S.Y.B.Sc. Botany CBCS Pattern

BO 241: Plant Anatomy and Embryology

Credit-II Plant Embryology

Chap – 9 Megasporangium and female gametophyte

Semester IV, Paper I- 2020-2021

BY

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Learning Objects

- 9.1 Structure of Ovule
- 9.2 Types of ovules
- 9.3 Types of megaspore tetrads
- 9.4 Female gametophyte: structure of typical embryo sac
- 9.5 Types of embryo sacs – monosporic, bisporic and tetrasporic

Introduction

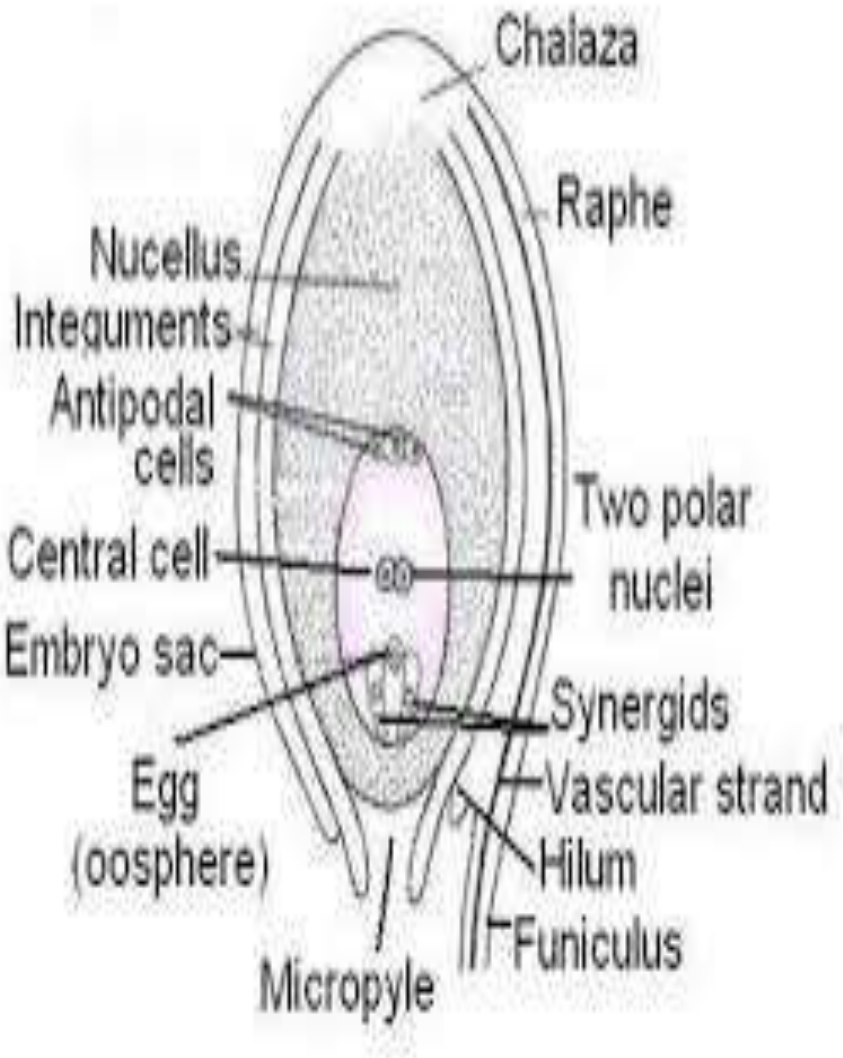
- The gametophyte in Angiosperms develops within sporophytic tissue –the sexual organs of the flower. The male gametophyte (developing pollen grain composed of two sperm cells encased within a vegetative cell) develops within the anther, fertile part of the stamen . The female gametophyte (embryo sac) develops within the ovule which is found within the ovary.
- Gynoecium or pistil represents the female reproductive organ in a flower and carpel is a unit of it. A carpel consists of a basal swollen ovary bearing one or more ovules, a receptive stigma, and often a stalk-like style between them.
- Ovules are enclosed by the ovary wall. The part of the carpellary tissue to which the ovules are attached is called placenta and the distribution of ovules in the ovary is described as placentation.**Ovule also known as megasporangium** is the place of formation of the **megaspores** and the **female**

9.1 Structure of Ovule

- The megasporangium or ovule consists of nucellus and its protective coats, the **integuments.** It is attached to the placenta, on the inner wall of ovary by a stalk called **funiculus** (funicle) and the point of attachment of the body of the ovule to the funiculus is called **hilum.**
- A mature ovule, ready for fertilization, consists of nucellus enveloped almost completely by one or two sheaths, known as **integuments,** leaving a small opening at the apical end. This opening is known as **micropyle.** The basal region of the ovule where it is attached to the placenta by funicle, is called **chalaza** and so this side is known as **chalazal end**. Its opposite end is termed as **micropylar end,** the main passage for the entry of the pollen tube into the ovule. In the nucellus, female gametophyte is present, also known as **embryo sac.**
- Nucellar tissue is parenchymatous and represents the wall of the megasporangium. The nucellus is mostly consumed by the developing embryo sac or endosperm. Each ovule has only one nucellus.

The ovule with a single integument is called **unitegmic**, with two integuments iscalled **bitegmic** and without integument is called **ategmic.**

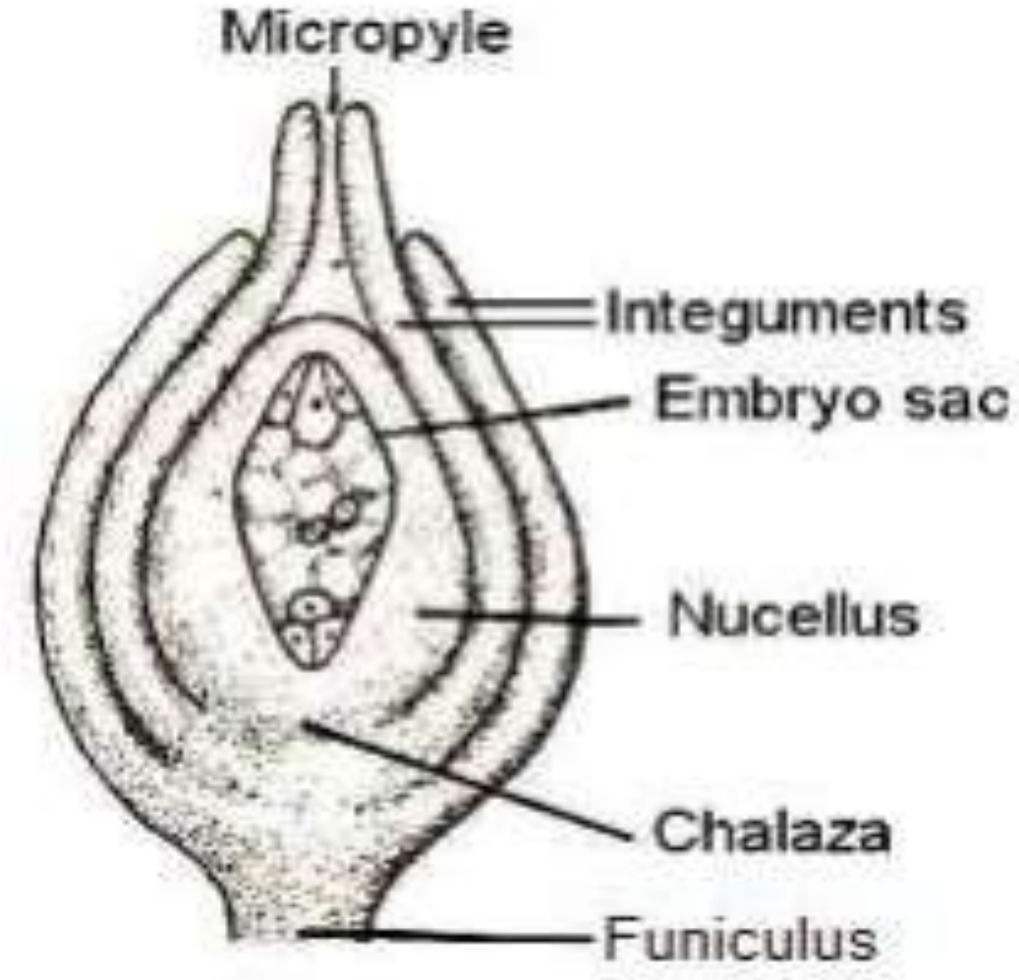
- Parts of the ovule:
- 1. Funiculus or Funicle: A stalk by which ovule is attached to the placenta
- 2. Nucellus: the body of ovule
- 3. Integument: the protective covering of nucellus
- 4. Micropyle: small opening formed by two integuments over nucellus
- 5. Chalaza: basal part of the ovule
- 6. Hilum: region where ovule fuses with funiculus
- 7. Embryo sac: female gametophyte located in the nucellus, developed from megaspore



