1. Distribution of Cycas:

Cycas, the largest genus among the Old World Cycads, is the most widely distributed genus of order Cycadales. It is distributed in Japan, Australia, India, Indochina, China, Mauritius, Africa, Nepal, Bangladesh, Sri Lanka and Myanmar. In India, Cycas grows naturally in Orissa, Assam, Meghalaya, Tamil Nadu, Karnataka and Andaman and Nicobar Islands (Fig. 8.7).

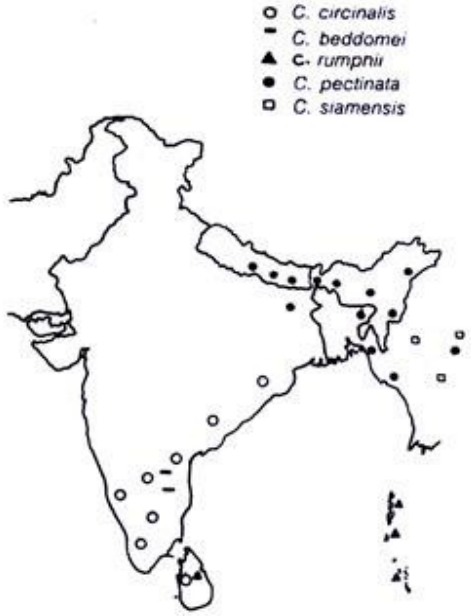

Fig. 8.7. Distribution of *Cycas* species in India and adjacent countries. (after Pant, 1973)

Cycas is represented by 15 species but according to Willis (1966) there are 20 species of the genus. Schuster (1932), however, recognizes only 8 species, mentioning for the rest as the forms, varieties or sub-species of the other species. Besides Cycas circinalis, C pectinata, C. rumphii and C. beddomei, which occur in the wild state in India, C. revoluta and C. siamensis are such species which are cultivated commonly in the Indian gardens. Cycas revoluta is the most commonly cultivated species of the Indian gardens.

Some Indian Species:

1. Cycas beddomei Dyre: A small shrub with a trunk of about 40 cm long. It is distributed in Andhra Pradesh, Madras, Calicut, etc. Leaves are large and reach up to 1 metre in length with quadrangular rachis. Leaflets are narrow and linear. Male cones are oblong to ovoid, bearing a short peduncle. Megasporophylls are ovate, lanceolate with dentate margins. They are produced in November-December.
2. Cycas circinalis Linn: Commonly called 'Jangli-madan-mast-ka-Phul' (Hindi) or 'Kamakshi' (Telugu), C. circinalis is commonly distributed in western part of Peninsular India, Western Ghat and Orissa Hills in India. It is often cultivated in Indian gardens. It is an evergreen tree bearing leaves of 1.5 to 3 metres in length with about 100 pairs of leaflets. Leaflets are linear-lanceolate with flat margin and acuminate apex. Upper sterile part of megasporophyll is longer than broad with dentate margins. Male cones are cylindrical to ovoid with a short peduncle. Megasporophylls contain brown tomentose hairs.
3. Cycas pectinata Griff: It is distributed in Sikkim, Assam, Manipur and Someshwar Hills of Bihar in India along with some other countries including Nepal and Bangladesh. Its trunk ranges from 1.5 to 2.5 metres in length. Leaves attain a length of about 1.5 to 2 metres. Leaflets are narrow, linear, tapering into a minute spine and measure from 14 to 25 cm. in length. Male cone is cylindrical-ovoid. The upper part of the megasporophyll is as broad as long.
4. Cycas revoluta Thunb: It grows in wild state in Japan, China and Taiwan and is widely cultivated in several parts of the world, including India. It is so named because of the revoluted margins of its leaflets It is a palm-like tree, the trunk of which reaches up to 2 metres in length. Male cones are cylindrical or ovoid-oblong. Megasporophylls are 10-25 cm in length and densely tomentose

5. Cycas Rumphii Miq: It is an evergreen palm-like tree distributed in Andaman and Nicobar Islands of India along with Sri Lanka, Malaysia and Australia. Its trunk reaches up to 4 metres while the leaves attain a length of 1-2 metres with 50 to 100 or more pairs of leaflets. Male cone is shortly stalked and ellipsoidal to oblong in shape. Megasporophylls are ovate-lanceolate with many small teeth.
6. Cycas siamensis Miq: It is found in Myanmar, Thailand, China and Laos. It is a palm like tree. The leaves reach about 1 metre in length. Leaflets are narrow, linear with mucronate or acuminate apex. Male cone is ovoid oblong. Megasporophyll's sterile blade is as broad as long with usually only 2 ovules. Burkill (1933) considered Cycas siamensis as a geographical form of C. pectinata. Pant and Nautial (1963) also consider the two species similar, mainly because of their epidermal and anatomical studies.

