

These efforts have focused primarily on sorghum, where two mutant lines showing facultative apospory have been isolated.

3. **Isolation of Apomictic Recombinants from Interspecific Crosses:**

Sometimes apomictic recombinants can be recovered from segregating generations of crosses between two sexually reproducing species. For example, seed formation has been reported in the intergeneric hybrids between *T. aestivum* and *Avena sativa, H. vulgare* and *T. aestivitm* etc…

Role in plant breeding

- **Rapid production of pure lines**
  Apomixis is an effective means for rapid production of pureline.
- **Maintenance of superior genotypes**
  Apomixis is useful in maintaining the characteristics of mother plant from generation to generation.
- **Conservation of heterosis**
  In some cases, hybrid vigour may be conserved for many generation by using recurrent apomixis.

Advantages of apomixis in plant breeding

1.Rapid multiplication of genetically uniform individuals can be achieved without risk of segregation.

2. Heterosis or hybrid vigour can permanently be fixed in crop plants, thus no problem for recurring seed production of F 1 hybrids.

3. Efficient exploitation of maternal effect, if present, is possible from generation to generation.

4. Homozygous inbred lines, as in corn, can be rapidly developed as they produce sectors of diploid tissues and occasional fertile gametes and seeds.

Advantages of Apomixis

- ✓ Obligate apomixis permits fixation of heterosis in the hybrids. Therefore, farmers can resow the seeds produced by apomictic hybrids generation after generation.
- ✓ The new hybrid variety could be multiplied from few hybrid seeds in the same manner as purelines. This greatly simplifies hybrid seed production.
- ✓ Even such parents that flower at different times may be crossed in a greenhouse to obtain few hybrid seeds, which can be used to establish the new hybrid variety.
- ✓ The nucleus seed of hybrid varieties can be conveniently maintained as hybrid varieties.

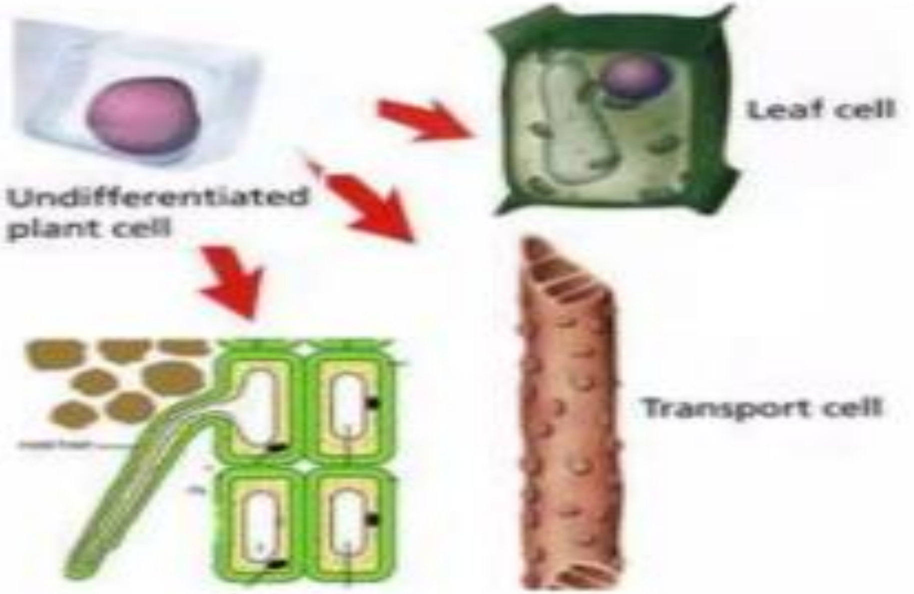
Problems in Utilization of Apomixis

- Apomixis is a very complicated phenomenon.
- Estimation of the level of facultative apomixis, is tedious and time consuming.
- In case of facultative apomicts, the proportion of sexual progeny is affected by environmental factors like day-length and temperature.
- In the absence of morphological markers linked with apomictic development, maintenance of apomictic stock becomes difficult.
- The genetic basis of apomixis is not clear in most cases.