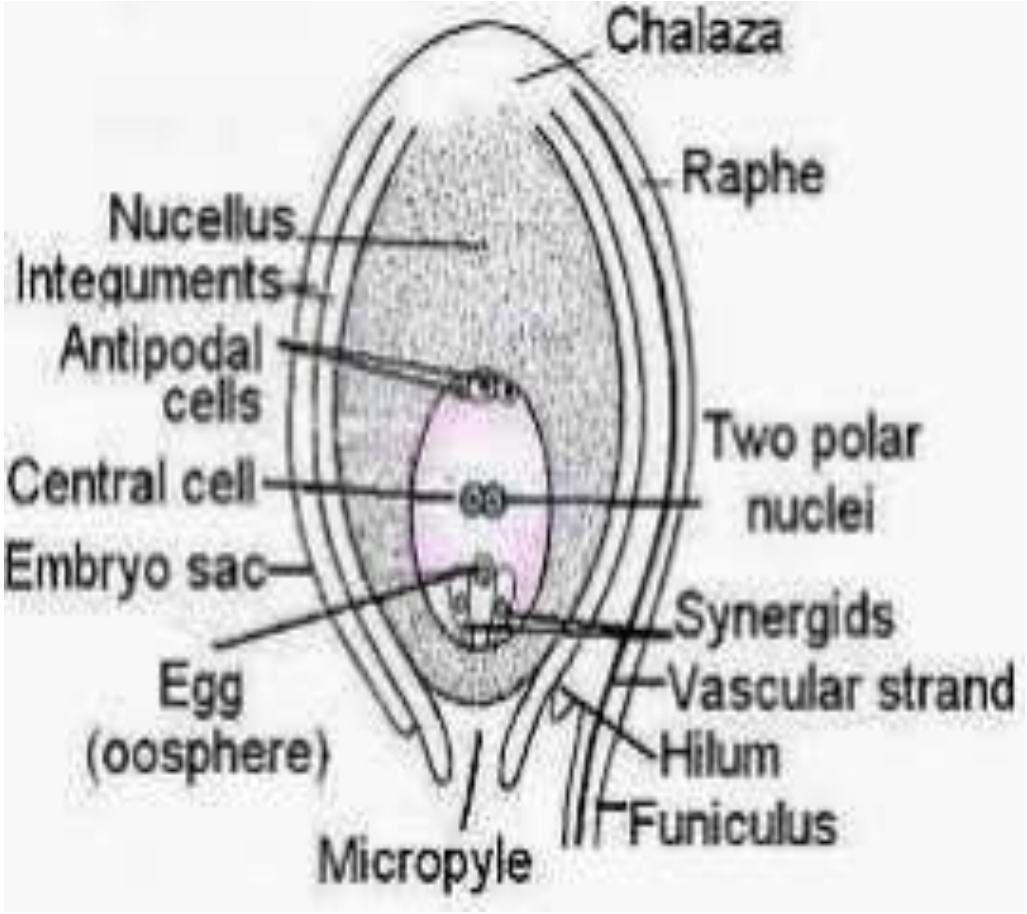
Types of ovule

- On the basis of the position of the micropyle with respect to the funiculus, mature ovule can be classified into six main types. These are:
- 1. Orthotropous
- 2. Anatropous
- 3. Campylotropous
- 4. Amphitropous
- 5. Hemianatropous
- 6. Circinotropous

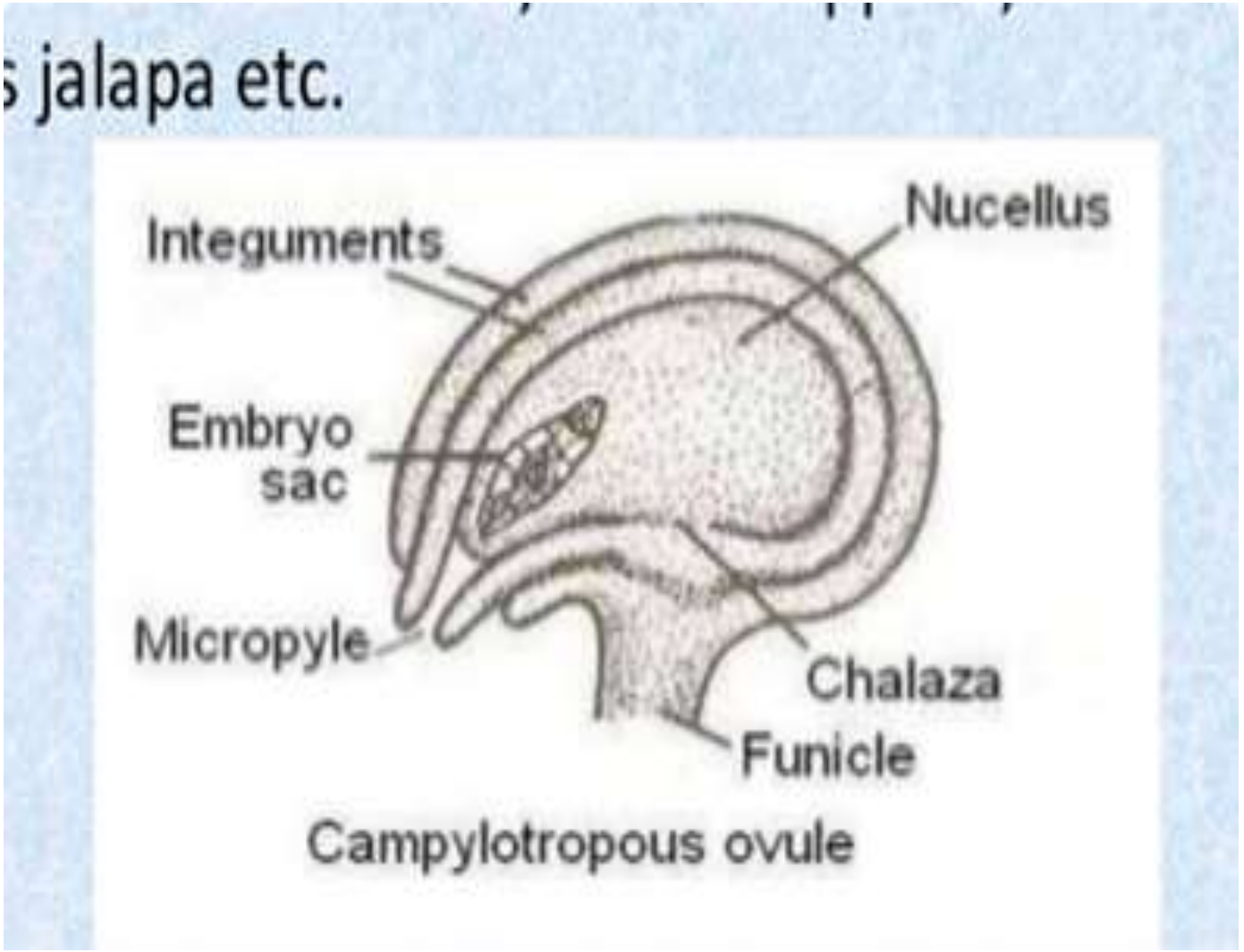
- 1. **Orthotropous ovule:** Orthotropous ovule is also known as atropous. It is upright. In this type the micropyle, chalaza and the funiculus lie in one straight line as in Polygonaceae and Piperaceae