2.Coralloid Root:

Anatomically, the coralloid roots (Fig. 8.18) resemble normal roots except some under mentioned differences:
1. The secondary vascular tissue in coralloid roots is either totally absent or poorly-developed.
2. The cortex is wider in comparison with the normal root.
3. Presence of a greenish algal-zone in the middle of the cortex. But according to Chaudhary and Akhtar (1931) the algal-zone is not of universal occurrence in the coralloid roots of Cycas. It may be absent in such coralloid roots which go very deep in the soil. According to these workers only those coralloid roots are negatively geotropic which are infected by algal members.

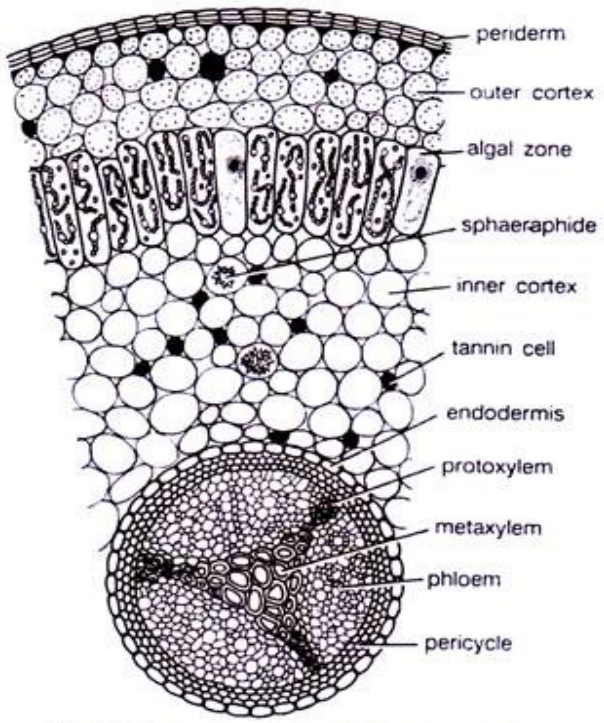

Fig. 8.18. *Cycas revoluta* T.S. coralloid root

Algal-zone consists of radially elongated, large, thin-walled cells having large intercellular spaces occupied by algae. Life (1901) opined that these spaces are formed because of the retardation of growth of such cells which are already infected by fungi and bacteria. Such infected cells cannot keep pace with the neighbouring cells, and a tension is produced which results in the formation of air spaces by breaking of certain cells. These spaces are further widened by the algal infection. But according to Chaudhary and Akhtar (1931) the alga is mainly responsible for the formation of these large intercellular spaces. Following members have been reported from the algal zone of coralloid roots: Anabaena cycadae, Nostoc punctiforme, Oscillatoria, Azotobacter, Pseudomonas radicicola and even a few fungi. According to Kubitzki (1990) blue green algae or Cyanoba cteria (Anabaena, Nostoc and Calothrix) may rarely be present intracellularly (i.e. inside the cell) in the coralloid roots of Cycas. He opined that these algae fix nitrogen and promote the growth of host plant. Due to the presence of blue-green algal members and some nitrogen-fixing bacteria, the function assigned to the coralloid roots is chiefly the nitrogen fixation. The presence and structure of endodermis, pericycle and vascular bundles in the coralloid roots are similar to that of normal roots. The xylem is exarch and triarch.

3. Range of Cycas Megasporophylls:

1. Like foliage leaves, megasporophylls are spirally arranged at the apex of stem, in very large number, and thus appear like a rosette. 2. They are loosely arranged in acropetal succession without showing any effect on apical meristem. 3. They are formed once in a year in the mature plant. 4. Each megasporophyll is considered as a modification of foliage leaf and reaches up to 20 cm or more in length. 5. Each megasporophyll is a flat body consisting of an upper dissected or pinnate leafy portion and a lower stalk. On stalk, the ovules are arranged in two rows. 6. Megasporophylls are covered by many yellow or brown-coloured hair. 7. The ovules are green when young but at maturity they are fleshy and bright orange or red-coloured structures. 8. The ovule of C. circinalis is the largest amongst the living gymnosperms, measuring about 6 cm in length. External morphology of megasporophyll is different in different species of Cycas with regard to the number of ovules and the dissected nature of the upper portion. Variations appear species wise in megasporoplylls. The upper, conical sterile part of the megasporophyll is pinnately divided in Cycas revoluta , C. pectinata and C. siamensis . But the margin of the upper part is variously serrate with a tapering acute apex in C. beddomei , C. circinalis and C. rumphii .

(A) Megasporophyll of Cycas rumphii: 1. The pinnae are reduced in size (Fig. 23A).

