VIVEKANANDA COLLEGE

THAKURPUKUR

KOLKATA-700063

NAAC ACCREDITED 'A' GRADE

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Name of the Department:	Botany (Morning)

Reproduction of Cycas

Cycas reproduces both by vegetative and sexual methods:

I. Vegetative Reproduction:

- *Cycas* reproduces vegetatively by means of **bulbils or adventitious buds**.
- These bulbils develop from the parenchymatous cells of the cortex in the base of the stem at the crevices between persistent leaf bases. Initially bulbils are covered only with scale leaves, but a few foliage leaves develop with further growth.
- Bulbil arising on male plant gives rise to male plant, if it forms on a female plant it produces a female plant. This is a very common method of vegetative propagation in *C. revoluta*.

➢ The vegetative propagation in *C. circinalis* takes place **by suckers that develop on root**s. With further growth they start producing new plants.

II. Sexual Reproduction:

The sexual life cycle of *Cycas* is **diplohaplontic**. It shows **heterologous or heteromorphic type of alternation of generations** because the sporophyte (2n) and gametophyte (n) generations exhibit morphological differences. In *Cycas*, the

sporophyte (2n=22) is a complicated, independent and dominant generation whereas the gametophytes (n=ll) are inconspicuous and endosporic. The gametophytes of *Cycas* are of 2 types: male or microgametophyte and female or magagametophyte. Female gametophyte is retained whereas male gametophyte is transferred during pollination.

Cycas is strictly a **dioecious plant**, but the male and female plants are indistinguishable at the vegetative stage. The compact male cone develops at the apex of the stem in the male plant. However, *Cycas* is the only genus of Cycadaceae which **does not produce any female cone.** Instead, several megasporophylls arise spirally in acropetal succession around the stem apex of the female plant.

A. Male Cone:

The surface of male cone is covered with brown scales at a young stage. At maturity, the male cone becomes very large (40-80 cm in length), oval or conical in shape (Fig. 1.17A) which emits odour that can be smelt from quite a moderate distance. The male cone of *Cycas* is the largest among the plant kingdom.

MICROSPOROPHYLL:

- The male cone has a central cone axis and numerous microsporophylls are arranged spirally and acropetally around the axis.
- A single micro- sporophyll is a nearly triangular flattened woody structure.
- It is differentiated into a proximal wedge-shaped fertile part and a distal sterile part, tapering into an upcurved apex called **apophysis** (Fig. 1.17C).
- Numerous microsporangia (700 in *C. circinalis*, 1100 in *C. media)* are borne on the abaxial (lower) surface of the microsporophyll except at the apex and the base (Fig. 1.17B).

MICROSPORANGIA:

- Microsporangia are borne in groups of 3-5 forming **sori** that are surrounded by many single- called delicate hairs (Fig. 1.17D).
- Each sporangium is oval or circular in shape having a very short massive stalk.
- The dehiscence of sporangia takes place by longitudinal slit (Fig. 1.17D).
- The development of sporangia is of eusporangiate type.

- The sporangial wall is multilayered with a thickened epidermis and a ill- defined tapetum enclosing numerous microspore (pollen) mother cells.

MICROSPORES or POLLEN GRAINS:

- Further, microspore mother cells through meiotic division produce numerous microspores or pollen grains.
- The pollen grain is oval-shaped having a large rounded monosulcate aperture.
- The pollen is bounded by two concentric wall layers; the outer thick exine and the inner thin intine .

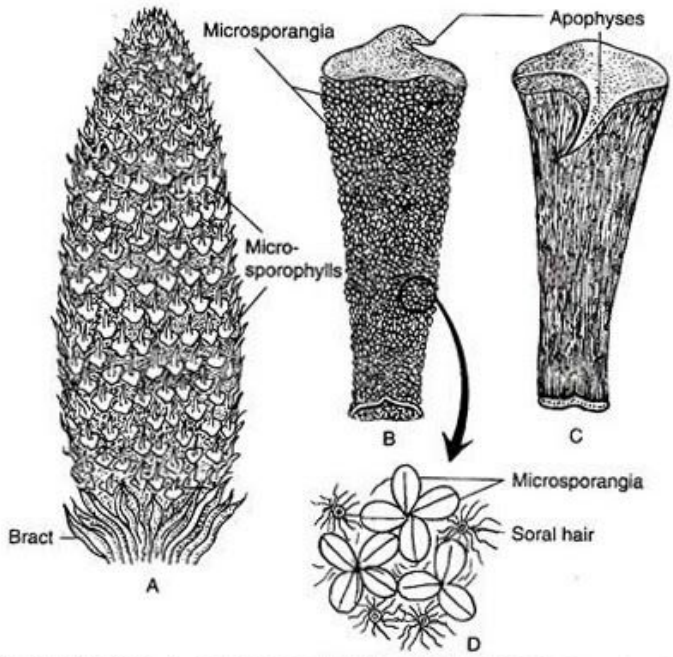


Fig. 1.17 : *Cycas* : A. A male cone, B. A microsporophyll (Abaxial view), C. A microsporophyll (Adaxial view), D. Microsporangia arranged in sori