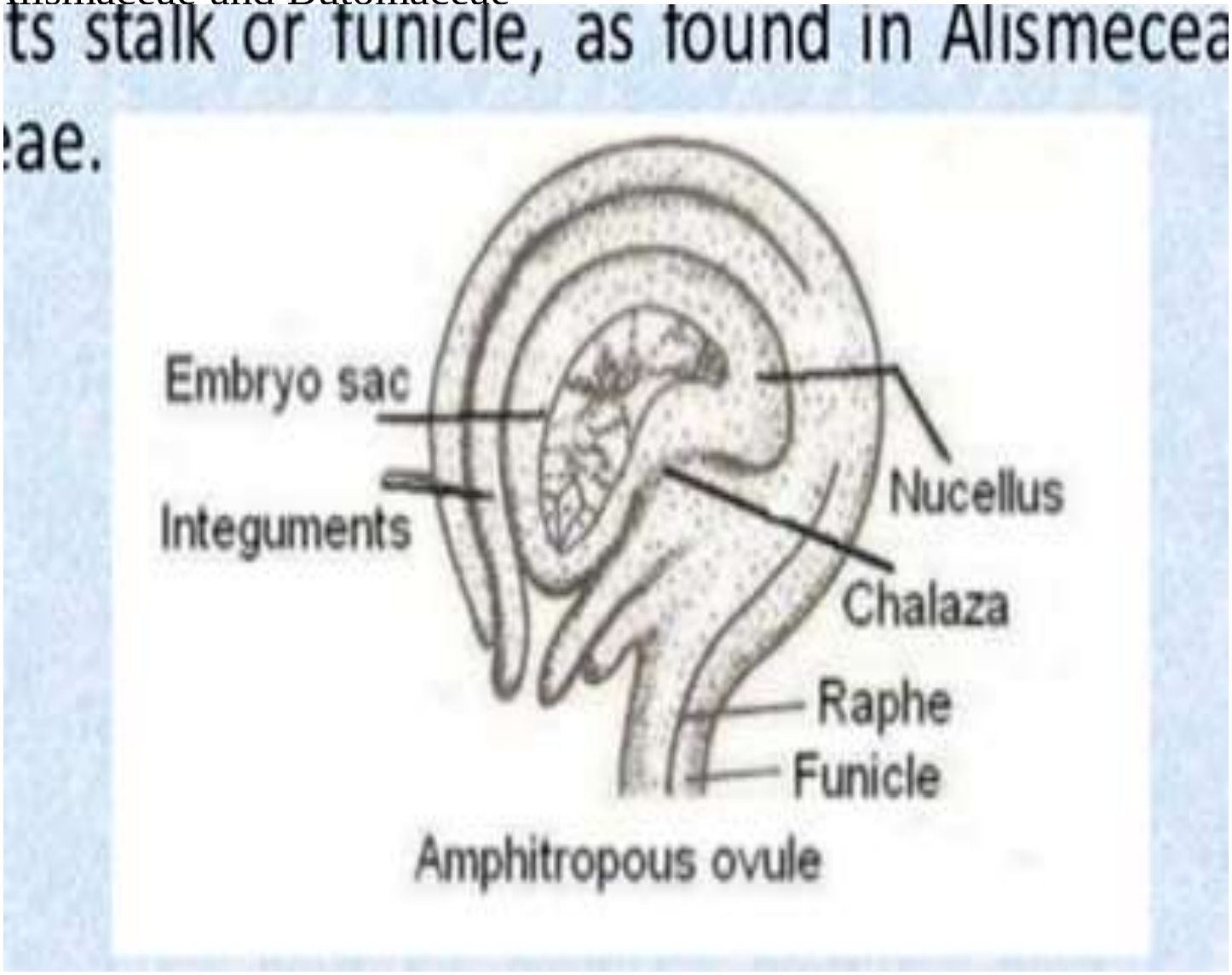
- **2. Anatropous ovule:** In this type, the funiculus is long; the body of the ovule becomes completely inverted so that micropyle comes to lie close to the base of the funiculus. This happens due to unilateral growth of the ovule. The nucellus remains straight so micropyle and chalaza lie in one line and funiculus lie parallel to it. It is the most common type of ovule inAngiosperms.



- **3. Campylotropous ovule:** In campylotropous ovules body of the ovule is not completely inverted, the curvature is less than that in anatropous ovules. The micropyle and chalaza do not lie in the straight line and the funiculus lies at right angle to the chalaza as in Chenopodiaceae and Capparaceae

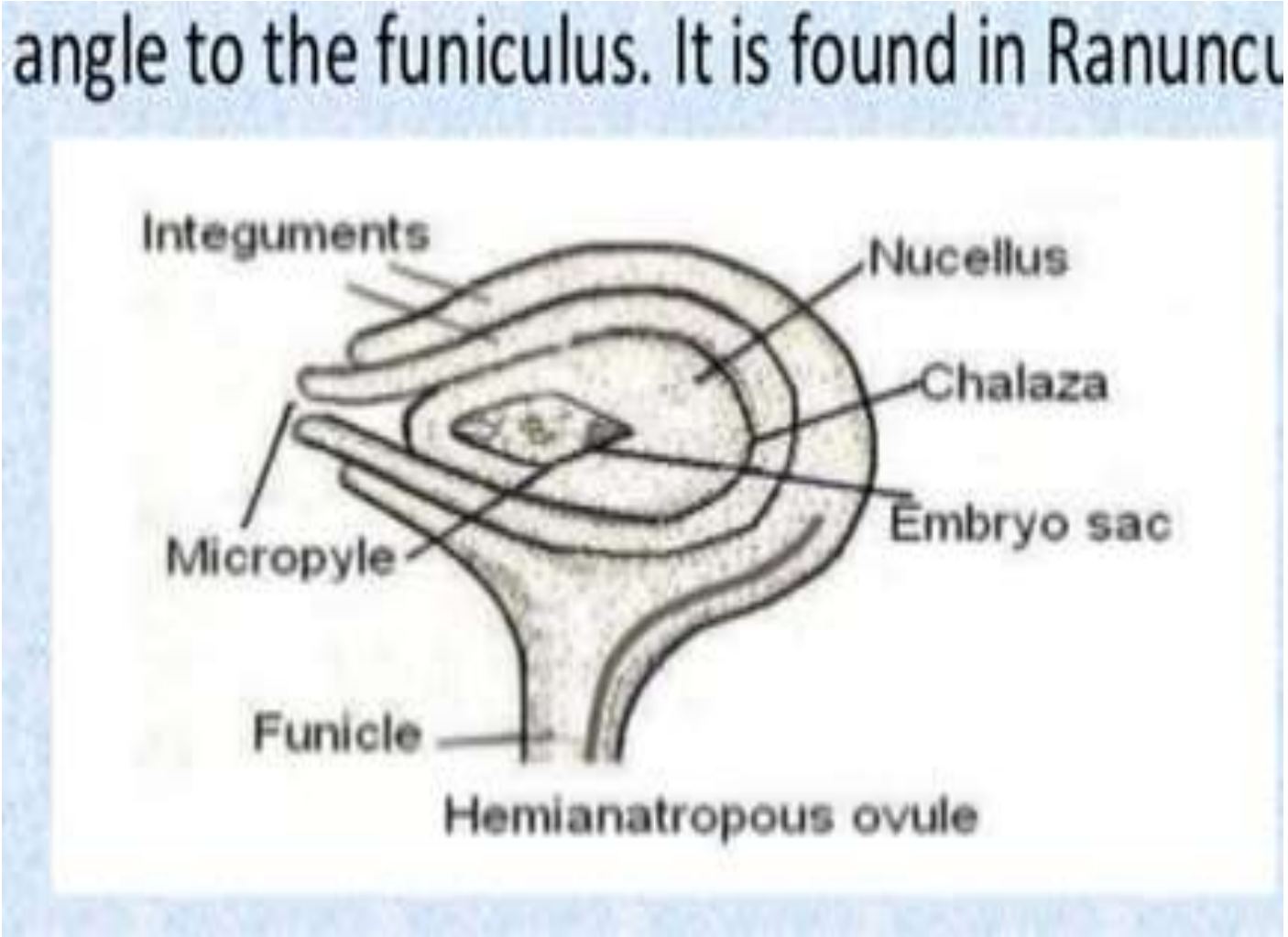


- **4. Amphitropous ovule:** It is similar to campylotropous, but in this case the curvature of the ovule also affects the nucellus/embryo-sac so that it bent like „horse shoe‟ as in Alismaceae and Butomaceae

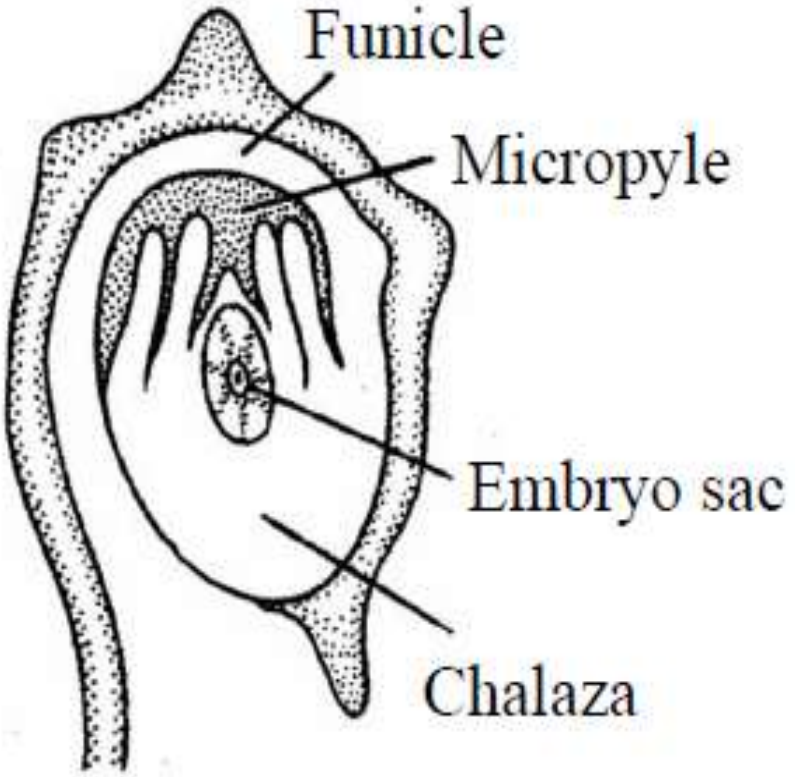


- **5. Hemianatropous ovule:** Also known as hemitropous. In this type of ovule the funiculus is at right angle to the nucellus and the integuments. Micropyle and chalaza, lie in the same plane as in Ranunculus, Nothoscordum, and Tulbaghia