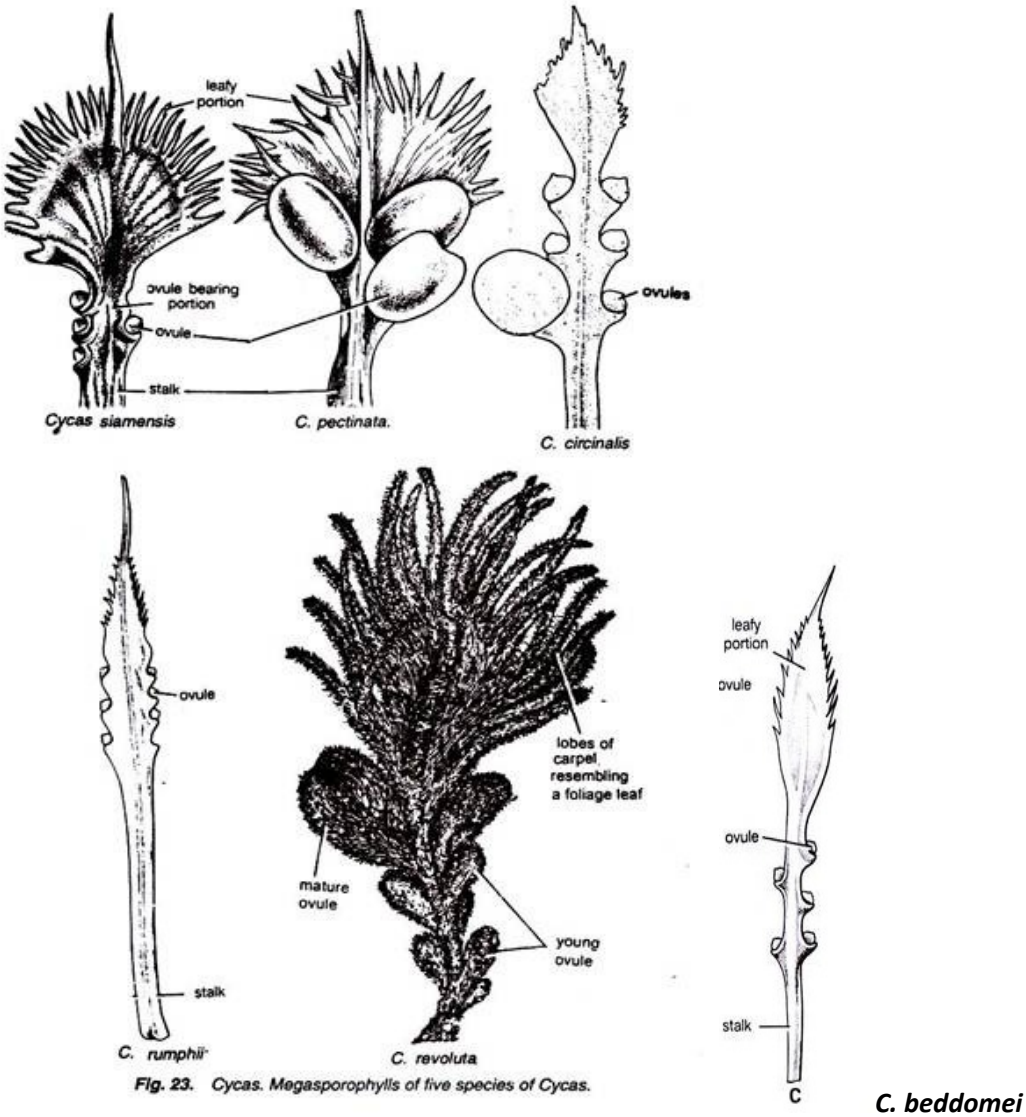

Fig. 23. Cycas. Megasporophylls of five species of Cycas.

C. beddomei

2. The number of ovules is 4 to 6.
3. The base of the megasporophyll is covered by scaly leaves.

(B) Megasporophyll of Cycas revolute:

1. Upper part is much dissected and pinnate (Fig. 23B).
2. Tip of each pinna is generally acute.
3. The size of megasporophyll ranges between 15 to 20cm.
4. The number of ovules is 2 to 12.

(C) Megasporophyll of Cycas circinalis:

1. The upper part is not much dissected.

2. The margin of the upper part is serrate (Fig. 23C).
3. The ovule is largest amongst the living gymnosperms.

(D) Megasporophyll of Cycas Siamensis:

1. The leafy portion is much dissected.
2. Few upper pinnules unite to form a solid structure (Fig. 23D).
3. The number of ovules is only two.

