ST. LAWRENCE HIGH SCHOOL

A JESUIT CHRISTIAN MINORITY INSTITUTION

STUDY MATERIAL -3

Class: XII **Sub: BIOLOGICAL SCIENCE** **Date: 15.06.2020**

Topic - <u>Sexual reproduction in flowering plants (Part 2)</u>

DEVELOPMENT OF OVULE AND FEMALE GAMETOPHYTE

STRUCTURE AND DEVELOPMENT OF THE OVULE (MEGASPORANGIUM)

The ovule has a massive parenchymatous body, called **nucellus**. It is enclosed and protected by one or two sheaths, known as **integuments**. The ovules with a single integument are said to be unitegmic and with two integuments, bitegmic. The integuments completely cover the nucellus, leaving only a small opening at one end, called **micropyle**. The ovule is attached to the placenta by a stalk, known as **funicle**, and the point of attachment of the body of the ovule to the funicle is called **hilum**. The basal part of the ovule where nucellus, integuments and funicle merge is known as **chalaza**.

The ovule arises on the placenta as a hemispherical protuberance which grows into a projecting mass of tissue, the nucellus. Integuments arise as complete rings below the nucellar apex. The inner integument, which is usually formed first, initiates from the epidermal layer and the outer integument from the sub-epidermal layer. The growth of the outer integument is slower than that of the inner integument and at the area near micropyle.

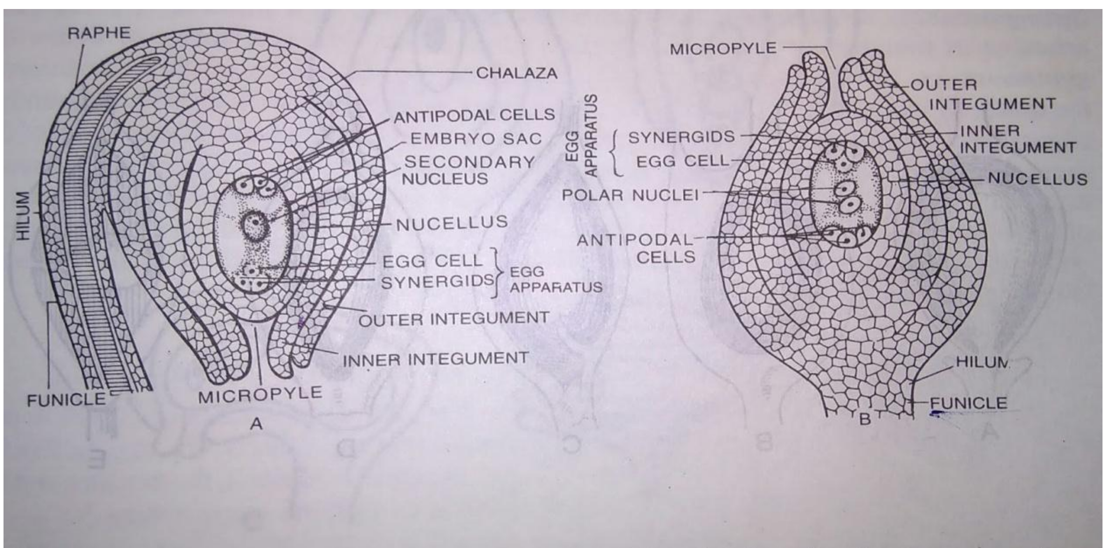


Fig. 6.32 (A)—Longitudinal section of an ovule of angiosperm; A—Anatropous ovule, B—Orthotropous ovule.

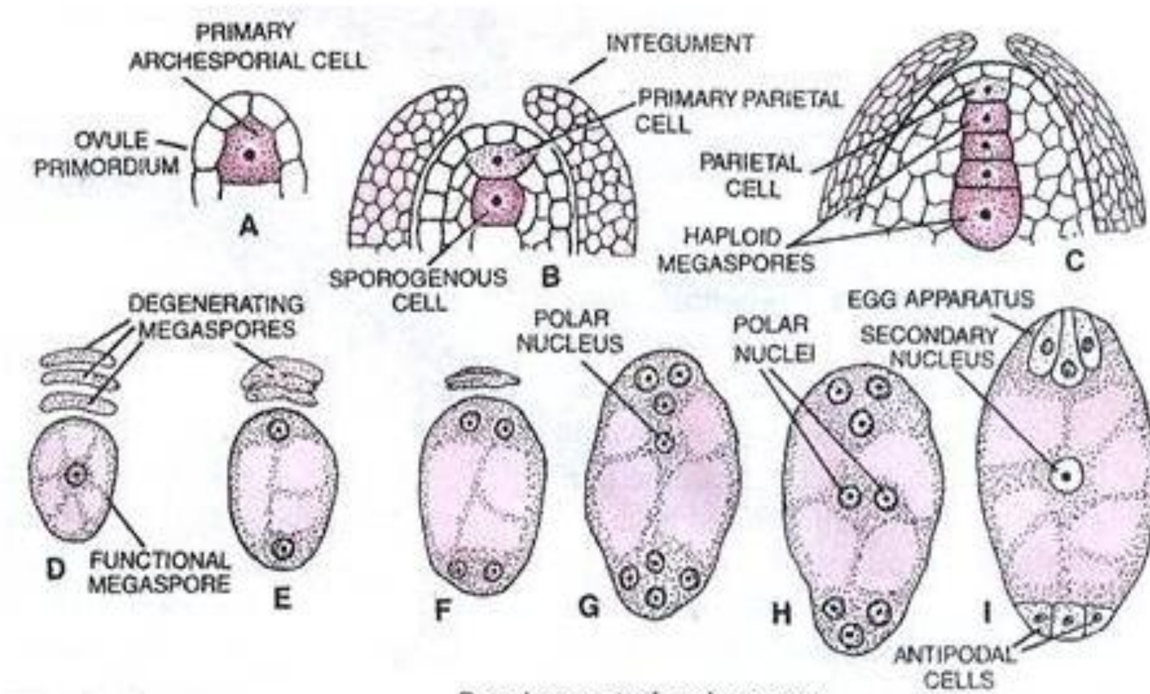
MEGASPOROGENESIS

Development of the megaspore within the ovule (mega sporangium) is known as **megasporogenesis**. A hypodermal cell of the nucellus at the micropylar end differentiates as **archesporial cell**. It is distinguishable from the other cells by its conspicuous size, dense cytoplasm and prominent nucleus. The archesporial cell may directly function as the megaspore mother cell as it divides transversely cutting a mother cell undergoes **meiosis** and forms four haploid **megaspores** of these, only **one is functional and the remaining three degenerate**.