B. Female Fructification:

- The **megasporophylls** of *Cycas* are not organised into a definite cone. Instead, they arise at the stem apex spirally and acropetaily forming a loose crown.
- The megasporophylls are pinnate in nature and are covered with brown hairs called rementa.
- Hence the megasporophylls of Cycas are considered to be the modified foliage leaves.
- A single megasporophyll is a flat dorsiventral structure, measuring up to 30 cm in length.
- It is differentiated into an **upper pinnate lamina** and a **basal stalk that bears two rows of opposite or sub-opposite, one to six pairs of ovules** (Fig. 1.18A-F).

There is a great variation in structure of megasporophylls and in the number of ovules per megasporophyll in Cycas and these criteria can be applied to identify the species of Cycas.

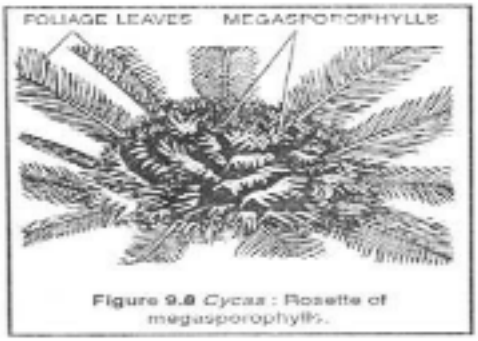


Figure 9.8 *Cycas* : Rosette of megasporophylls.

There is a great reduction in the structure of megasporophylls and in number of ovules among the various species of *Cycas*.

- ➢ *C. revoluta* is the most primitive species where the megasporophyll lamina is much dissected and tapers into a point, bearing 3-4 pairs of ovules (Fig. 1.18A).
- ➢ In *C. pectinata*, the mere serrated lamina is orbiculate with pectinate margins, bearing 2-3 pairs of ovules (Fig. 1.18 B).
- ➢ In *C. circinalis,* the lamina is lanceolate with dentate margins and acuminate apex, bearing 4-6 pairs of ovules (Fig. 1.18C). The further reduction in lamina has been observed in C. rumphii (Fig. 1.18D) and *C. beddomei* (Fig. 1.18E) where lamina is ovate-lanceolate with acuminate apex, bearing 2-3 pairs of ovules.
- ➢ The maximum reduction in megasporophyll has been noted in *C. normanbya*. Its lamina shows a mere serrated margins bearing only one pair of ovule (Fig. 1.18F).

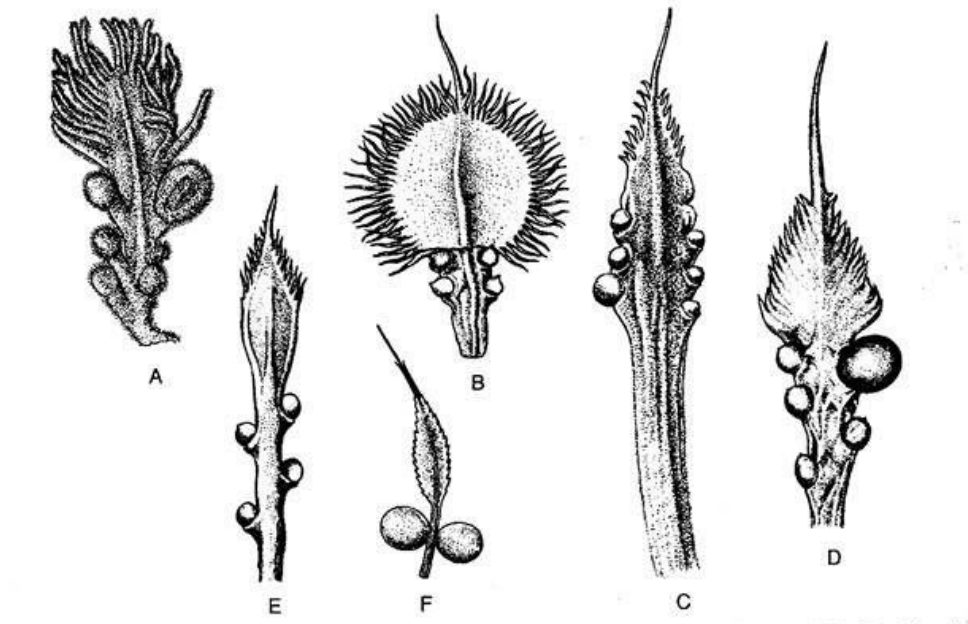


Fig. 1.18 : Megasporophylls : A. *Cycas* revotuta, B. *C. pectinata*, C. *C. circinalis*, D. *C. rumphii*, E. *C. beddomei*, F. *C. normanbyana*