angle to the funiculus. It is found in Ranuncu

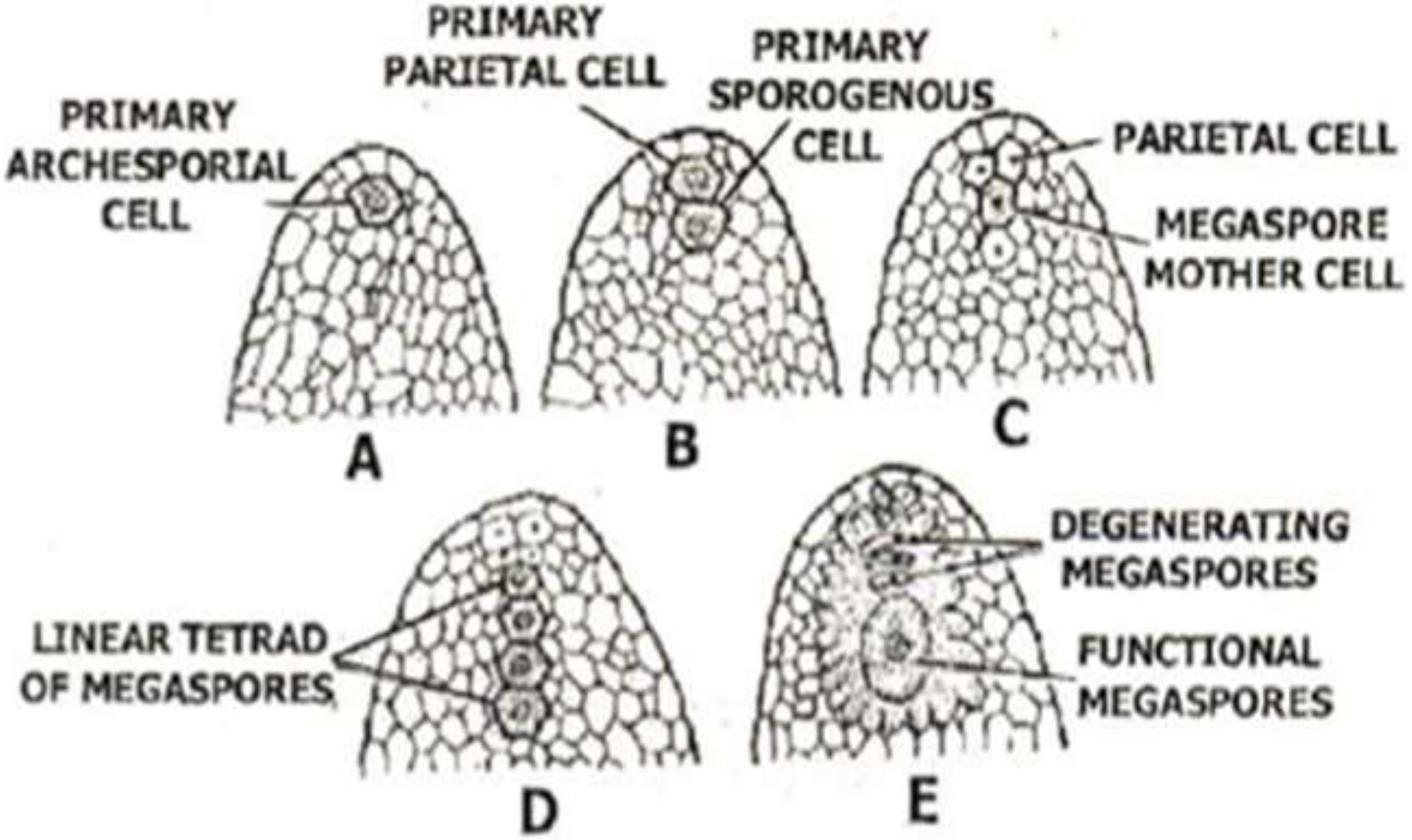


- **6. Circinotropous ovule:** A very peculiar type of ovule is seen in some members of the Plumbaginaceae. Here the nucellar protuberance is at first in the same line as the axis, but the rapid growth on one side causes it to become anatropous. The curvature does not stop but continues until the ovule has turned over completely so that the micropylar end again points upwards. It has been suggested that this kind of ovule, also seen in Opuntia, is distinctive enough to merit a separate name, Circinotropous



9.3 Megasporogenesis and Types of megaspore tetrads

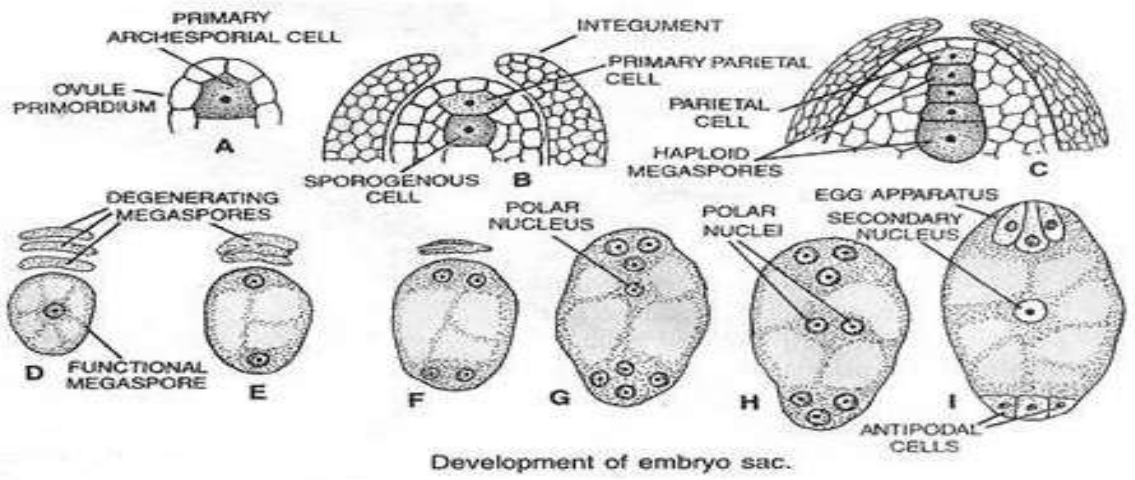
- “Development of the megaspore within the ovule (megasporangium) is known as megasporogenesis.”
- A hypodermal cell in the nucellus (at the micropylar end) differentiates and functions as the archesporium (archesporial cell). During the initial stage of development of ovule, primary archesporial cell demarked at the apex of the nucellus below the epidermis. It divides periclinal into an outer primary parietal cell and an inner primary sporogenous cell. The latter as a primary sporogenous cell which is enlarged in size and divides meiotically to form a row of four megaspores. Of the four cells, the upper three cells degenerate. While the lowest one functional and is called the functional megaspore.
- This cell forms four haploid megaspores by meitiocally, which are arranged linearly tetrad.Of the four megaspores, three megaspores which are near the micropylar end degenerate and one megaspore of the chalazal end becomes functional. This functional megaspore during development forms female gametophyte.
- The functional megaspore now forms the female gametophyte (embryo sac). Haploid tetrad of megaspores may be **T-shaped, isobilateral or tetrahedral,** T-shaped tetrad arises due to vertical division in the micropylar dyad cell and transverse division in the chalazal dyad