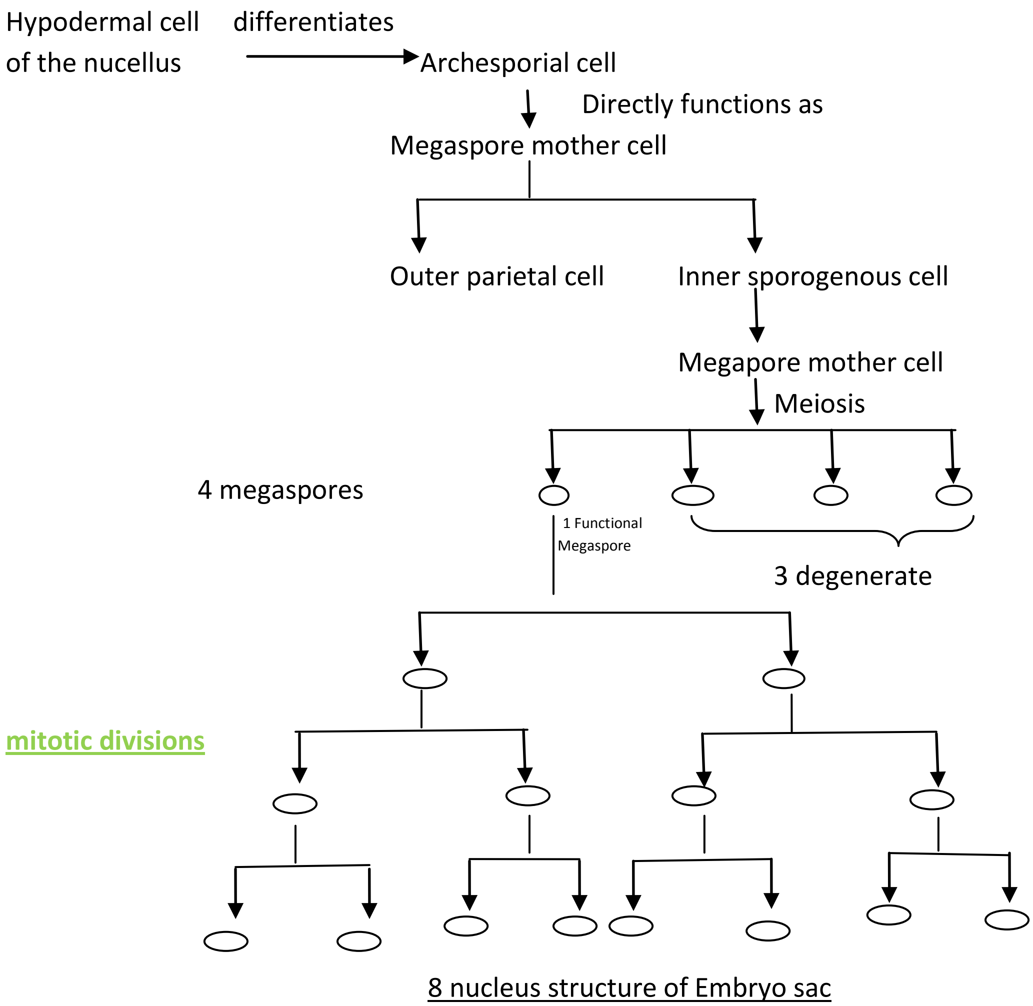
DEVELOPMENT OF FEMALE GAMETOPHYTE OR EMBRYO SAC

The functional megaspore is the mother cell of the female gametophyte. It grows in size and forms an embryo sac. The haploid nucleus of the megaspore divides **mitotically**, forming usually **eight nuclei** which organize in a definite manner within the embryo sac. Three nuclei at the micropylar end organize into an **egg apparatus**, three at the chalazal end form **antipodal cells** and the remaining two, called **polar nuclei**, migrate to the centre of the embryo sac and later fuse to form a single diploid **secondary nucleus**. The central large cell of the egg apparatus is female gamete (egg) which is partially surrounded by two lateral **synergid** cells. The mataure gametophyte or embryo sac thus has two polar nuclei, three antipodals, one egg and two synergids.

Since, this type of embryo sac develops from a single megaspore and has eight nuclei, it is said to be **monosporic 8-nucleate** embryo sac or Polygonum type of embryo sac. It is the most common type of embryo sac and is found in about 81% flowering plants.



Development of embryo sac.



SCHEMATIC REPRESENTATION OF MEGASPOROGENESIS AND FORMATION 8 – NUCLEATE EMBRYO SAC

FERTILIZATION

Fertilization is the process of two dissimilar sexual reproductive units, called gametes. In flowering plants, the process of fertilization was first discovered by Strasburger in 1884. The female gametophyte (embryo sac) of angiosperms is situated in the ovule, at a distance from the stigma. The process of fertilization is divided into following stages :-

GERMINATION OF POLLEN GRAINS AND GROWTH OF POLLEN TUBES

When the pollen is shed from anther it has usually **two** cells, a **generative** cell and a **tube** cell (vegetative cell). The generative cell forms **two male gametes**. Once the pollen has landed on the receptive stigma, its germination starts. On the surface of the stigma the pollen hydrates, i.e. it absorbs water, swells and produces a pollen tube. The stigmatic fluid secreted by the stigma contains sugars, lipids, resins, etc. and thus provides a suitable medium for the germination of pollen grains. The pollen tube penetrates into the stigmatic papillae by the activity of an enzyme, known as cutinase, present in the pollen grain and pollen tube. This enzyme degrades the cutin of the stigma at the place of contact with pollen tube. The entire contents of the pollen, following its germination, move into the pollen tube. The growth of the pollen tube is primarily restricted to its tip where most of the cytoplasm is concentrated.

The emerging pollen tube penetrates the stigma and pushes its way and pushes its way through the style and down the wall of the ovary. If the style is hollow, then the pollen tube grows along the epidermal surface, i.e., through the stylar canal. But when the style is a solid column of tissue, the pollen tube travels through intercellular spaces between the cells which lie in its path.

ENTRY OF POLLEN TUBE INTO OVULE

The pollen tube is directed towards one of the ovules. It may enter the ovule through one of the following three routes.

(i) **Porogamy** : When pollen tube enters the ovule through the micropyle, the condition is known as prorogamy. This is the most common mode of pollen tube entry into the ovule.

(ii) **Chalazogamy** : When pollen tube enters the ovule through the chalazal end, the condition is said to be chalazogamy.

(iii) **Mesogamy** : When pollen tube enters the ovule through integument, the condition is described as mesogamy.

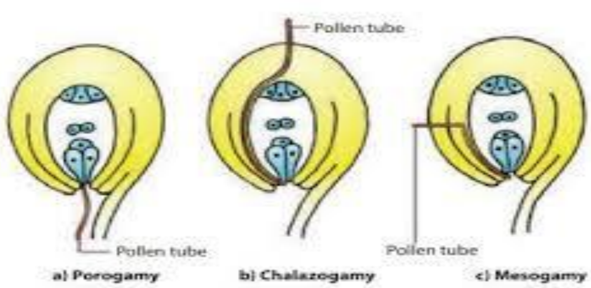


Figure 1.18 Path of pollen tube entry into the ovule

Entry of pollen tube in the embryo sac

Irrespective of the route of pollen tube into the ovule, it always enters the embryo sac them the micropylar end. The entry of pollen tube into the embryo sac may be :-

- between the egg cell and one of the synergids
- Between the wall of the embryo sac and one or both the synergids.
- Between the two synergids, or
- Directly penetrates one of the synergids.

Synergids thus not only play an important role in determining the entry of pollen tube in the embryo sac but they also affect dissemination of male gametes in the embryo sac.

(iv) **Discharge of male gametes from pollen tube** : After entering into the embryo sac, the tip of the pollen tube bursts and the two male gametes are discharged. The tube nucleus disorganizes before bursting of the pollen tube. The male gametes, as they are released. Show amoeboid movements. One of them moves towards the egg and the other to the polar nuclei.

(v) **Fusion of gametes (syngamy) and triple fusion** : One male gamete fuses with the egg and this results in the formation of a diploid zygote. This fusion of male and female gametes is known as fertilization. The other male gamete fuses with the two polar nuclei (or secondary nucleus, if the two have already fused) and forms a triple fusion nucleus, called primary endosperm nucleus. The contact between one of the male gametes and the egg is established earlier than between the other male gamete and polar nuclei. But the primary endosperm is formed earlier than the zygote, perhaps because the cytoplasm of the central cell is more active than the egg.

This type of fertilization which involves the fusion of one male nucleus will the egg and the other with the polar nuclei is unique to angiosperms. This is known as double fertilization, a phenomenon first discovered by S.G. Nawaschin (1897) in Lilium and Fritillaria species).