Ovule:

- The ovules of *Cycas* are orthotropous and shortly stalked.
- The ovules are large, attaining a length of about 6-7 cm with a diameter of 4 cm and are perhaps the largest amongst the plant kingdom.
- The mature seeds are elliptical, bilobed and slightly flattened — they become fleshy and bright orange or red in colour.
- There is a single integument which is fused with the nucellus except the top (Fig. 1.19).
- The integument is differentiated into three layers. The outer layer is fleshy and pulpy and becomes variously coloured at

maturity. The middle layer is very hard and stony, while the inner layer is fleshy and becomes papery before maturity.

- There are frequent mucilage canals and tannin cells in the integument.The ovule is supplied with three vascular traces (Fig. 1.19).
- The median strand supplies the base of the integument, which extends up to the chalazal end of the nucellus and further ramifies abruptly. The two side strands pass to the integument which again divide — one branch supplies to the outer pulpy layer and the other to the inner soft layer.

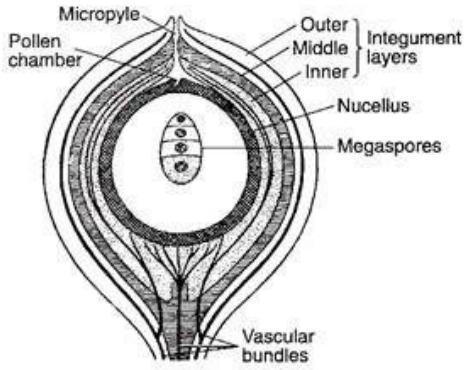


Fig. 1.19 : Vertical median section of *Cycas* ovule

- **Megasporogenesis:**

A deeply situated cell of the nucellus is differentiated into a large megaspore mother cell which undergoes meiotic division to form a linear tetrad of four megaspores. Out of the four megaspores the outer

three degenerate, while the lowermost megaspore becomes functional (Fig. 1.21 A).

The upper free opening of the integument forms the micropyle and a concavity in the top of the nucellar tissue forms the pollen chamber. After pollination, the pollen grains are collected in the pollen chamber and the development of pollen grains takes place in the nucellar tissue.

Gametophyte of Cycas:

The spore is the first phase of gametophyte generation.

The **microspore or pollen grain is the male gametophyte**, while the **megaspore represents the first stage of female gametophyte** which develops to form a female gametophyte.

Development of Male Gametophyte before Pollination:

- Each microspore divides asymmetrically into a 2-cells: a **smaller prothallial cell and a larger antheridial cell**.
- The prothallial cell does not divide further while the antheridial cell divides into a **smaller generative cell** near the prothallial cell and **a larger tube cell**.
- Finally **pollination takes place at 3-celled stage (a prothallial cell, a generative cell and a tube nucleus)** (Fig. 9.12).

- After pollination, the further development takes place within the nucellus tissue of the ovule.

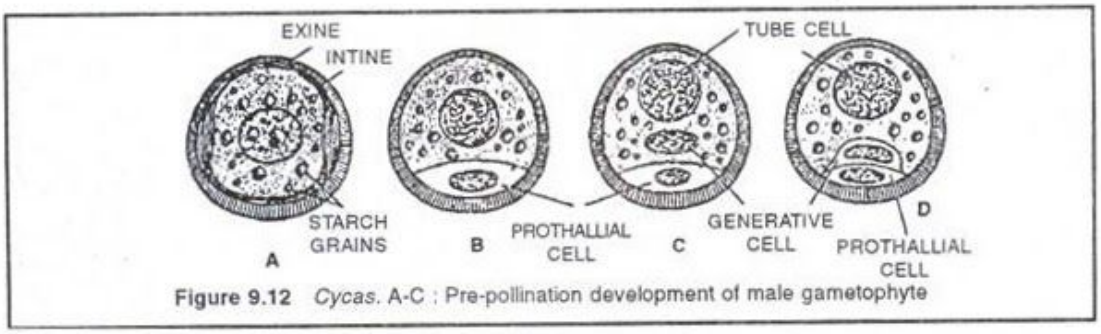


Figure 9.12 *Cycas*. A-C : Pre-pollination development of male gametophyte

Pollination:

In *Cycas* pollination is **anemophilous (**by wind). The 3-celled microspores liberated from microsporangia are blown away by wind. Finally microspores reach on ovules and get enlarged in the pollination drop (ooze) of micropyle. As the ooze dries up, the microspores are drawn into the pollen chamber.