Various stages of megasporogenesis

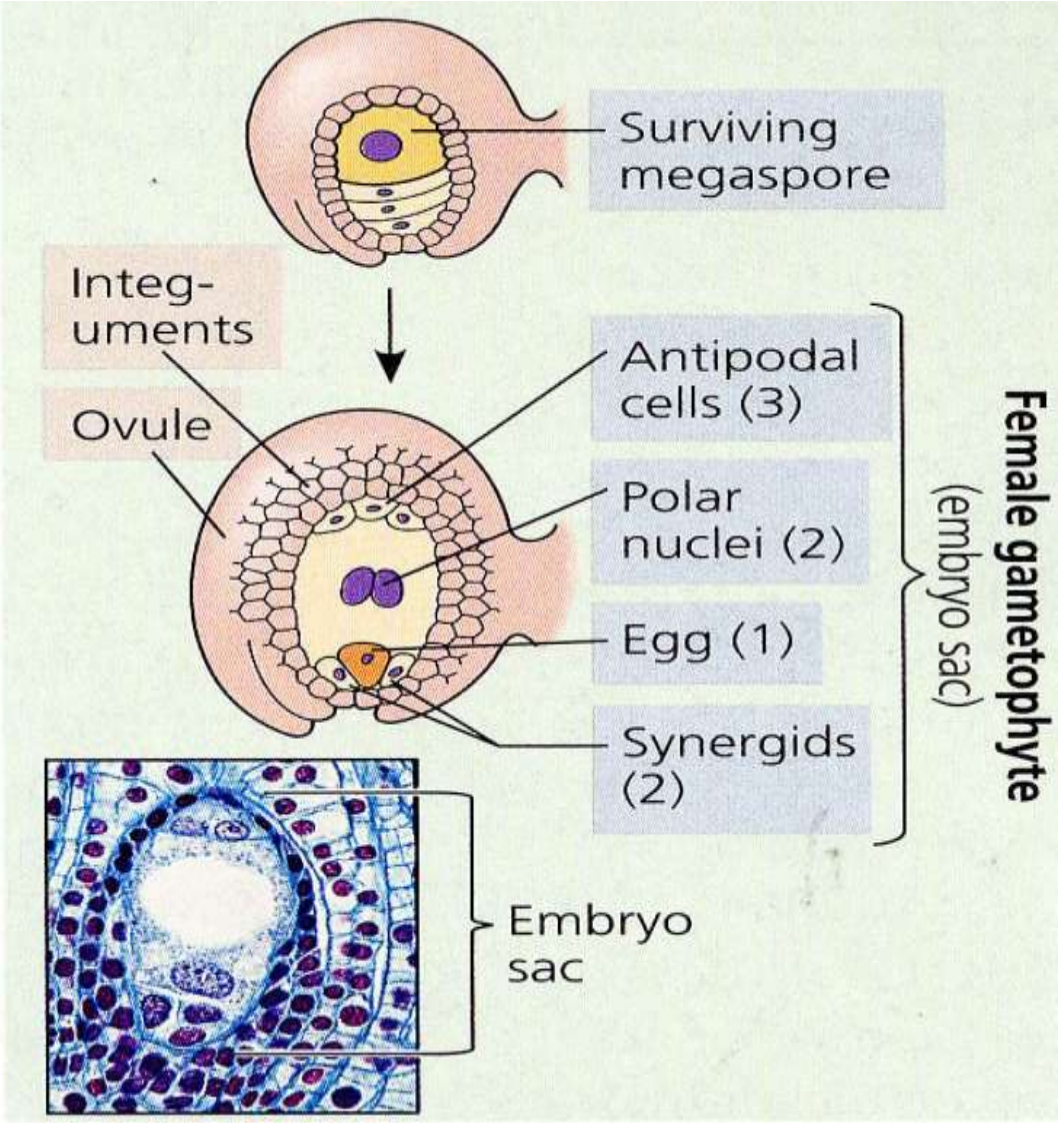
9.4 Female gametophyte: structure of typical embryo sac

- The functional megaspore is the first cell of female gametophyte. The cell enlarges and undergoes three free nuclear mitotic divisions. The first division produces two nucleate embryo sac. The two nuclei shift to the two ends and divide there twice forming four nucleate and then eight nucleate structure. One nucleus from each side moves to the middle. they are called polar nuclei. The remaining three nuclei form cells at the two ends. 3 celled apparatus at the micropylar end and three antipodal cells at the chalazal end. The two nuclei which migrates to the centre, called polar nuclei. These polar nuclei later fuse to form a single diploid secondary nucleus (a central cell).



Development of embryo sac.

- These events result in a mature seven celled structure called female gametophyte or embryo sac consisting of three antipodal cells, one central cell having two polar nuclei, two synergid cells, and one egg cell. Since, this type of embryo sac develops from a single megaspore and has eight nuclei, it is said to be monosporic eight nucleate embryo sac or Polygonum type of embryo sac.



9.5 Types of embryo sacs – monosporic, bisporic and tetrasporic

- The Polygonum type of embryo sac as described above is formed from one of the four haploid megaspore nuclei which in turn formed from **diploid megaspore mother cell** as a result of meiosis. Although it is the most common type of mode of embryo sac development in Angiosperms, even there is a substantial number of plants where more than one megaspore nuclei take part in the process.
- Therefore depending on the basis of involvement of number of megaspore nuclei in its formation, the embryo sac can be of different types:
- 1. Monosporic
- 2. Bisporic
- 3. Tetrasporic

- 1. Monosporic Embryo sac
- Monosporic embryo sac is the one where only one of the four megaspores take part in its formation as in the Polygonum type. Three of the megaspores, usually those which are at micropylar end, degenerate, leaving only one functional megaspore. In this type of embryo sac all the nuclei are genetically identical because they are formed through mitosis of a single nucleus.
- Monosporic embryo sacs are further divided into two types.
- 1. Polygonum type (8 -nucleate)
- 2. Oenothera type (4- nucleate)

- 1. Polygonum type (8-nucleate): As described earlier, it is formed by the chalazal megaspore of the tetrad and is eight nucleate. A mature Polygonum type of embryo sac comprises a 3-celled egg apparatus, three antipodal cells and a binucleate central cell .
- This type of embryo sac is the most common and is, therefore, commonly designated as the "Normal type." However, it is also designated as the Polygonum type because it was reported for the first time in *Polygonum divaricatum*
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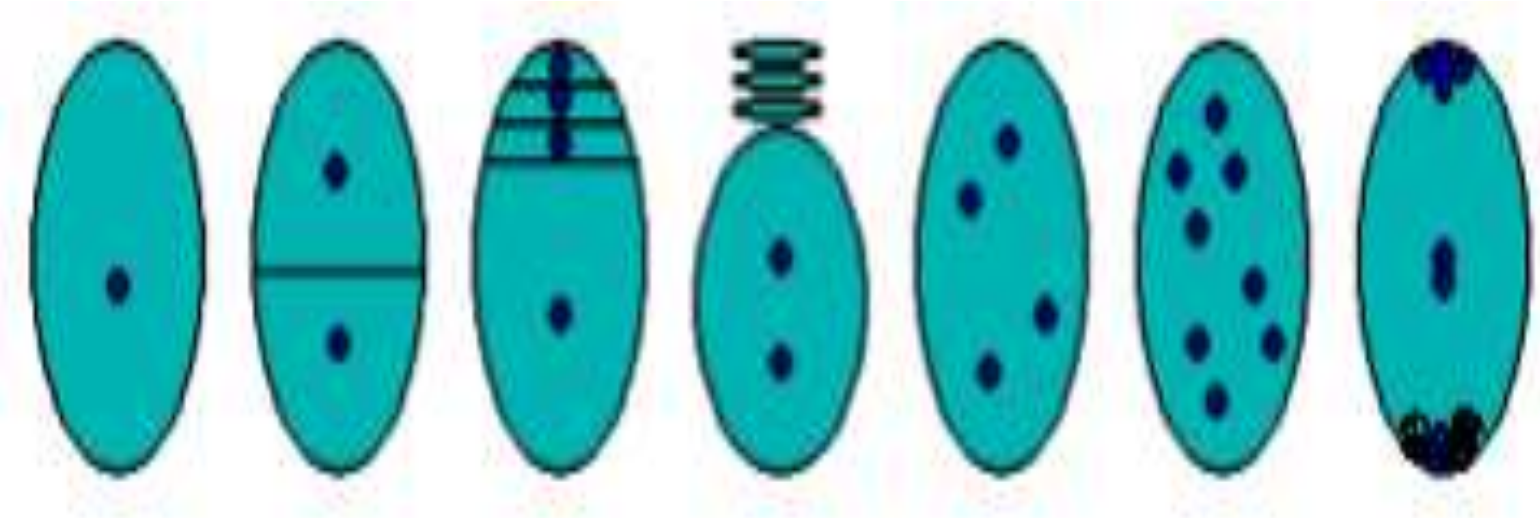
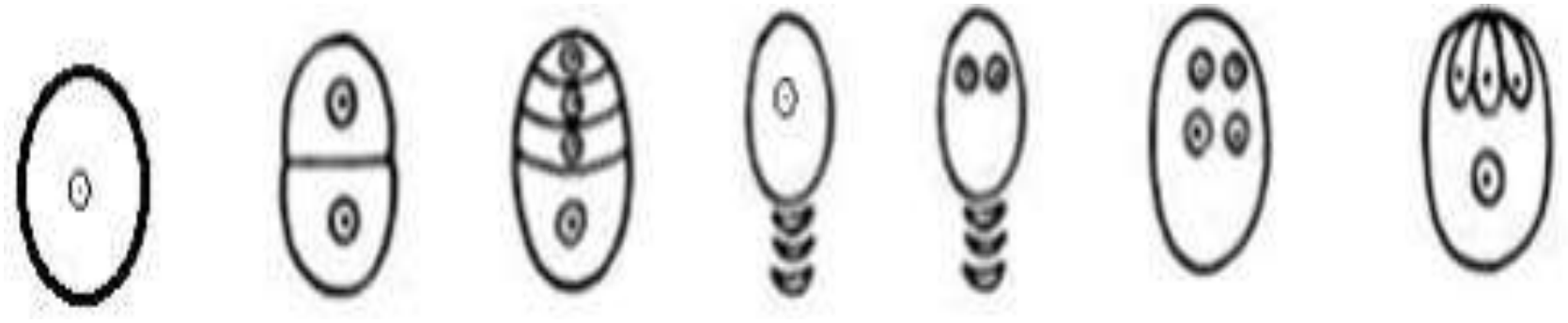
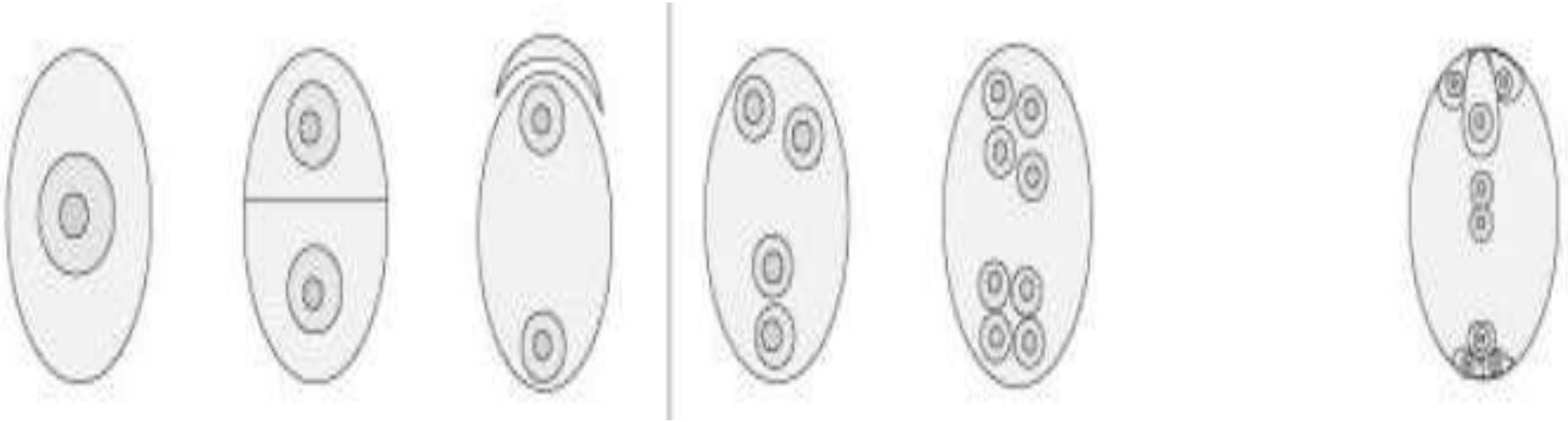