ENDOSPERM

The primary endosperm nucleus undergoes a series of divisions and ultimately forms endosperm, a highly nutritive tissue which provides nourishment to the developing embryo. In plants like beans, peas, etc., the entire endosperm is consumed in the nutrition of the developing embryo. The mature seeds are thus without endosperm. Such seeds are known as non-endospermic and they store food material in cotyledons. On the other hand, seeds of cereals, coconut, castor, etc., which retain endosperm even at maturity, are said to be endospermic. The endosperm present in the seed is used up after germination in the establishment of young seedling.

TYPES OF ENDOSPERMS

The endosperm is usually triploid (3n) tissue as it is formed by the fusion of three haploid nuclei ; two of these nuclei belong to the female gametophyte (i.e., polar nuclei) and one to the male gametophyte (i.e., male gamete). On the basis of development, three types of endosperms have been recognized :

(i) Nuclear endosperm
(ii) Cellular endosperm
(iii) Helobial endosperm

NUCLEAR ENDOSPERM

This type of endosperm commonly occurs in polypetalous dicotyledons. In the development of nuclear endosperm, the first few divisions of the primary endosperm nucleus are not accompanied by cell wall formation and nuclei thus produced remain free in the cytoplasm of the embryo sac. Wall formation takes place subsequently or the nuclei remain free indefinitely.

Cocos nucifera is the classical example of nuclear endosperm. The watery liquid endosperm which fills the large embryo sac contains numerous free nuclei. It is known as liquid syncytium.

The watery endosperm of coconut contains growth promoting 'Coconut milk factor', and that is why it is used as a nutrient medium in culture experiments.

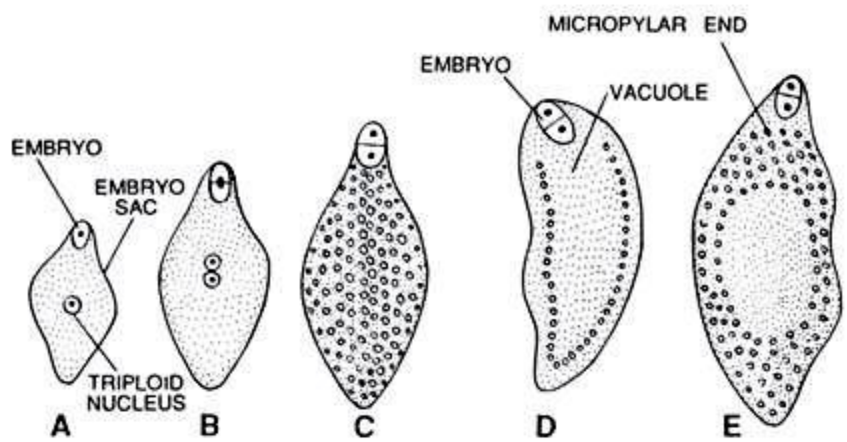


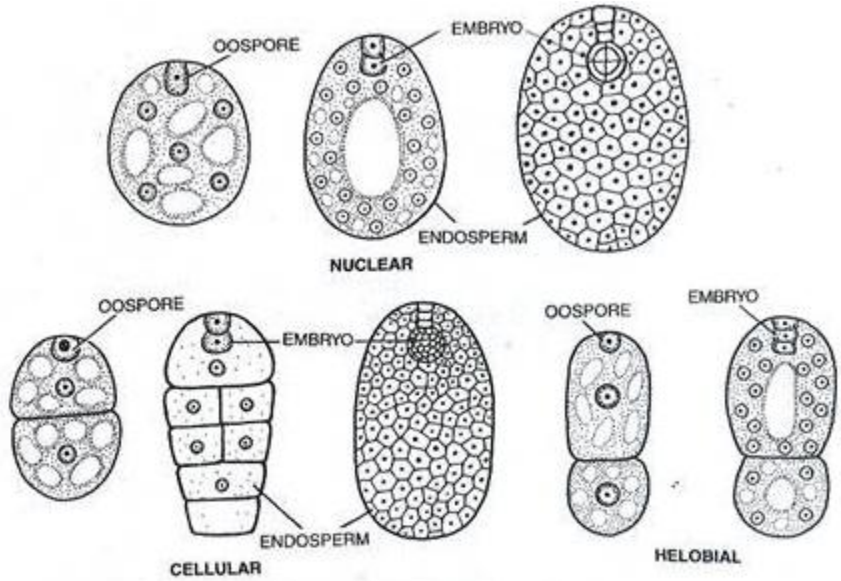
Fig. 46.40. A-E, stages in the development of nuclear type of endosperm.

CELLULAR ENDOSPERM

This type of endosperm formation commonly occurs in gamopetalous dicotyledons. In the development of cellular endosperm, wall formation commences with the first division of the primary endosperm nucleus. The first wall is usually laid down transversely, but the subsequent divisions are irregular. This results in the formation of an endosperm tissue where cells do not any regular arrangement.

HELOBIAL ENDOSPERM

This type of endosperm, intermediate between the nuclear and cellular type, occurs in the members of the order Helobiae. The first division of the primary endosperm nucleus is accompanied by the formation of a transverse wall. This divides the embryo sac unequally into a small chalazal chamber and a large micropylar chamber. This is followed by free nuclear divisons in both chambers. But there are relatively few divisions in the chalazal chamber and this region often degenerates. The free nuclear divisions in the micropylar chamber are usually followed by wall formation and thus cellular endosperm tissue is formed.



Types of endosperm.