Development of Male Gametophyte after Pollination:

- The further development of male gametophyte takes place within a week after pollination.
- The **tube cell** of 3-celled male gametophyte **comes out through the pollen aperture in the form of a pollen tube** which penetrates into the nucellar tissue.

- The pollen tube destroys all the tissues between the pollen chamber and the female gametophyte.
- Thus, the fertilisation is **siphonogamous**, though it is haustorial in nature.
- Now, the **antheridial cell within the pollen tube divides into a stalk cell and a spermatogenous (body) cell** .
- The spermatogenous cell enlarges considerably and two blepharoplasts develop at the opposite end of the spermatogenous cell.
- Then the spermatogenous cell divides to form two large, top-shaped, **motile sperms** with spiral bands bearing numerous flagella around the distal end of the sperm .
- The sperms of *Cycas* are very large (180-210 pm) and can be visible to the naked eye .

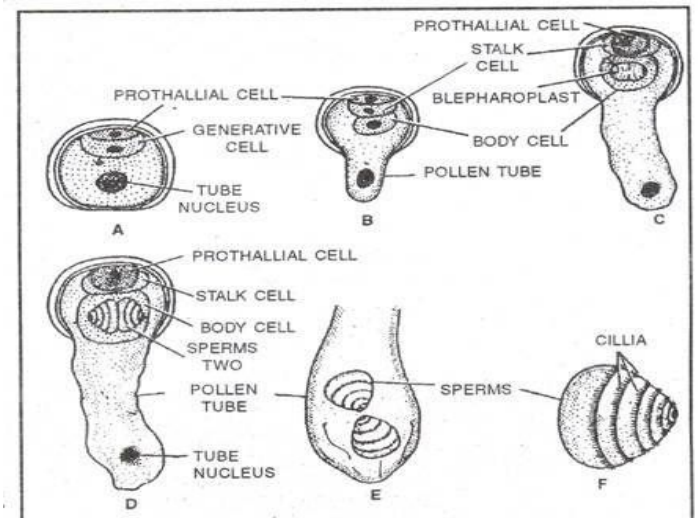
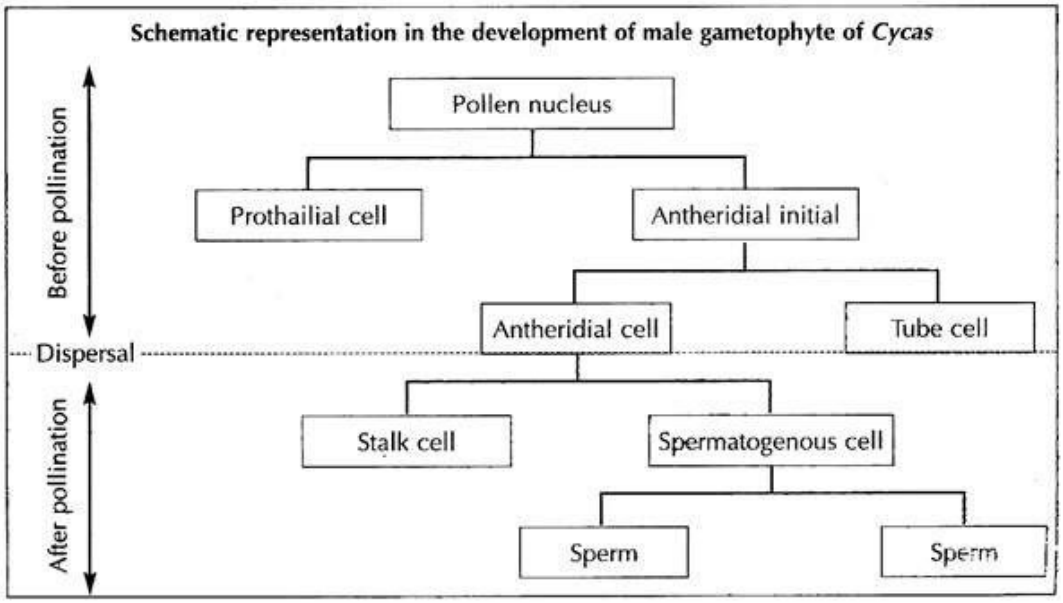


Figure 9.13 *Cycas*. A-F : Post-pollination development of male gametophyte



Development of Female Gametophyte:

- The female gametophyte of *Cycas* develops from the functional megaspore surrounded by a tough membrane that persists in the gametophyte (Fig. 1.21B).
- The nucleus of the megaspore divides by free nuclear divisions forming a large number of nuclei unaccompanied by wall-formation.
- In the meantime, the megaspore increases in size and develops a vacuole in the center which forces the cytoplasm along with nuclei towards the periphery.
- Thus the nuclei lie in a thin film of cytoplasm around the vacuole (Fig. 1.21B).