- 2. Oenothera type (4-nucleate): Oenothera type of embryo sac is derived from the micropylar megaspore of the tetrad and is four nucleate. The mature embryo sac consists of an egg apparatus and a uninucleate central cell. Oenothera type of embryo sac is found in Onagraceae family
- in *Oenothera lamarckiana* the embryo sac is usually formed by the micropylar megaspore of the tetrad, which undergoes only **two nuclear divisions** instead of the usual three occurring in the Polygonum type of embryo sac. In this way, 4 nuclei are produced which organize into the two synergids, the egg and a single polar nucleus. Since the third division is omitted and all the nuclei are situated in the micropylar part of the developing embryo sac, there is neither a lower polar nucleus nor any antipodal cells.
- Fig. : Oenothera type

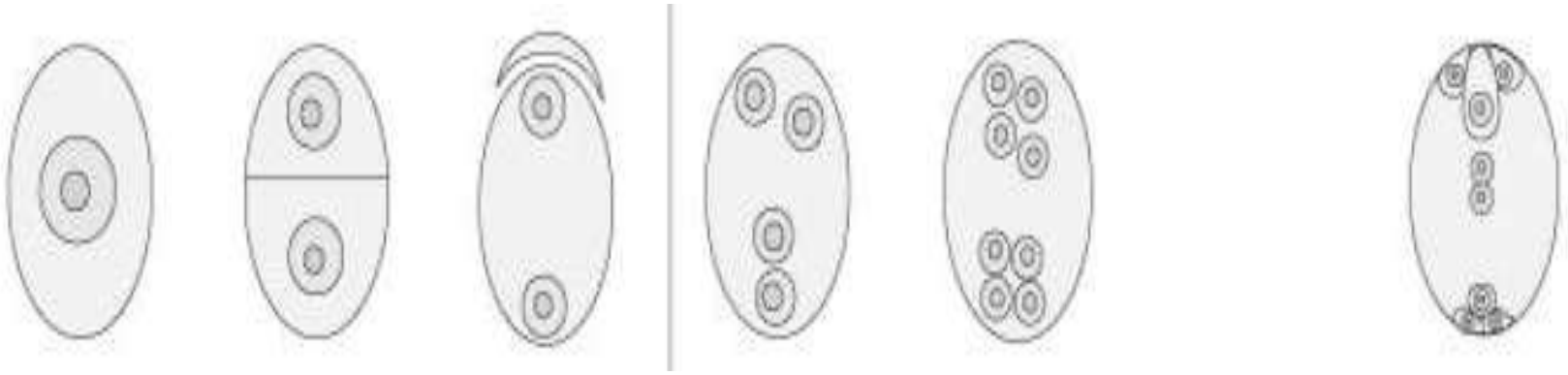


BISPORIC EMBRYO SAC DEVELOPMENT

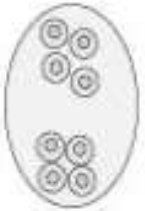
- No tetrad in megaspore development
- • From the dyad one degenerates and the other develops into embryo sac
- **1.ALLIUM TYPE**
- • Reported in *Allium fistulosum* by Strasburger in 1879
- • **The functional megaspore is the chalazal one**
- • From it by **three** mitotic divisions 8-nucleate embryo sac is formed and latter organised to 7-celled structure



- **2.ENDYMION TYPE**
- Reported in *Endymion hispanicus*
- **• The functional megaspore is the micropylar one**
- • From it by **three** mitotic divisions 8-nucleate embryo sac is formed and latter organised to 7-celled structure



TYPES OF EMBYROSAC DEVELOPMENT
MONOSPORIC & BISPORIC

Female Gametophyte Type	Megasporogenesis			Megagametogenesis			
	Mega-sporocyte	Meiosis I	Meiosis II	Mitosis I	Mitosis II	Mitosis III	Mature female gametophyte
Monosporic 8-nucleate *Polygonum* type							
Monosporic 4-nucleate *Oenothera* type							
Bisporic 8-nucleate *Allium* type							
Bisporic 8-nucleate Endymion type							

TETRASPORIC EMBRYO SAC DEVELOPMENT

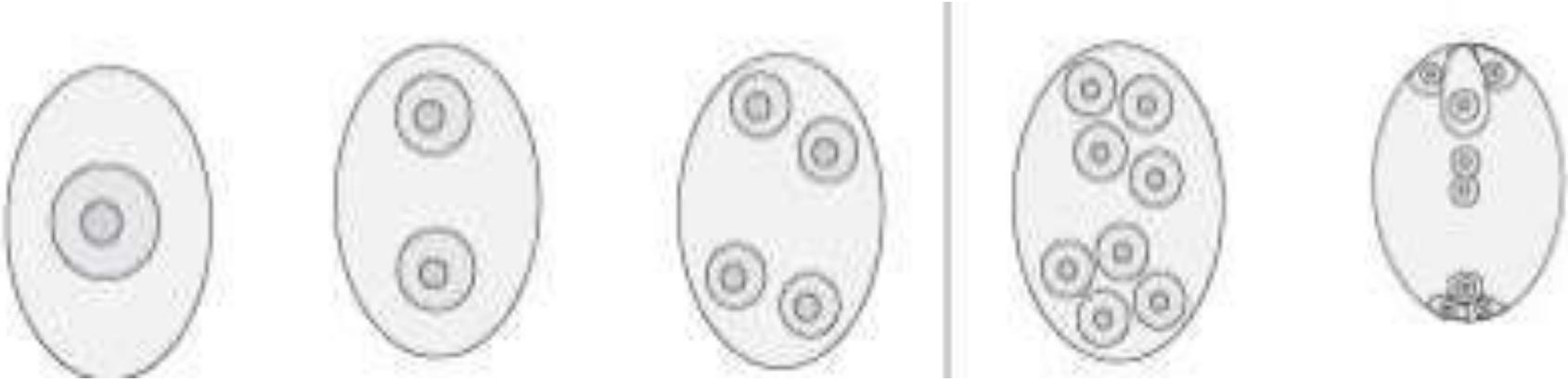
- Meiotic division of MMC is not followed by cytokinesis
- All the 4 nuclei take part in embryo sac formation
- The development of embryo sac from the 4-nucleate coenomegaspore is complicated and the further divisions vary in different species
- Based on the arrangement of nuclei, post meiotic divisions in the coenomegaspore and presence or absence of nuclear fusion various types are recognized
- Two major types, which are sub-divided again into seven types
- The two major types are:
- 1 Those without nuclear fusion
- 2 Those with nuclear fusion

ETRASPORIC EMBRYO SAC DEVELOPMENT
Without nuclear fusion

- 5 types (Two 8- nucleate and three16 nucleated)
- 1.Adoxa type (8- nucleate)
- 2. Plumbago type (8- nucleate)
- 3. Penaea type (16- nucleate)
- 4. Drusa type (16- nucleate)
- 5. Peperomia type (16- nucleate)