THE EMBRYO

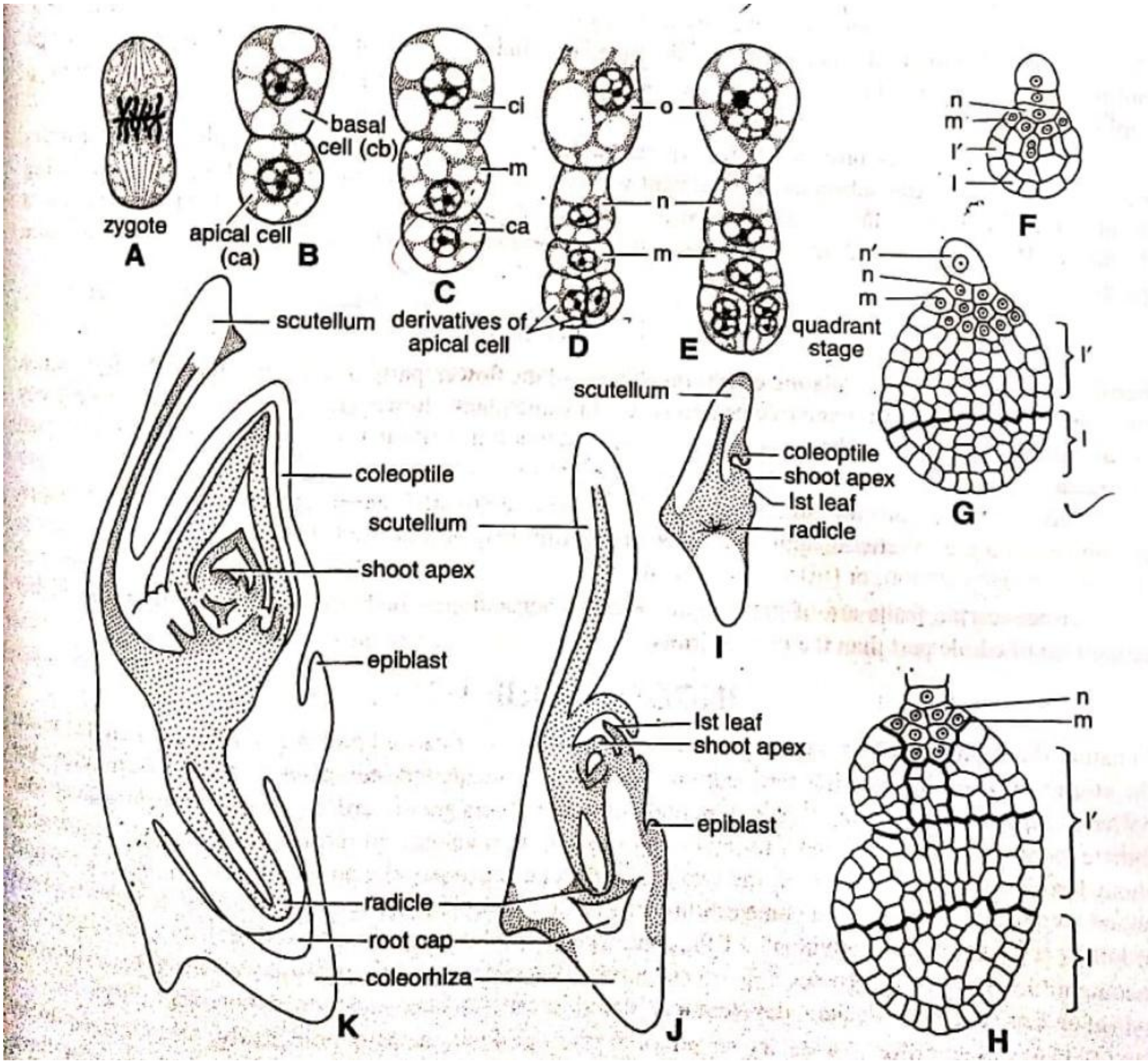
INTRODUCTION

After fertilization, a series of changes takes place in the ovule and as a result seed is formed. The fertilized egg (zygote) after a period of rest (or perhaps reorganization) develops into embryo. The process of development of mature of embryo from diploid zygote is called embryogenesis.

The dicotyledonous embryo has two cotyledons attached laterally to an embryonal axis, whereas in the monocotyledonous embryo, the embryonal axis has a single cotyledon at its apex. Due to his organographic difference the two types of embryos can be easily distinguished. But there are no fundamental differences in the early stages of development of these two types of embryos. The development is very similar till the gloubular stage, but difference do occur in the later stages of development.

DEVELOPMENT OF DICOTYLEDONOUS EMBRYO

The first division of the zygote is usually transverse resulting in the formation of a small apical cell (ca) and a large basal cell (cb). The basal cell of the 2-celled proembryo lies close to the micropyle, whereas the apical cell is away from it (48A-B). The basal cell (cb) divides by a transverse wall (into cm, ci) and the apical cell (ca) by a longitudinal wall (Fig 48 C). The proembryo thus assumes the shape of an inverted ‘T’. The two terminal cells formed by the longitudinal division of the apical cell divide again by a longitudinal wall at right angles to the first and thus a quadrant is formed (Fig 48 D-G). Each cell of the quadrant divides by a transverse wall, giving rise to octant stage (Fig 48 H).



At the same time the two basal cells (cm, ci) undergo several transverse divisions, this giving rise to an elongated suspensor of 6-10 cells. The distal most cell of the suspensor, which is contiguous with the spherical distal part of the proembryo, functions as hypophysis (Fig. 48I).

The cells of the distal spherical region of the proembryo undergo further divisions. As the two cotyledons differentiate, the spherical proembryo becomes a somewhat flattened caudate body. The cotyledons and hypocotyls elongate chiefly by transverse divisions of their constituent cells. The shoot apex differentiates as a small region in the depression between the two cotyledons. (Fig 48J-M).

The mature embryo consists of two cotyledons and an embryonal axis. The part of the embryonal axis above the level of cotyledons forms the plumule (epicotyls) and below the cotyledons, the radical (hypocotyls). When the seed germinates, the plumule gives rise to the shoot system and the radical to the root system. The food material stored in the cotyledons is used in the establishment of the young seeding.

SCHEMATIC REPRESENTATION OF FORMATION OF DICOT EMBRYO

Zgyote (2n) $\xrightarrow{\text{Transverse division}}$ BASAL CELL (micropylar end)
APICAL CELL (Chalazal end)

Transverse division to form 2 cells

Cm Ca

Longitudinal division to form 2 cells (forms inverted T shaped Structure)

C1 C2

Transverse Divisions

(4-cellled) Also known as Quadrant cells

Transverse division

8-Celled Structure

Divisions

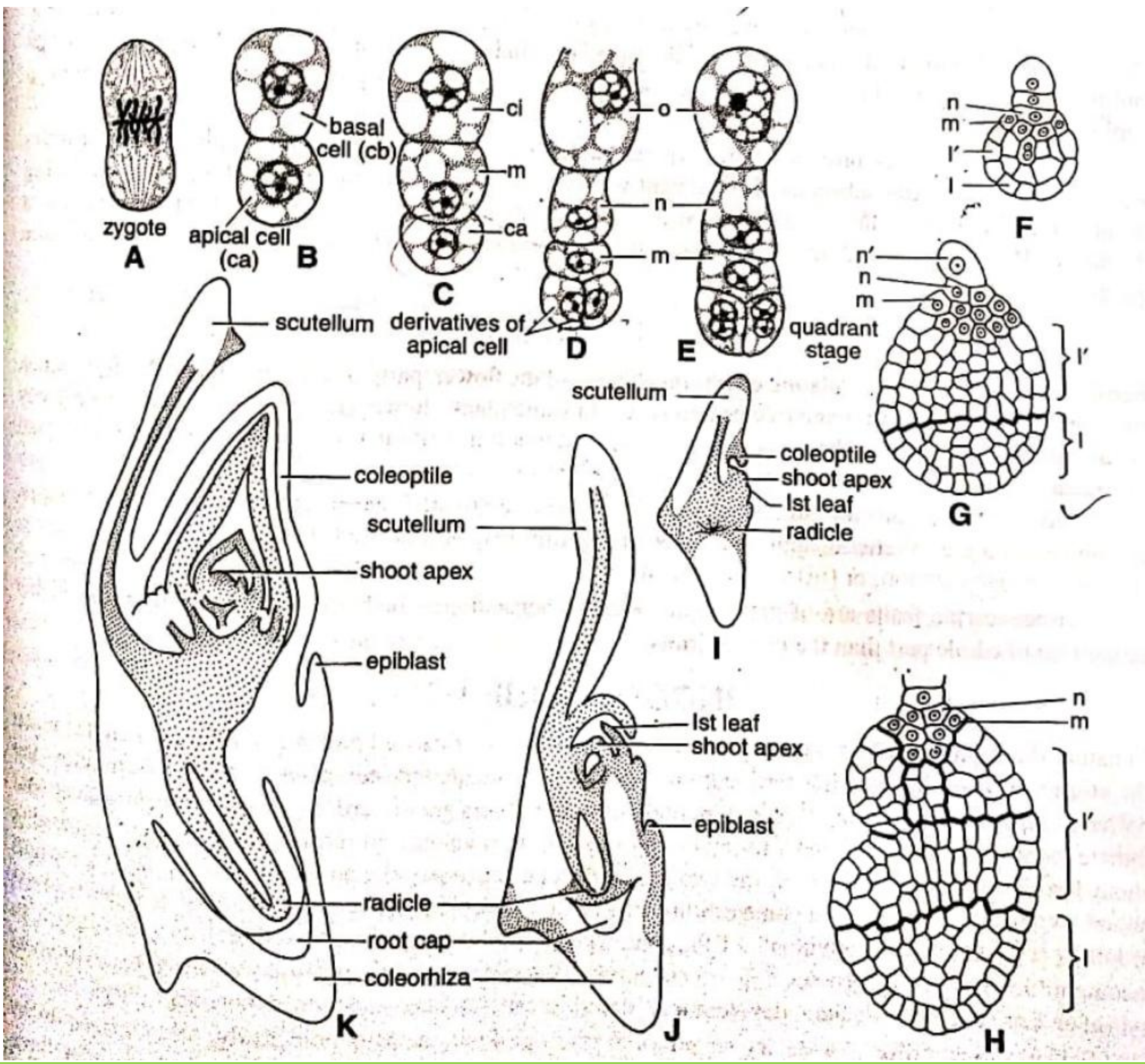
6-8 Celled structure called suspensor
(Cell closest to the 8- celled structure is called Hypophysis)