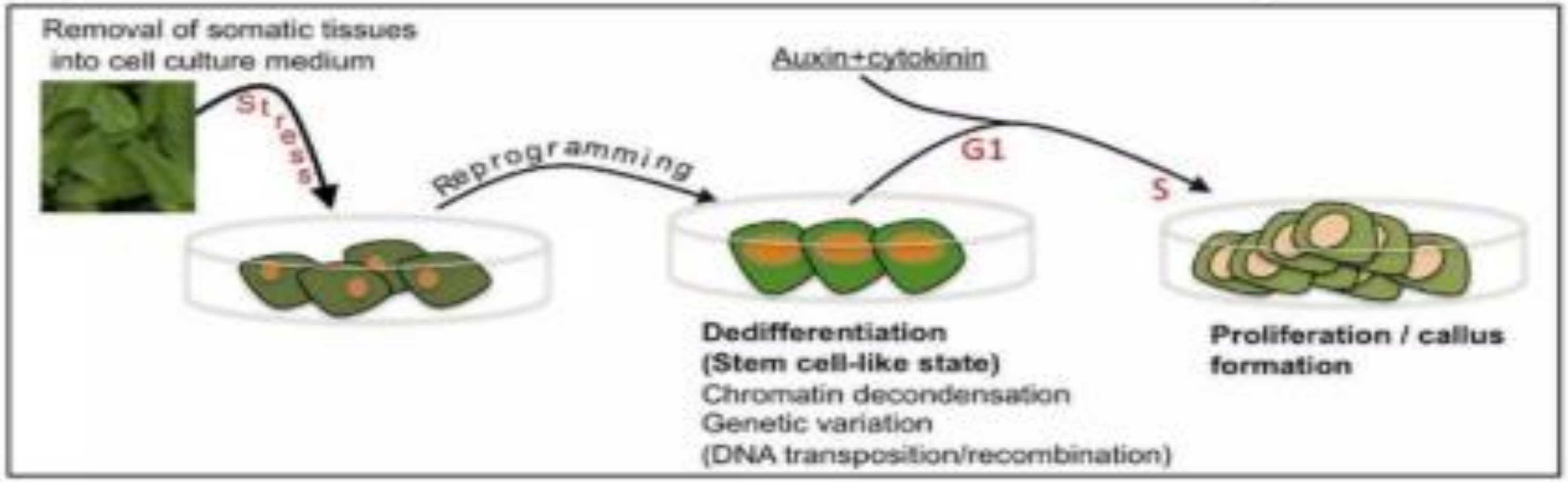
Morphogenesis

Differentiation, Dedifferentiation & Redifferentiation

- **Cellular differentiation** is the process by which a less specialized cell becomes a more specialized cell type.
- Cells derived from meristems and cambium differentiate and mature to perform specific functions which is termed as **differentiation**.