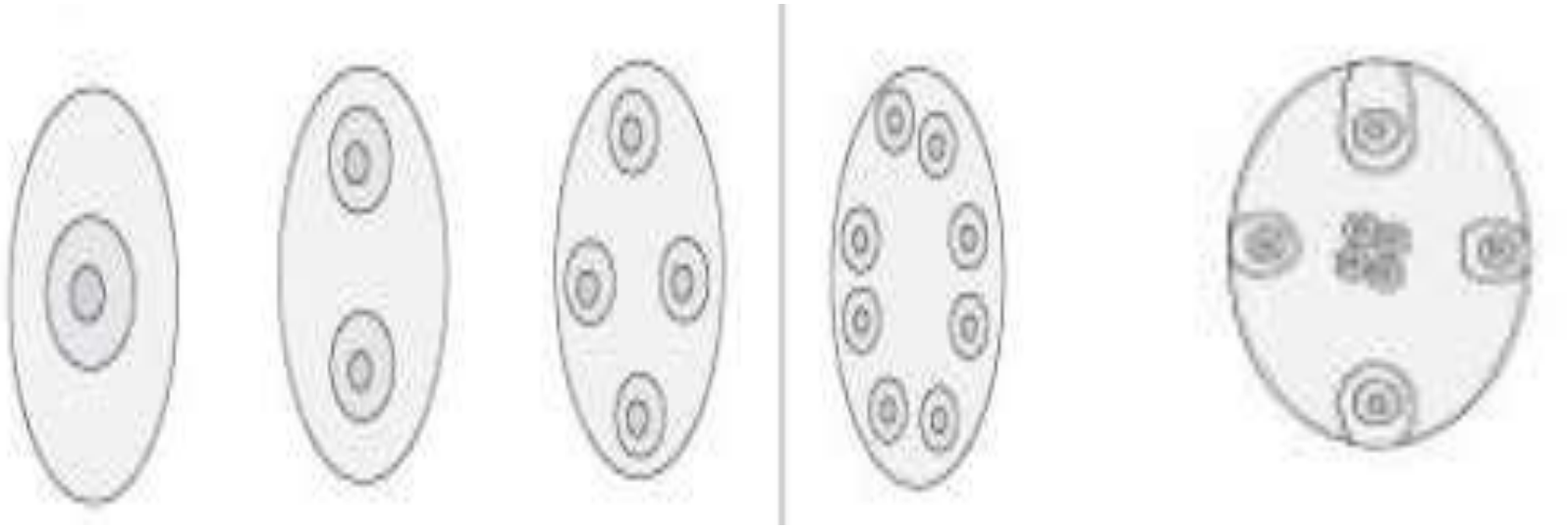
TETRASPORIC EMBRYO SAC DEVELOPMENT
8- nucleate without nuclear fusion

- 1. ADOXA TYPE
- Reported in *Adoxa moschatellina* by Jansson in 1880
- The 4 nuclei after **one mitotic** division organised into 3 celled egg apparatus, 2nucleated central cell and 3 celled antipodal



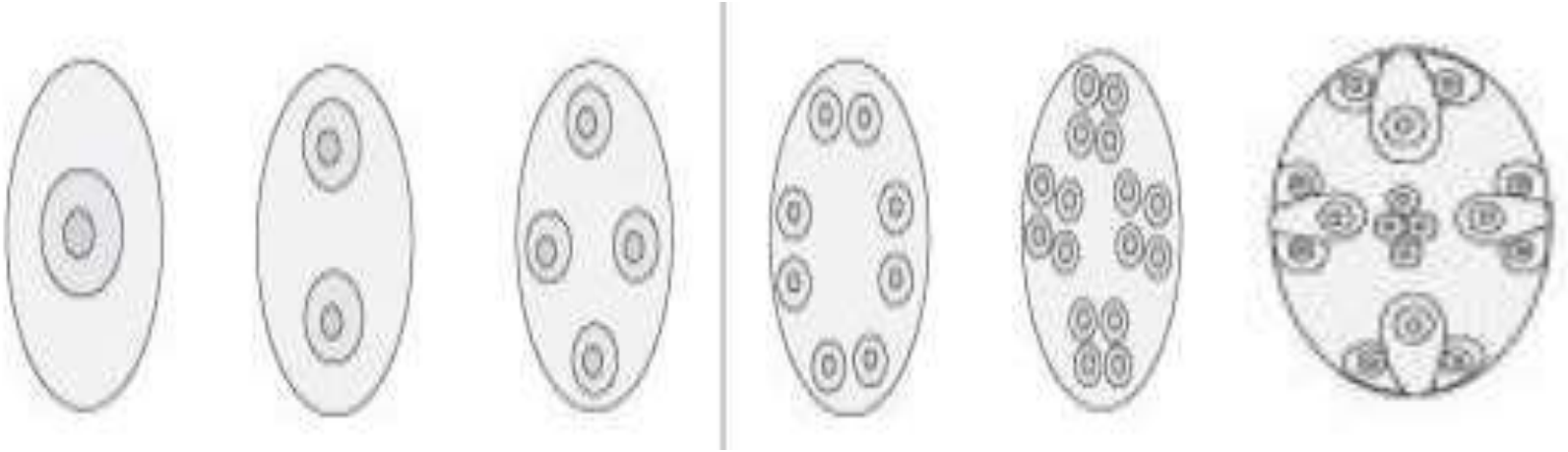
TETRASPORIC EMBRYO SAC DEVELOPMENT
8- nucleate without nuclear fusion

- 2. PLUMBAGO TYPE
- observed in *Plumbago campensis*
- Out of the 4 nuclei, after **one mitotic division**, one uninucleate egg cell, a 4 nucleate central cell and 3 uninucleate peripheral cells are formed



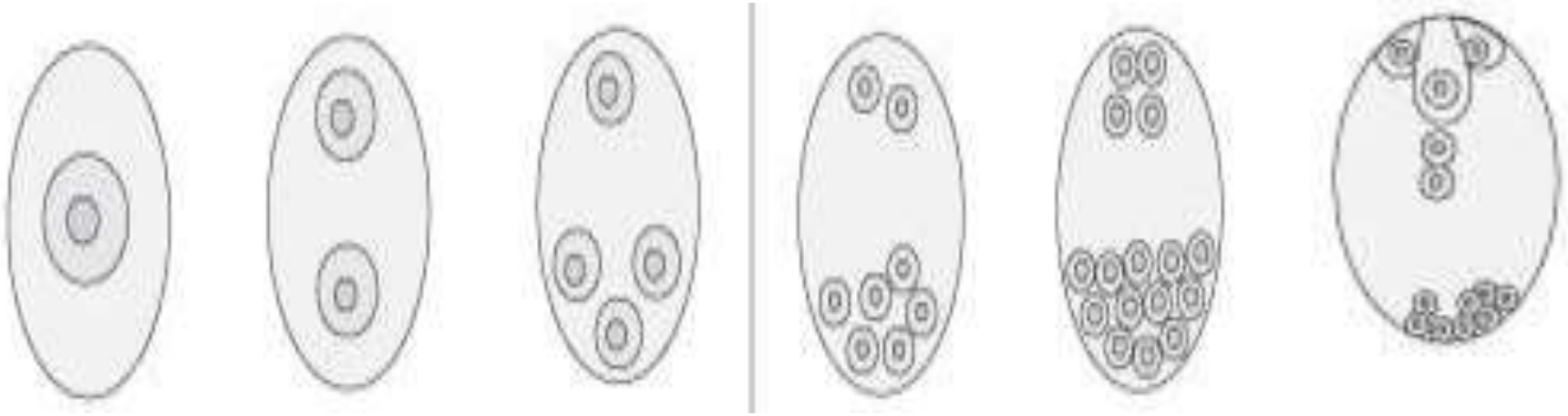
TETRASPORIC EMBRYO SAC DEVELOPMENT 16 nucleate without nuclear fusion

- 3. PENAEA TYPE
- Reported in Penaea, Brachysiphon and Sarcocolla
- The 4 nuclei by two mitotic division 16 nuclei are formed
- They are arranged in 3+3+3+3+4 condition as 3-celled micropylar egg apparatus, 3-celled chalazal antipodals, two lateral groups of 3 cells and 4 functional polar nuclei at the centre