1. Distal Region forms Cotyledons (caudate shape)
2. Later plumule and radicle also develops From the central region

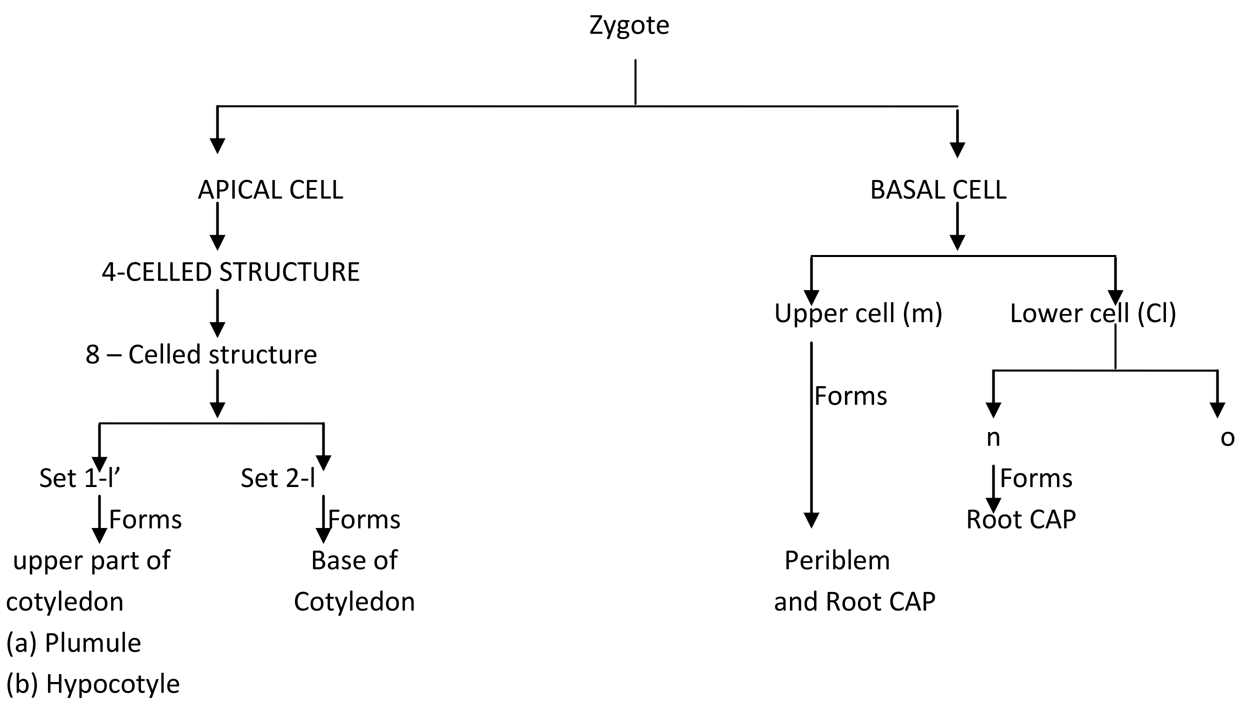
DEVELOPMENT OF MONOCOTYLEDONOUS EMBRYO

The first division of the zygote is by a transverse wall and thus an apical cell (ca) and a basal cell (cb) are differentiated (Fig 49 A-B). The apical cells cell undergoes to divisions at right angles to each other, giving rise to a quadrant.

Simultaneously, the basal cell (cb) divides transversely forming two cells. The upper derivative (m) , which lies close to the quadrant, becomes contiguous with the quadrant while the lower derivative (ci) divides transversely forming two cells (n and o ; Fig 49 D-F). At this stage, the cells of the quadrant also divide transversely and two regions are differentiated. Of these, I forms the basal part of the cotyledon and I' gives rise to the other cells of the embryo; m forms periblem and a part of the root cap, and n the remaining part of the root cap (Fig 49 J, K).



SCHEMATIC REPRESENTATION OF FORMATION OF MONOCOT EMBTRYO



FORMATION OF SEED AND FRUIT

INTRODUCTION

The fertilized ovule increases in size and develops into a seed. The integuments of the ovule give rise to the seed coat, which as a hard testa and a thin membranous tegmen. In most dicotyledons, the food material present in the endosperm is completely absorbed by the cotyledons, which become thick and fleshy. But in some, endosperm persists within the seed. After fertilization, usually synergids and antipodals disorganize, and nucellus is also used up. But sometimes nucellus persists in the seed in the form of perisperm. The funicle becomes the stalk of the seed. A minute scar present on the seed surface is hilum.

The ovary develops into fruit after fertilization and thus morphologically the fruit is a ripened ovary. The ovary wall at maturity forms the wall of the fruit, known as pericarp.

The fate of various parts of the ovary in the formation of fruit is summarized below.

Ovary		**Fruit**	
Ovary Wall	-	Pericarp	
Ovule	-	Seed	
Funicle	-	Stalk of the seed	
Hilum	-	Hilum	
Nucellus	-	Perisperm (when present)	
Micropyle	-	Micropyle	
Outer integument	-	Testa	} Seed coat
Inner integument	-	Tegmen	
Embryo-sac			

Synergids	-	Disorganized
Egg cell	-	Embryo
Antipodal cells	-	Disorganized
Secondary nucleus	-	Endosperm

THE FRUIT

The fruit is a mature or ripened ovary. It is formed by the act of pollination and fertilization, which provide a stimulus to the ovary to grow into a fruit. If, for some reason, fertilization fails, the ovary simply withers and falls off. But in certain plants, fruits may be formed without the act of fertilization and such fruits are called parthenocarpic fruits.

A fruit consists of pericarp, that develops from the ovary wall, and seed (s), derived from the ovule (s). The pericarp may be thin or thick and is usually differentiated into an outer **epicarp**, a middle **mesocarp**, and an inner **endocarp**. But in dry fruits, the pericarp is undifferentiated and is usually papery or woody.

When a fruit develops exclusively from the ovary, it is said to be true fruit. Mango, guava, grapes, etc. are the common examples of true fruits. But when in addition to the ovary, some other floral parts like tepals (e.g., *Morus*), bracts (e.g., *Ananas*) or thalamus (e.g., *Pyrus*) also participate in the formation of the fruit, then it is known as false fruit (pseudocarps). Apple, pear, cashew but, *Ananas*, mulberry, etc., are some well known examples of false fruits.

THE SEED

The seed is a fertilized mature ovule which possess an embryonic plant, usually usually stored food material and a protective coat. After fertilization changes occur in various parts of the ovule and it transforms into a seed. The zygote develops into embryo, the primary endosperm nucleus gives rise to endosperm, and the integuments form protective coats. A seed thus has the basic structure of an ovule with some parts lost and some new ones developed.

The seed remains attached to the placenta through a small stalk-like structure, known as funicle. The place of detachment of the seed from the funicle appears as a scar, called hilum. In some seeds, a bright coloured structure develops on the surface as an outgrowth and this structure is known as aril. When aril occurs as an outgrowth of the funicle, it is said to be strophioles (e.g., *Acacia*) and when around the micropyle, is is called caruncle (e.g., *Ricinus*). In Litchi, the aril is very prominent and forms the edible part of the fruit.