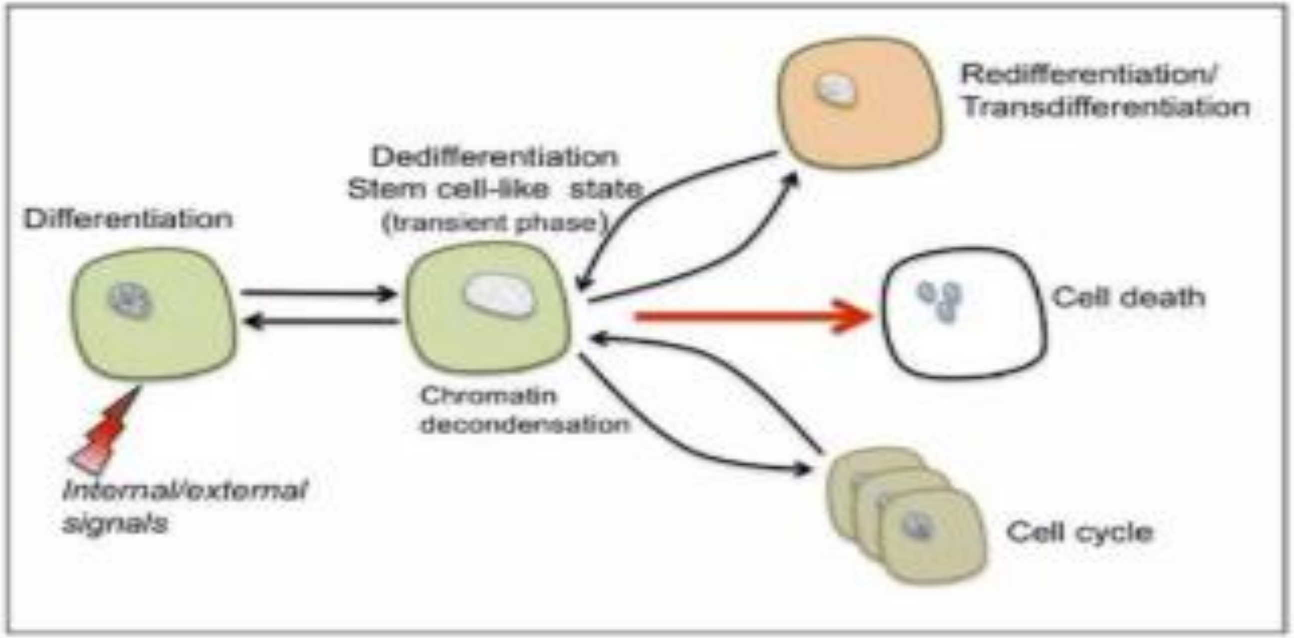
DEDIFFERENTIATION



- Dedifferentiation is an important biological phenomenon whereby cells regress from a specialized function to a simpler state reminiscent of stem cells.
- An undividable differentiated cell sometimes regains the power of division. This process is called dedifferentiation.
- Dedifferentiation is a common process in plants during secondary growth and in wound healing mechanisms.

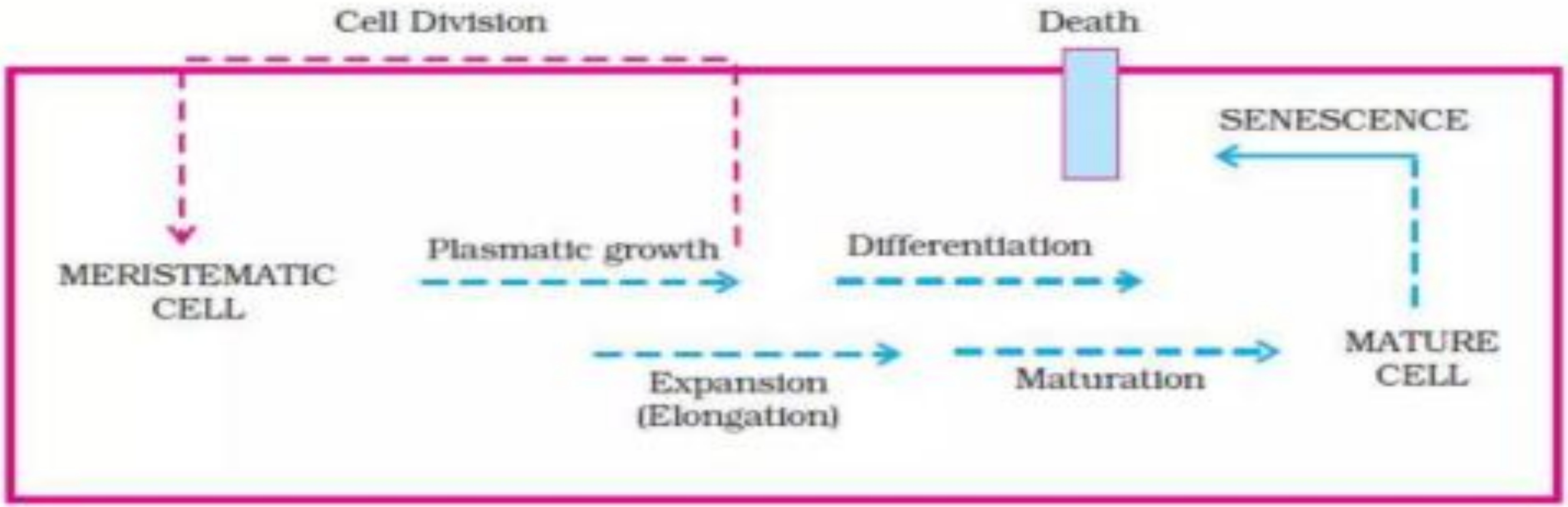
REDIFFERENTIATION

- A dedifferentiated cell can divide and produce new cells.
- New cells produced again loose the power of division and become a part of permanent tissue which is called "redifferentiation'.
- Example:- Formation of tumour cells.