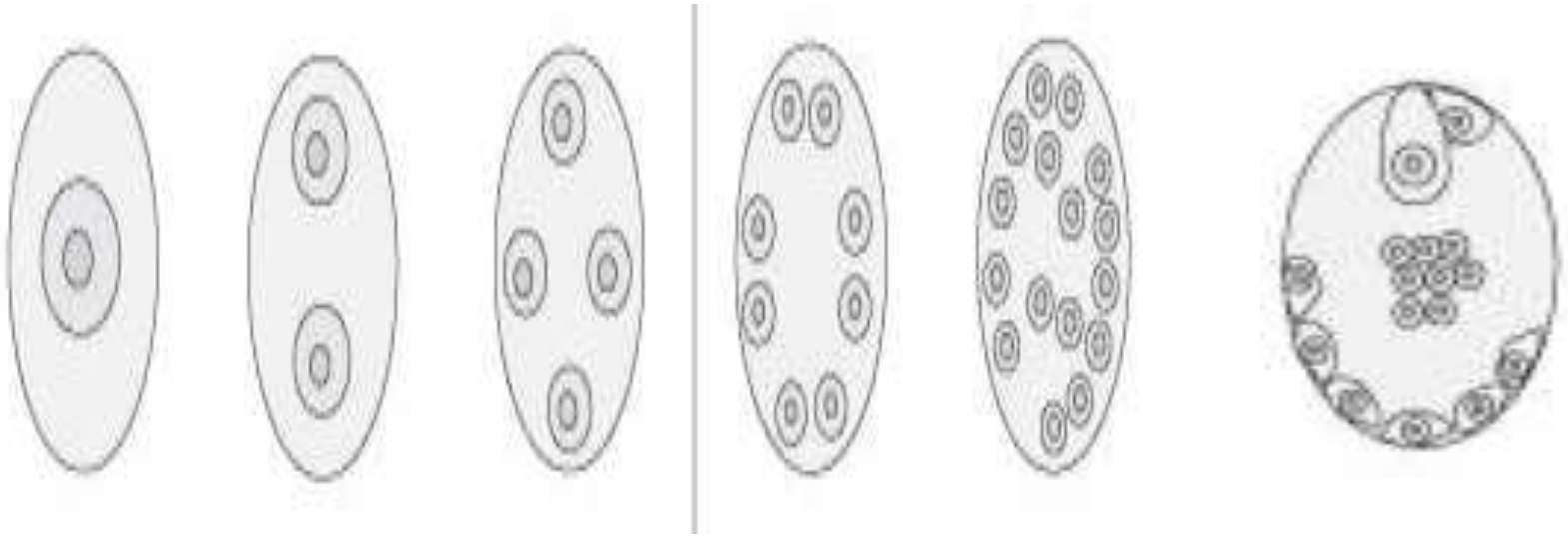
TETRASPORIC EMBRYO SAC DEVELOPMENT
16 nucleate without nuclear fusion

- 4. DRUSA TYPE
- Observed in Drusa oppositifolia
- 16 nuclei are formed arranged as 3 celled egg apparatus+2polar nuclei +11 celled antipodals



TETRASPORIC EMBRYO SAC DEVELOPMENT 16 nucleate without nuclear fusion

- . PEPEROMIA TYPE
- Reported in *Peperomia pellucida*
- 16 nuclei are formed arranged as 2 celled egg apparatus, a central cell with 8 polar nuclei and 6 uninucleate peripheral cells

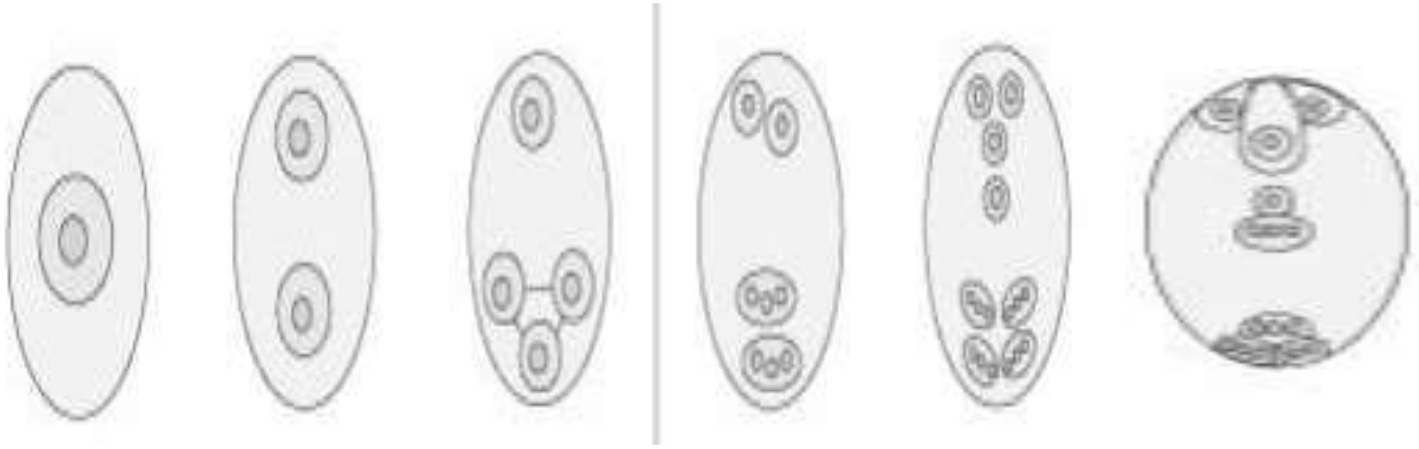


TETRASPORIC EMBRYO SAC DEVELOPMENT
8- nucleate with nuclear fusion

- Out of the **4 nuclei 3 fused to form a triploid nucleus at chalazal end**
- One remains as haploid at the micropylar end
- Two variations are reported
- Fritillaria type
- Plumbagella type

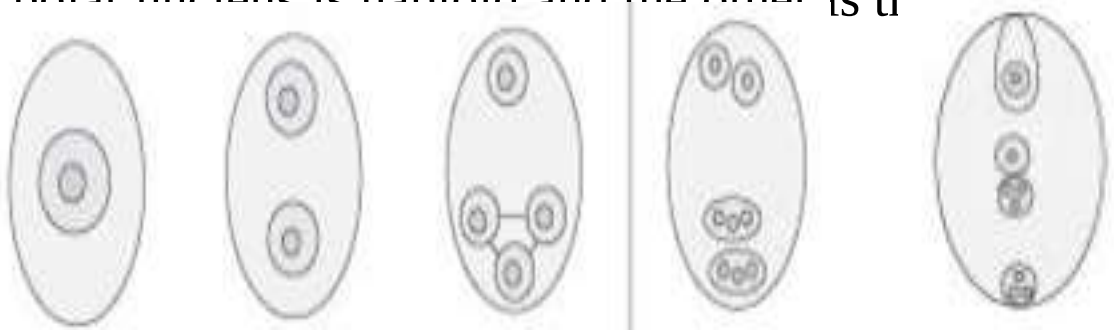
TETRASPORIC EMBRYO SAC DEVELOPMENT 8-nucleate with nuclear fusion

- 1. Fritillaria type
- Present in various species of *Lilium*
- Both haploid and triploid nuclei divide twice mitotically to form an 8- nucleate embryo sac
- 3-celled haploid egg apparatus, 3- celled triploid antipodal and two polar nuclei are organized
- One polar nucleus is haploid and the other is triploid



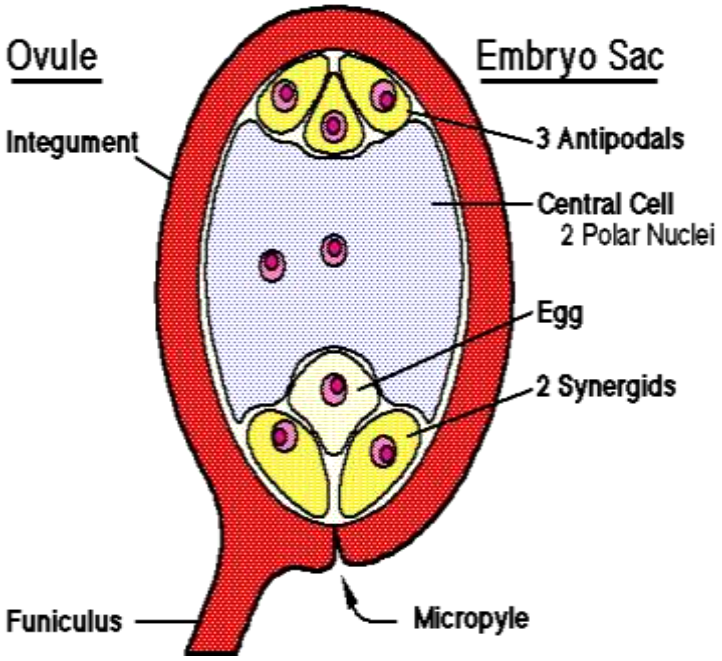
TETRASPORIC EMBRYO SAC DEVELOPMENT
8- nucleate with nuclear fusion

- 2. Plumbagella type
- Reported in *Plumbagella micrantha*
- Both haploid and triploid nuclei divide mitotically to form a 4- nucleate embryo sac
- Out of the 2 haploid nuclei at the micropylar end one remains as the 1-celled haploid egg apparatus
- The other moves to the centre as haploid polar nucleus
- At the chalazal end one haploid antipodal cell is organised and the other haploid nucleus moves to the centre as polar nucleus
- One polar nucleus is haploid and the other is tri



STRUCTURE OF MATURE EMBRYO SAC

- It is ellipsoid with thick, multilayered pecto-cellulosic cell wall, sometimes covered by cutin
- The cell wall is without plasmodesmata
- A mature embryo sac is generally a seven-celled structure consisting of one central cell, one egg cell, two synergid cells, and three antipodal cells
- The central cell is initially binucleate, but later the nuclei fuse to form a diploid secondary nucleus



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