Seeds are produced by the plant to ensure its perpetuation and spread to newer areas. In annual plants, seeds are the only means of their multiplication and continued existence. Seeds of cereals and legumes are the major source of human food. Several other important products of human use like fibres, oils, beverages, apices and condiments are also obtained from seeds.

CLASSIFICATION OF SEEDS

On the basis of the number of cotyledons present, seeds are classified into :

(i) dicotyledonous seeds, and (ii) Monocotyledonous seeds. Dicotyledonous seeds (e.g., gram, bean, pea, castor, etc.) have two cotyledons, whereas monocotyledonous seeds (e.g., rice, maize, etc.) have only one cotyledon.

On the basis of the present or absence of endosperm, seeds are classified into : (i) albuminous (endospermic) and (ii) Exalbuminous (non-endospermic). In albuminous seeds, cotyledons are thin and membranous and endosperm persists and nourishes the seeding during its early development. In exalbuminous seeds, food accumulates in the endosperm tissue at an early stage of development but it is utilized by the developing embryo and the mature seeds are without endosperm. In such seeds, cotyledons store food and become thick and fleshy. Monocotyledonous seeds are by and large albuminous, but in dicotyledons both albuminous and exalbuminous seeds occur.

Dicotyledonous seeds :

- **Exalbuminous** : Gram, pea, bean, mustard, mango, ground nut, etc.
- **Albuminous** : castor, poppy, custard apple (*Ananas*), etc.

Monocotyledonous seeds :

- **Exalbuminous** : orchids, *Alisma*, *Pothos*, *Amorphophallus*, *Vallisneria*, etc.
- **Albuminous** : cereals, millets, palms, lilies, etc.

STRUCTURE OF SOME COMMOND SEEDS

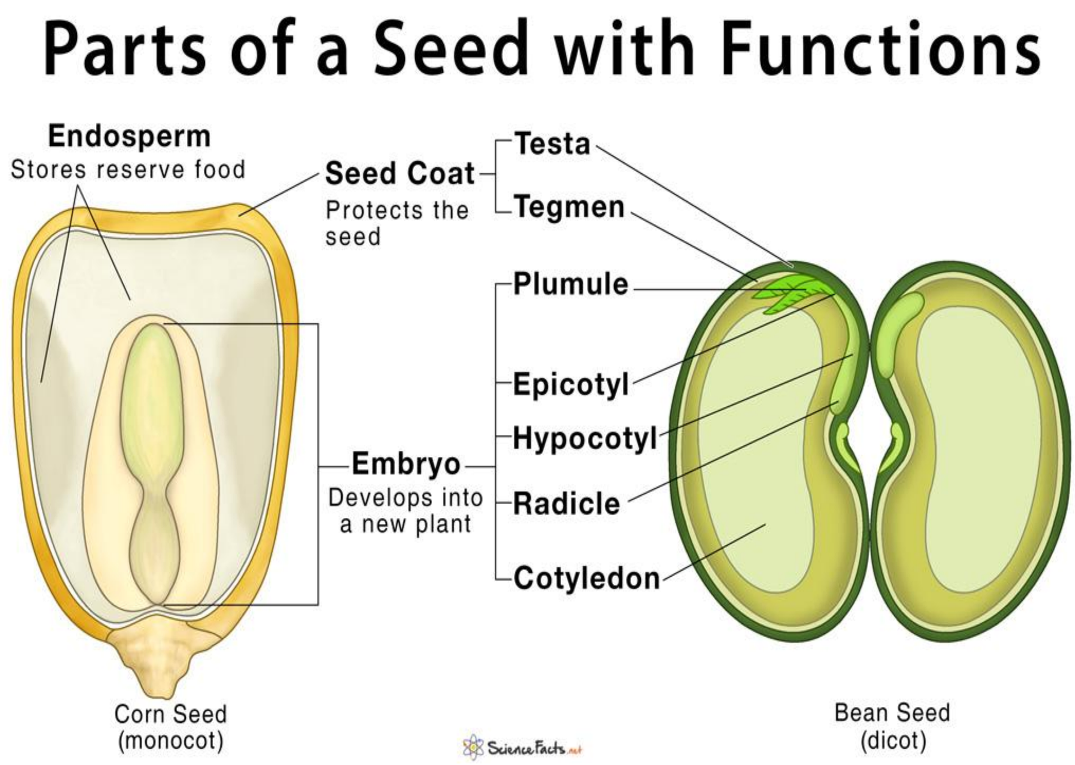
Dicotyledonous exalbuminous seed (**Bean** seed as an example). Bean seed (*Dolichos lablab*) is more or less kidney-shaped and is covered by a hard seed coat.

(i) Seed coat. The seed coat has two integuments, the outer testa and the inner tegmen. The testa is reddish-black and thick, while legmen is whitish, thin and membranous. The legmen remains fused with the testa. The seed coat provides necessary protection to the embryo which lies within. At one edge of the seed coat a whitish elongated ridge is present, which is known as raphe. The embryo receives food through raphe. A distinct broad scar present at the basal end of the raphe is said to be hilum. It represents the point of attachment of the seed to its stalk. At the other end of the raphe, away from the hilum, there is a minute pore, called micropyle. When a soaked seed is gently pressed, water and minute air bubbles can be seen ooze out through this pore.

(ii) Embryo. The entire fleshy body, as seed after removing the seed coat, is the embryo or the baby plant. It consists of (a) two fleshy cotyledons (seed leaves), and (b) a short axis to which the cotyledons remain attached laterally. The bean seed lacks endosperm and stores its reserve food in cotyledons which provide nourishment to the developing embryonal axis. The part of the embryonal axis lying towards the micropyle is called radical, and the one is between the two cotyledons is known as plumule. The retion of the embronal axis that lies between the radical and the point of attachment of cotyledons is said to be hypocotyls (below cotyledons), whereas the portion between the plumule and cotyledons is called epicotyls (above cotyledons). As the seed germinates, the radical gives rise to the root and the plumule to the shoot.

Monocotyedonous albuminous seed (Maize grain as an example). The maize grain (*Zea mays*) infact is not a seed but it is one-seeded fruit, known as **caryopsis**, where pericarp (fruit wall) is inseparably fused with the seed coat. The grains are attached to the cob by its pointed end. The following structures can be seen in the grain.