- The cell wall formation starts in a centripetal fashion, from periphery inwards. The wall formation proceeds very rapidly and as a result the central vacuole is obliterated (Fig. 1.21C).
- The entire gametophyte becomes cellular and the tissue thus formed is called endosperm. The peripheral cells of the gametophyte are small, isodiametric devoid of any food reserves, while the inner cells are large, irregular and filled up with starch grains.

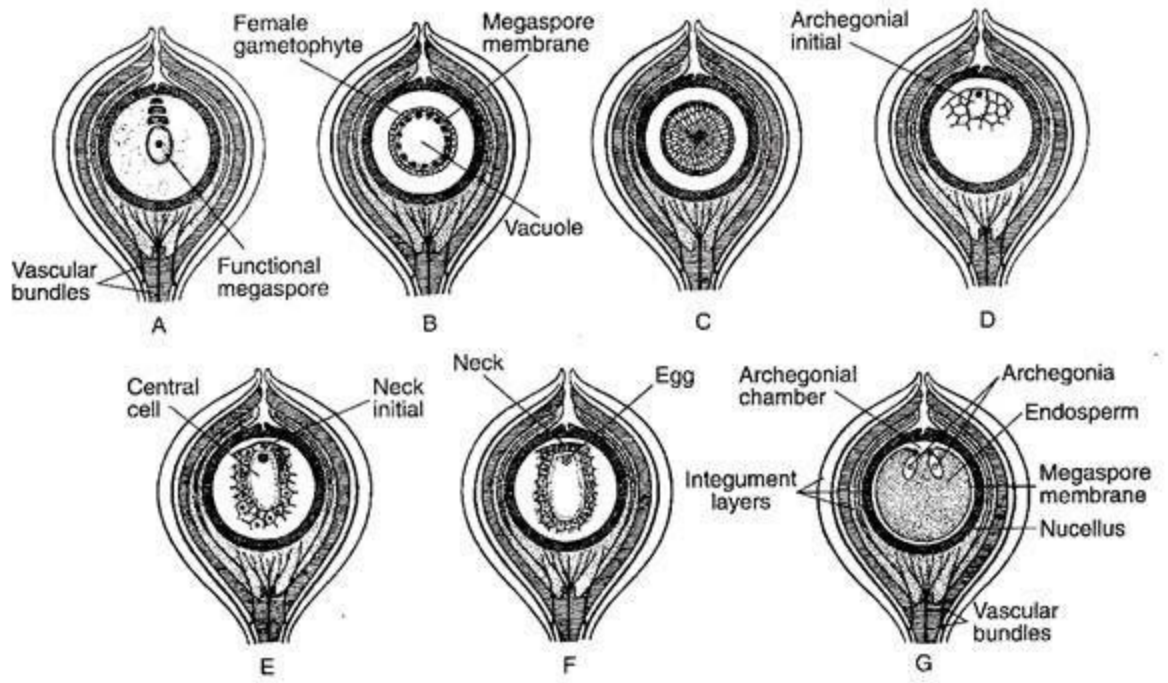
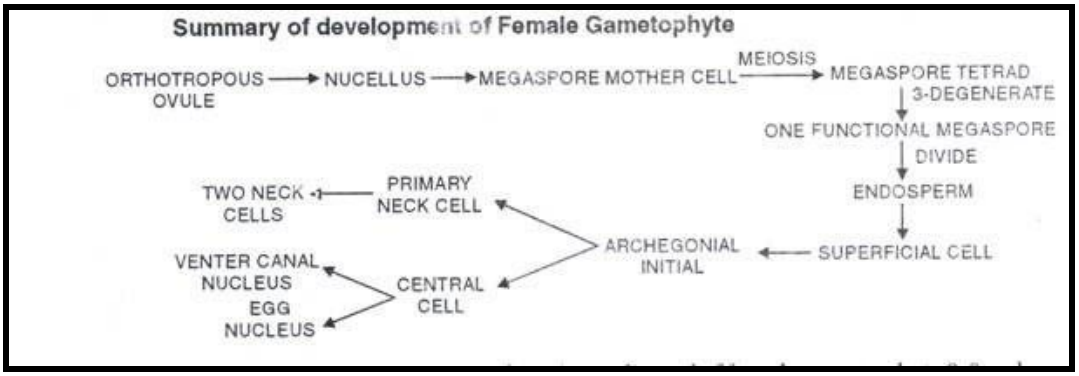


Fig. 1.21 : *Cycas*. Development of female gametophyte within ovule : A. Linear tetrad with one functional megaspore, B. Free nuclear stage, C. Cellular stage, D–F. Stages in development of an archegonium, G. A mature female gametophyte containing two archegonia

Development of Archegonia:

- Two to eight cells of the female gametophyte at the micropylar end enlarge in size and have dense cytoplasm and prominent nuclei. These cells function as archegonial initials (Fig. 1.21 D).
- Each **archegonial initial divides** periclinally to form an **outer small neck initial and a large central cell** (Fig. 1.21 E).
- The **neck initial divides** by a vertical (anticlinal) wall **to form two neck cells** (Fig. 1.21F).
- A second division takes place prior to fertilisation, thus the neck actually comprises four cells.
- The **central cell enlarges** considerably in size and its nucleus **divides into a small ephemeral ventral canal nucleus and a large egg cell** (Fig. 1.20G).
- The egg of *Cycas* is reported to be the largest among the living plants, thus it can be seen with naked eyes. The nucellar tissue above the archegonia disorganises to form an archegonial chamber (Fig. 1.21G).