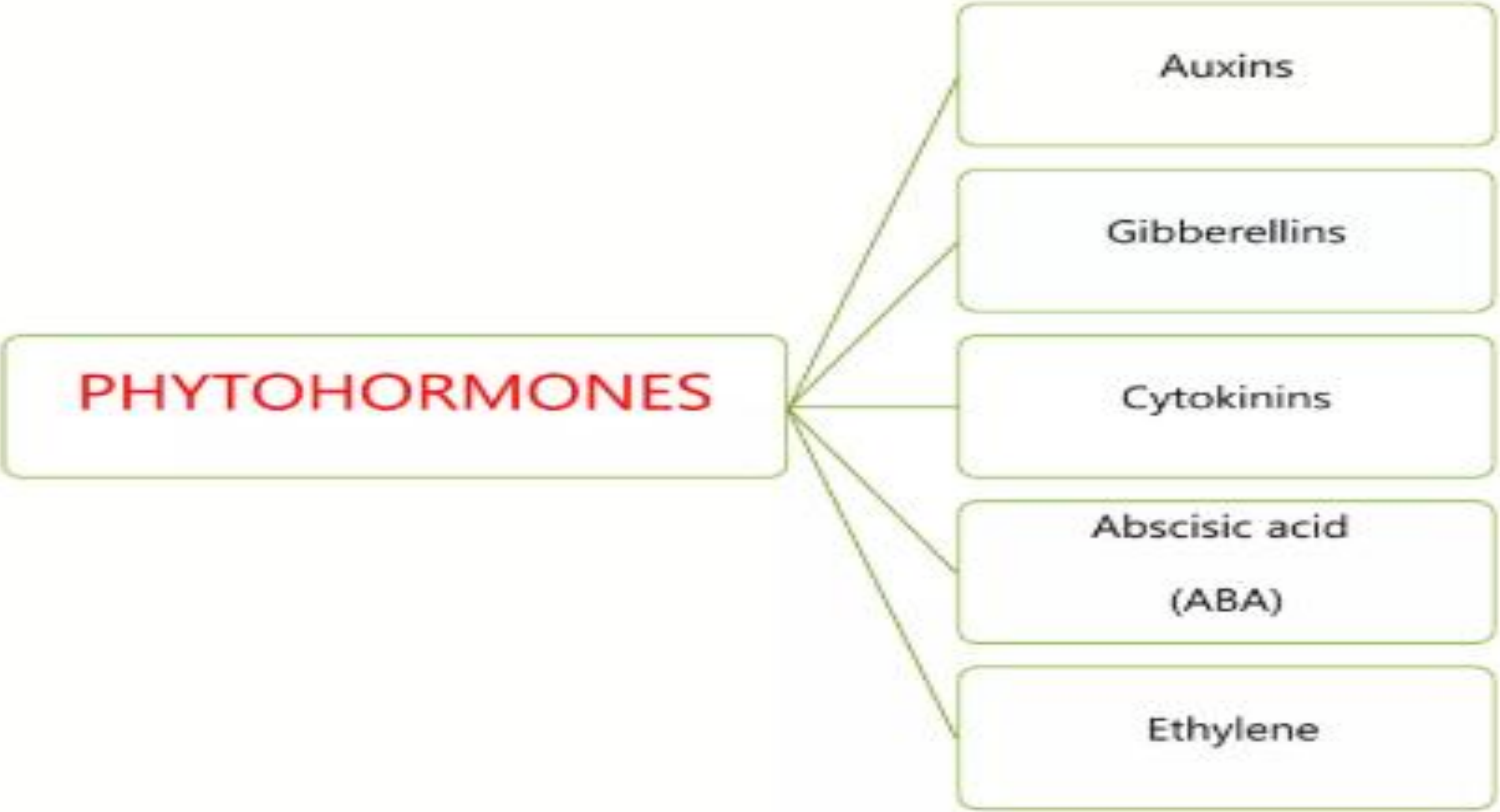


DEVELOPMENT

- Development is a term that includes all changes that an organism goes through during its life cycle from germination of the seed to senescence.



Sequence of the developmental process in a plant cell


PHYTOHORMONES
Auxins
Gibberellins
Cytokinins
Abscisic acid
(ABA)
Ethylene

Classification of PGRs

THANK YOU