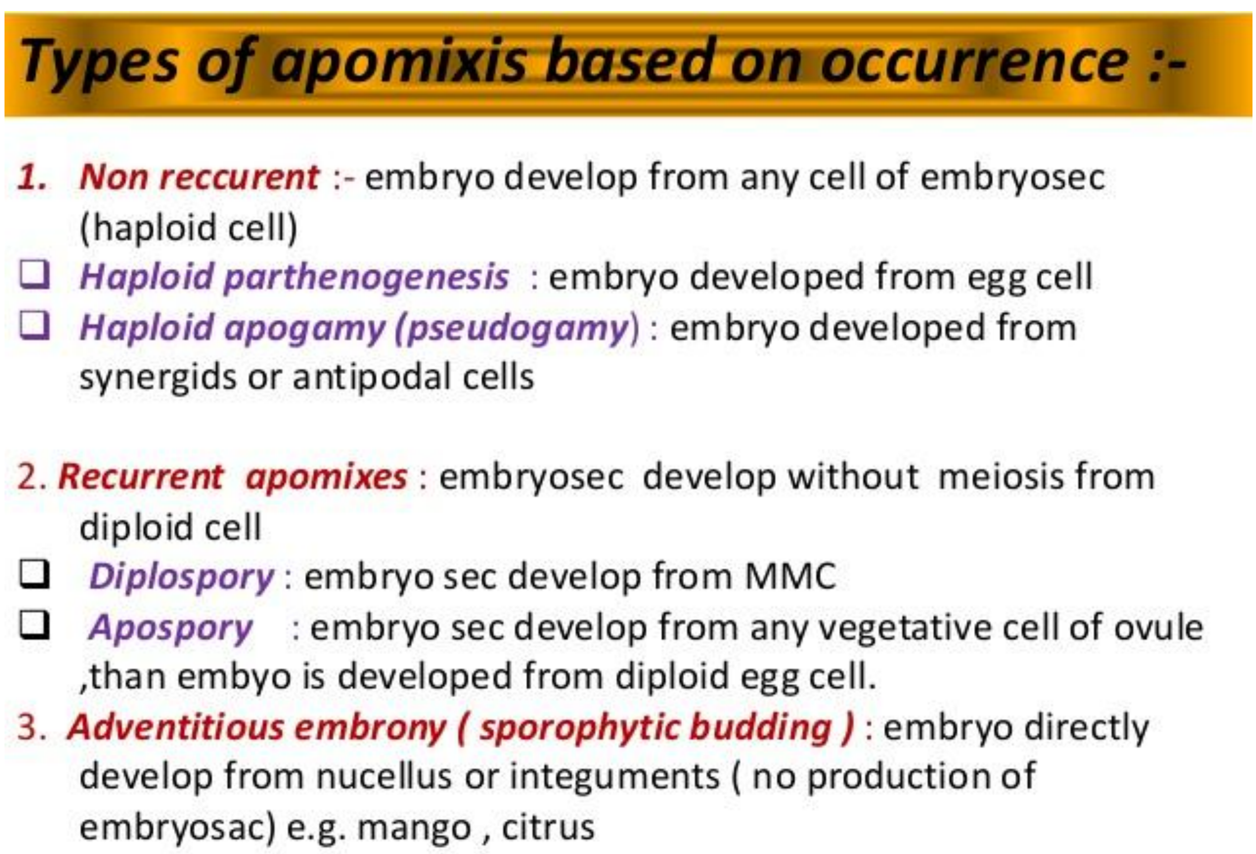
- **Seed coat**. It is represented by a thin layer which surrounds the grain. This layer is made up of the seed coat and pericarp fused together.
- **Endosperm**. Inside of the grain is divided into two unequal portions, endosperm and embryo, by an epithelial layer. The larger portion, which lies towards the broader side of the grain, is endosperm. It is the food storage tissue of the grain and is particularly rich in starch. The cells of the outermost two or three layers of the endosperm, which contain proteins, form a specialized sheath, called **aleurone** layer.
- **Embryo**. It consists (a) a single cotyledon (**scutellum**), and (b) a short axis. The shield-shaped scutellum is greatly reduced and is attached laterally to the embryonal axis. It supplies food material to the growing embryo which is absorbed from the endosperm with the helop of epithelium. The upper part of the axis with minute leaves arching over it is known as plumule and the lower part is called radicle. The plumule and radicle are surrounded by a separate protective sheath each called coleoptiles and coleorhizae respectively.

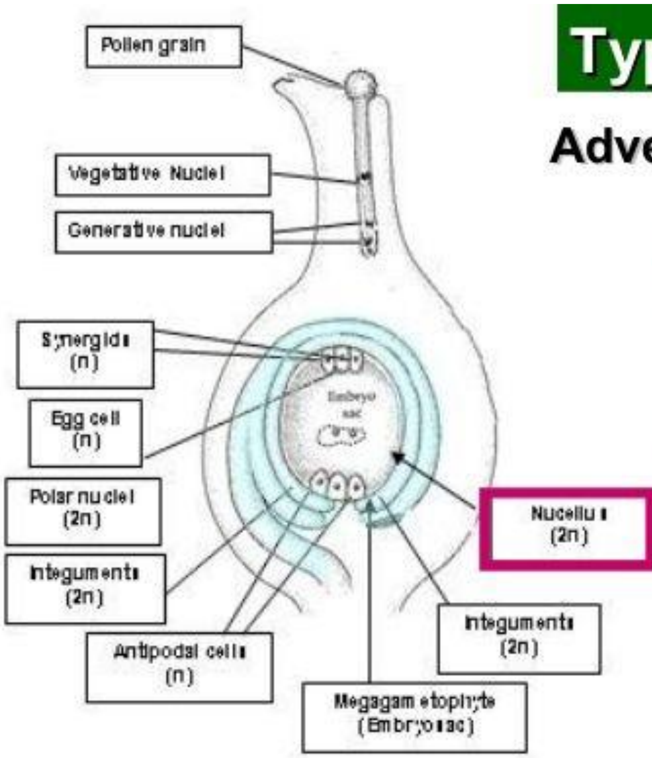


APOMIXIS

The phenomenon of substitution of sexual process by asexual methods is known as apomixes and the plants which show it are called apomictic plants. According to Winkler (1908), the term apomixes refers to the substitution of sexual reproduction by any such method which does not involve meiosis and syngamy. There are three types of apomixes : (i) Non-recurrent apomixes (ii) **Recurrent** apomixes, and (iii) **Adventive** apomixes. In **non-recurrrent** apomixes, the megaspore mother cell undergoes normal meiotic division and one of the four megaspores thus formed develops into haploid female gametophyte (i.e., embryo sac). However, there is no fertilization and the embryo develops either from the unfertilized egg (**haploid parthenogenesis**) or from some other cell of the embryo sac (haploid **apogamy**). The embryo, thus formed, is naturally haploid. The occurrence of haploid parthenogenesis is of considerable value in genetical studies as it enables to obtain true breeding homozygous forms. In recurrent apomixes the nuclei of the embryo sac are usually diploid. Such embryo sacs may arise either from a cell of the archesporium (generative **apospory**) or from some other cell of the nucellus (somatic apospory). The development of embryo from any diploid cell of the ovule lying outside the embryo sacs is referred to as adventives embryony.

As apomixes does not involve meiosis, there is no segregation and recombination of chromosomes. Thus it is useful in preserving desirable characters for indefinite periods.