Fertilisation:

- The sperms and the cytoplasm of the pollen tube are released in the archegonial chamber by the rupture of the basal end of the pollen tube.
- The osmotically rich pollen tube cytoplasm causes the rupture of neck cells.
- The motile sperms enter into the archegonium with a forward and circular motion, ciliary band forming the anterior end.
- The archegonial chamber is flooded with the fertilisation fluid produced by nucellar cells.
- The ciliary band of the sperm is left behind on the top of the egg cell. The sperm nucleus fuses with the egg nucleus and thus a zygote is formed.

Embryogeny:

- The **zygote enlarges** considerably and **undergoes numerous free nuclear divisions.**
- The cell formation in the proembryo begins nuclei have been reported.
- A large central from the basal part and extends up the periphery, **vacuole is formed and the nuclei are arranged**.
- The entire embryo never becomes cellular. The around the central vacuole.
- Most basal cells are smaller with dense cytoplasm; the free nuclei move to the base of the proembryo forming the embryo .
- A dicotyledonous embryo is developed at the tip.
- The upper cells elongate greatly to form the suspensor which may be coiled and twisted.
- Several egg cells may be fertilised to form many zygotes, but ultimately only one embryo in an ovule attains maturity.
- The layer of cells covering the outer curved face of the embryonal mass is called the cap.

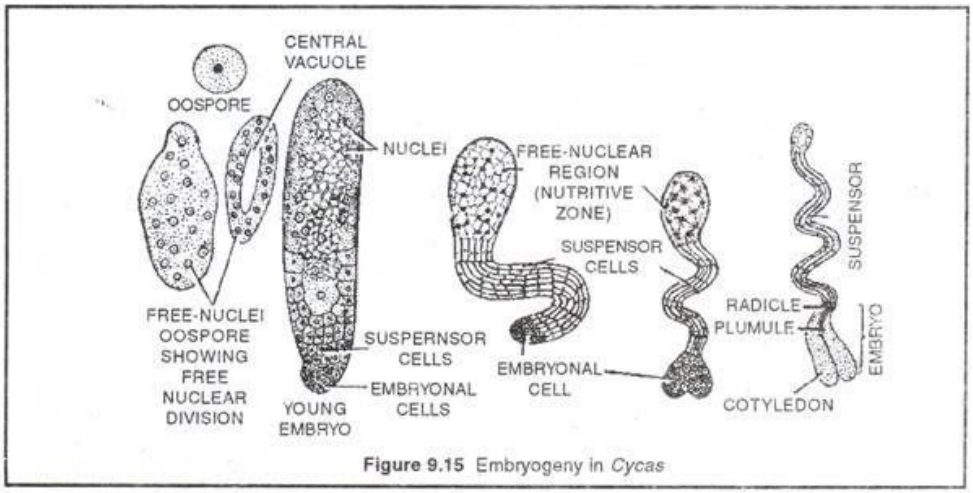


Figure 9.15 Embryogeny in *Cycas*

Seeds:

As a result of post-fertilization changes the entire ovule becomes a seed. Following changes take place in the process:

Ovule	→ Seed
1. Integuments.	
(*a*) Two outer layers of integument	
(*i*) Outer fleshy layer which becomes creamy orange or red coloured	Seed coat
(*ii*)	Middle stony layer
(*b*) Inner fleshy layer.	
2. Nucellus	Absorbed by developing gametophyte. Present in the form of a cap towards micropylar end. (absorbed by developing gametophyte at other places).
3. Female gametophyte (endosperm)	Function as food for developing embryo
4. Zygote	Embryo with radicle, plumule and two cotyledons.

Seed Germination:

- The testa of *Cycas* seed emits pleasant odour and is sweet in taste. This causes its dispersal by birds.
- The seed remains variable for a few months.
- Under favourable conditions, the seed germinates into a sporophyte. The **seed germination in *Cycas*** is **hypogeal** i.e. the cotyledon remains underground enclosed in the endosperm and absorbs food for the growing embryo.
- The plumule form leafy shoot and radicle elongates into a tap root (Fig. 9.16).

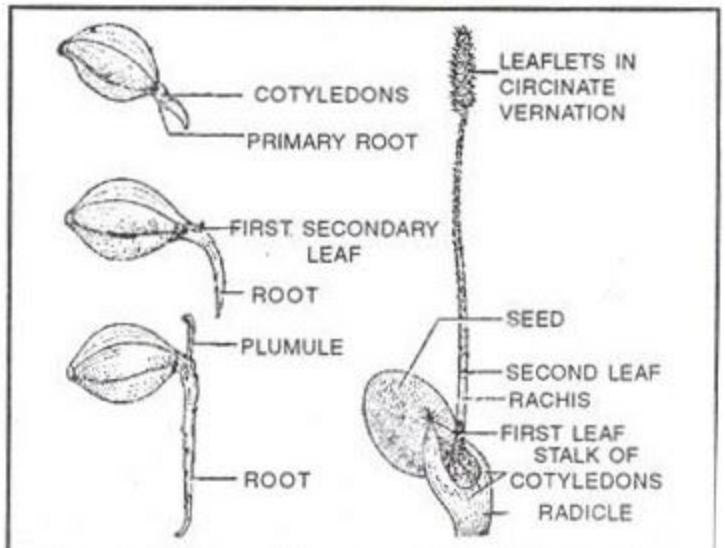


Figure 9.16 *Cycas* : Various stages of seed germination.

Three Generations Locked in Seed: A seed contains three generations locked one within another.

<u>The following three generations present in a Cycas Seed are:</u>

Parent Sporophyte: Seed coat and nucellus, **Female Gametophyte:** Endosperms,**Future Sporophyte**: Embryo (radicle, cotyledons and plumule).