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

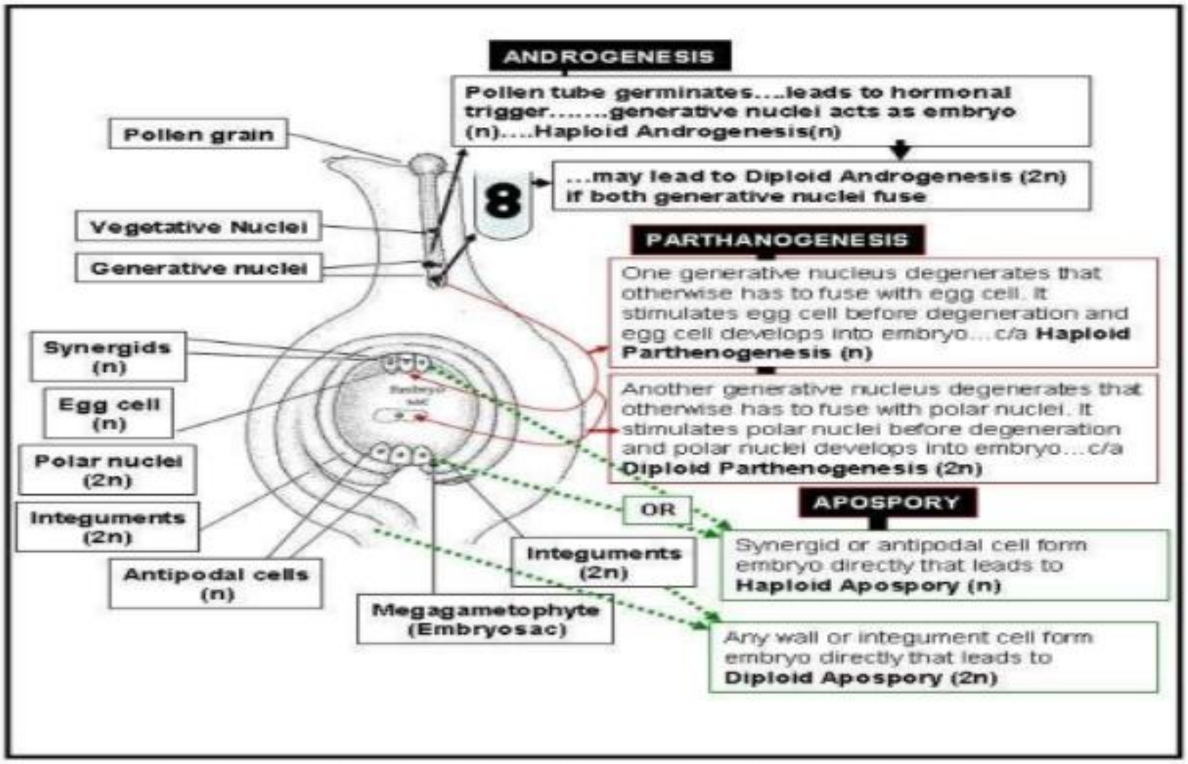
Types of apomixis

Adventitious Embryony

↓

Sporophytic apomixis = adventitious embryony

is a process in which the embryo arises directly from the nucellus or the integument of the ovule. The embryo development is initiated as a bud-like structure through mitotic division of the cell nucleus. The formation of the embryo sac is normal. Because it occurs normally, the embryo sac formation is not involved with apomixis. Sporophytic apomixis occurs commonly in *Citrus* species but rarely in higher plants.



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

PARTHENOGENESIS

Parthenogenesis may be defined as the development of female gamete into a new individual without fertilization. The megaspore mother cell undergoes the usual meiotic division to form haploid egg and embryo develops from the egg without fertilization.

Parthenogenesis can be classified on the basis of :-

- Mode of reproduction.
- Cytological characteristics. One the basis of the mode of reproduction parthenogenesis is of two types. In accidental parthenogenesis, a plant normally reproduces by sexual method but occasionally the unfertilized egg develops into embryo. But in normal parthenogenesis mode of reproduction in a plant is normal. The normal parthenogenesis may be obligatory (when embryo develops always from an unfertilized egg) or facultative (when embryos develop from both, fertilized and unfertilized eggs). On the basis of cytological characteristics of the egg the two types of parthenogenesis – Generative and Somatic – have been recognized. In generative or haploid parthenogenesis, embryo develops from an unfertilized haploid egg, whereas in somatic parthenogenesis embryo develops from a diploid egg without fertilization. The diploid

egg may develop either due to the absence of meiosis during egg formation or the megaspore mother cell may undergo normal meiotic division but later during the formation of embryo sac haploid nuclei fuse to give rise to a diploid egg.

As parthenogenesis provides homozygous haploids, it has much practical application in genetics and plant breeding. Any substance or treatment which can produce the same stimulating effect on the egg as produced by male gametes may be used to induce parthenogenesis. After the discovery of haploid in *Datura* by Blakeslee in 1922, many physical and chemical treatments have been used successfully to induce parthenogenesis.

PATHENOCARPY

Fertilization usually has stimulating effects on all parts of the flower, particularly the ovule. After fertilization the ovary develops into fruit and ovules into seeds. In some plants, however, normal fruit development may occur without fertilization. The fruits which develop without fertilization are called parthenocarpic fruits and this phenomenon is described as **parthenocarpy**.

Parthenocarpic fruits are produced normally in many cultivated plants such as banana, citrus, grape, pineapple and some varieties of apple and pears. These fruits may be produced due to :-

- Absence of pollination.
- Failure of fertilization
- Zygotic sterility.

Parthenocarpic fruits are of great significance in horticulture. Such fruits have comparatively higher proportion of edible part than the normal fruits.

POLYEMBRYONY

After fertilization, ovules mature into seeds. Normally, a single embryo is present in each seed. But sometimes more than one embryo are present in a seed. This condition is known asa polyembryony. In nature, there are many plants whose seeds have more than one embryo.. But in such plants normally only one embryo matures and the rest degenerate during the course of seed development. Thus, the mature seed has only one embryo.

Polyembryony was first time reported by Antony van Leeuwenhoek in 1719 in the seeds of orange. Since then it has been observed in a large number of seed bearing plants.

The following four types of polyembryony have been reorganized in angiosperms :

- Cleavage polyembryony, which develops due to splitting or cleavage of the proembryo.
- Formation of embryos by cells of the embryo sac other than the egg.
- Develoopment of more than one embryo sacs within the same ovule.
- Development of embryo sac from any sporophytic cell of the ovule.

Cleavage polyembryony is the common and simplest method of the development of more than one embryo in a seed. Two or more embryos are formed in a seed by the cleavage of the zygote or proembryo.

Several theories hae been advanced to explain the occurrence of polyembryony. The necrohormone theory, proposed by Haberlandit (1921, 22) states that degenerating cells of the nucellus act as source of stimulus to the adjacent cells to divide and form adventives embryos. On the other hand, according to recessive gene theory proposed by Kappert (1933), polyembryony is a recessive genetic character, controlled by multiple genes.

Adventive polyembryony is of great significance in horticulture and plant breeding. It provides uniform seeding of the parental line, as obtained through vegetative propagation by cuttings. Moreover, the nucellar embryos are free from diseases.

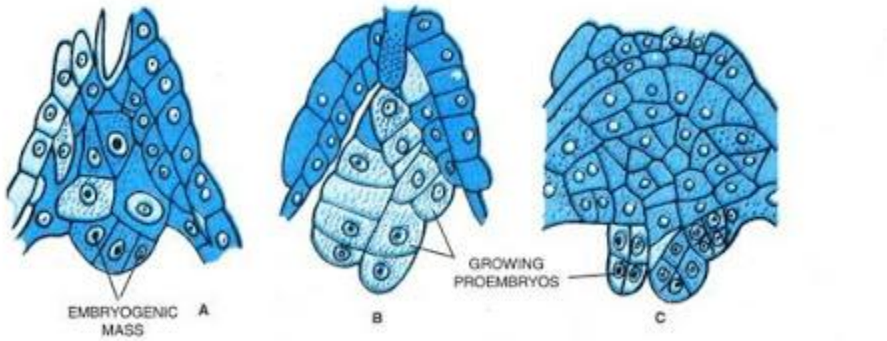
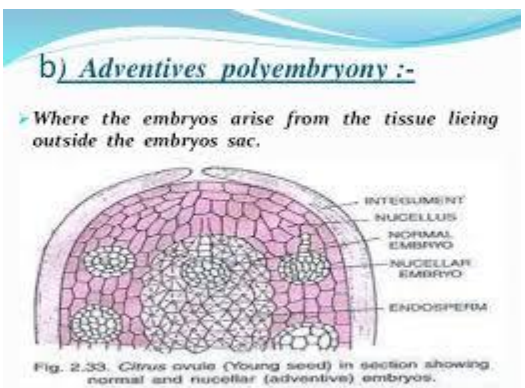


Fig. 2.35. A-C. Cleavage polyembryony : **A.** Embryonic mass formed by the basal cell of the zygote in *Erythronium americanum*, **B-C.** Differentiation of embryos from the cells of the embryonic mass.



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