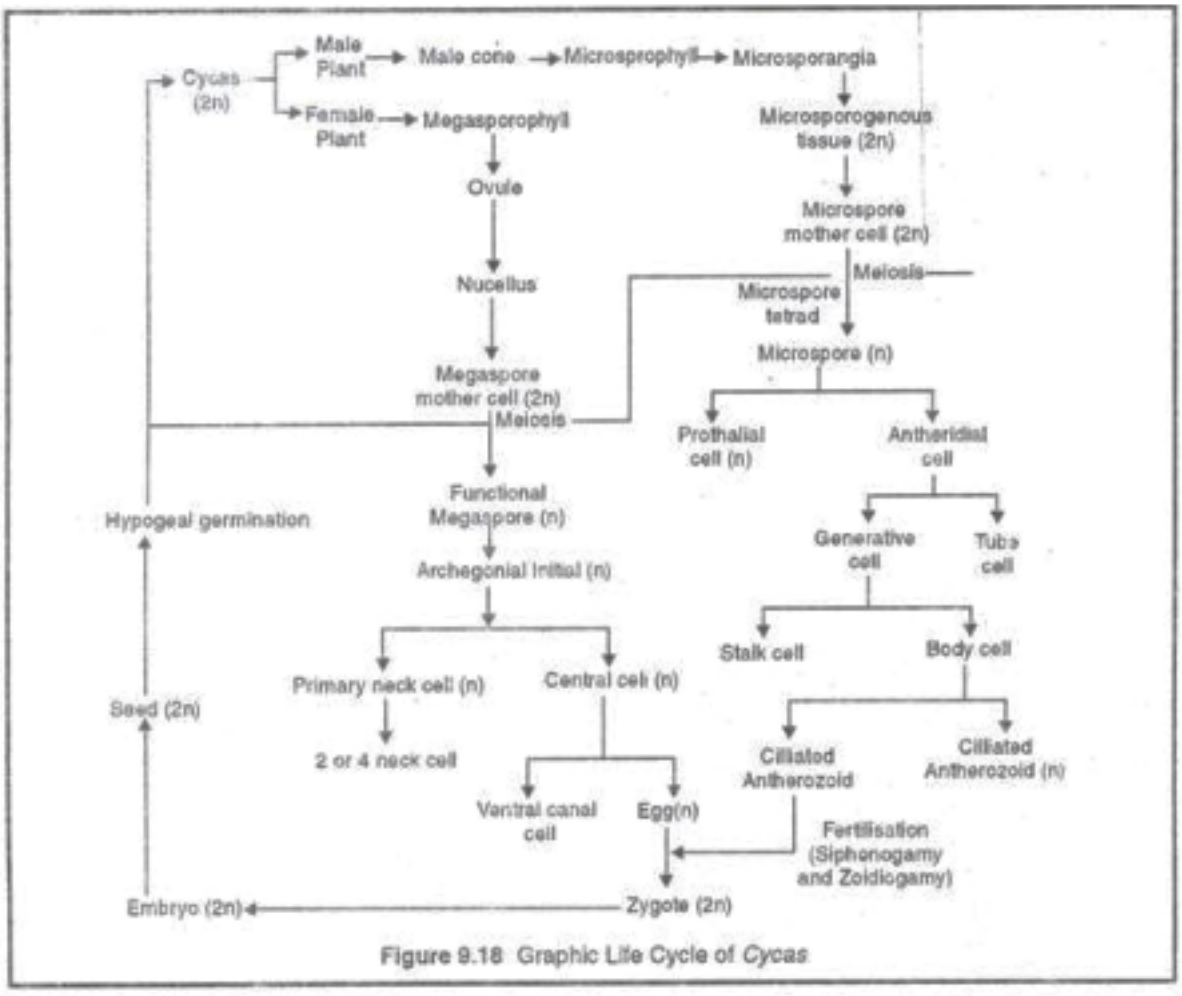


Figure 9.18 Graphic Life Cycle of *Cycas*

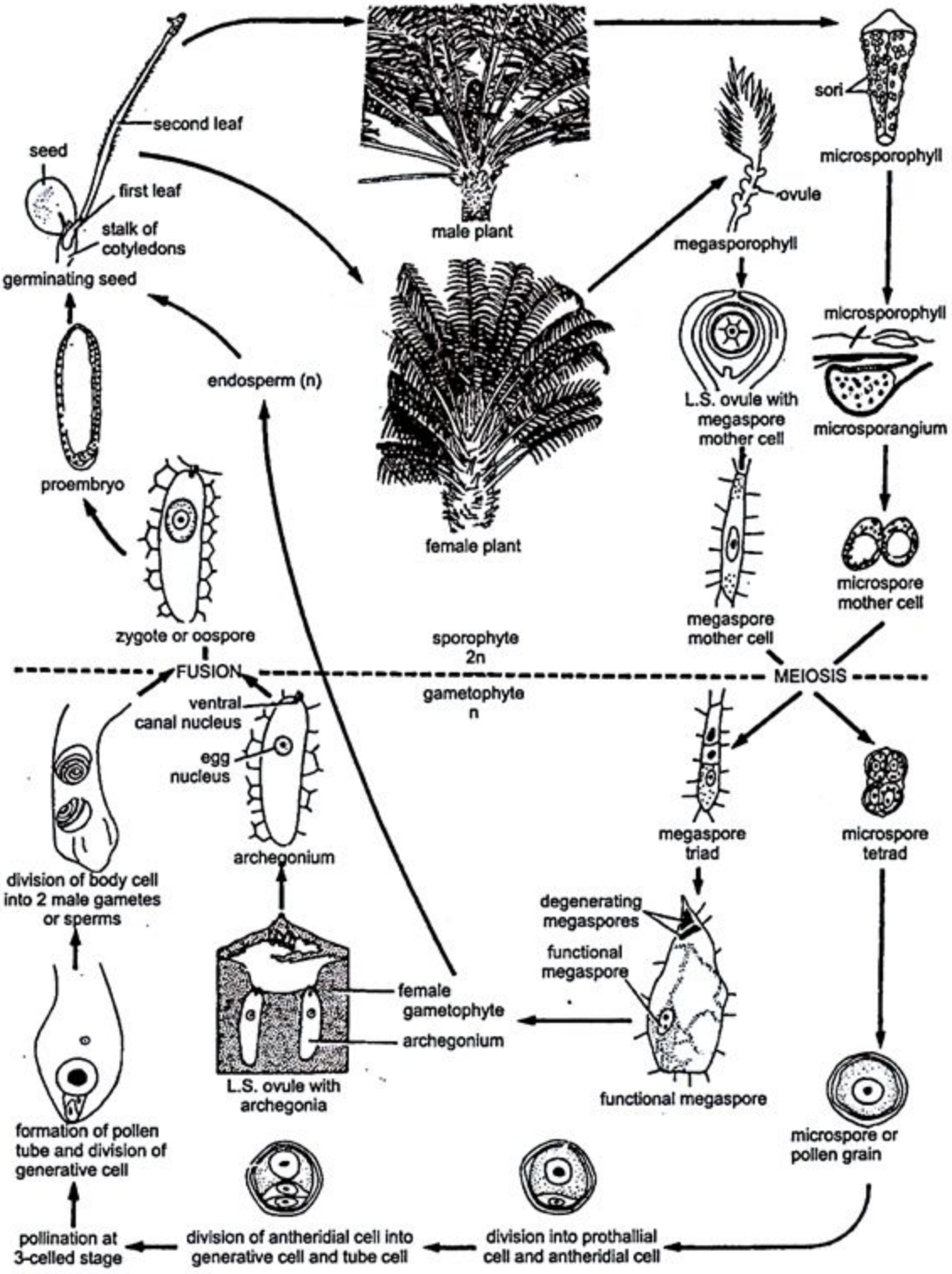


Fig. 34. *Cycas.* Diagrammatic life cycle.