4. Structure of Cycas Ovule:

Cycas ovules are orthotropous, unitegmic and shortly-stalked. Generally, one or sometimes a few more ovules develop fully on a megasporophyll. Many un-pollinated ones remain small and ultimately abort. Outer surface of the ovule may be smooth as in C. circinalis or covered with orange-yellow hairs as in C. revoluta. After fertilization these hairs are lost, the ovule changes into seed and its colour changes from orange-yellow to bright red.

The single integument is very thick and covers the ovule from all sides except a mouth-like opening called micropyle.

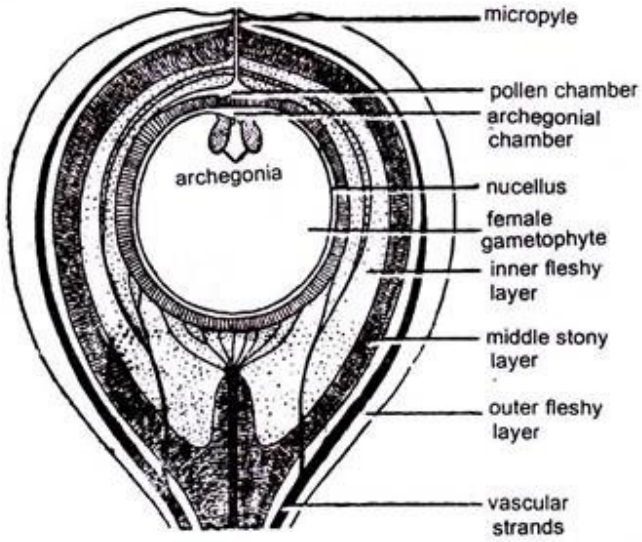

Fig. 8.43 *Cycas*. L.S. ovule showing two archegonia and female gametophyte.

The integument consists of three layers:

(i) Outer, green or orange, fleshy layer called sarcotesta, (ii) Middle, yellow, stony layer called sclerotesta, and (iii) inner fleshy layer.

Several tannin cells and mucilage canals are present in the parenchymatous region of sarcotesta. Some pigments are also present in sarcotesta and epidermis. The sclerotesta consists of lignified thick-walled cells. The inner fleshy layer consists of parenchymatous cells, and it remains in close association with the nucellus. The nucellus grows out into a beak-like portion called nucellar beak. The latter protrudes into the micropylar canal. Certain cells at the top of the nucellus dissolve and form a cavity like structure called pollen chamber (Fig. 8.43). Pollen grains are received in the pollen chamber after pollination. The nucellus gets reduced in the form of a thin papery layer in mature seeds and encloses the massive female gametophyte (endosperm). An enlarged megaspore or the embryo-sac is present within the nucellus. The endosperm is formed by the repeated divisions of the megaspore nucleus followed by free cell formation. Just below the pollen chamber is present an archegonial chamber. 3-6 archegonia are present in the female gametophyte near the archegonial chamber. The latter remains filled with a fluid.

5. Cycas Male Cone:

1. It is very large (Fig. 18), conical or ovoid structure, reaching sometime up to 0.5 metre in length.
2. In the centre of each male cone is present a cone axis, which is clearly seen in L.S. (Fig. 19).
3. On the cone axis are attached many leafy structures at right angle. These are called microsporophylls.
4. At the base of the male cone are present many young leaves.
5. All the microsporophylls in the male cone are fertile, except a few at the base and a few at the apex.

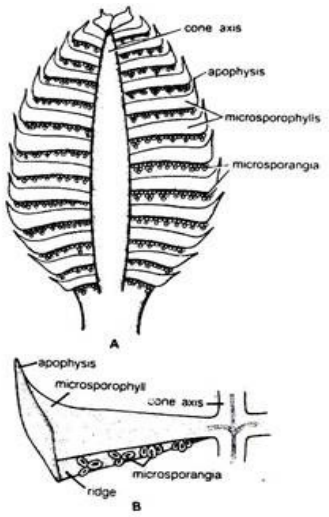

Fig. 19. Cycas. A, L.S. male cone; B, L.S. through a single microsporophyll with cone axis.

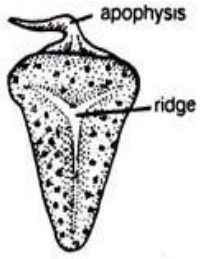

Fig. 20. Cycas. A single microsporophyll (adaxial surface)

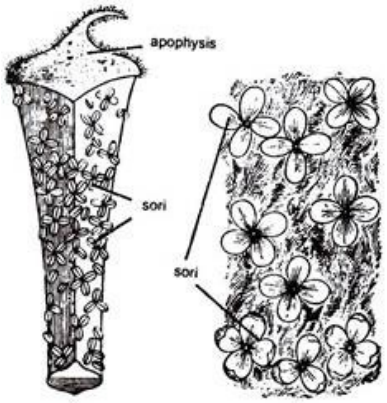

Fig. 21. Cycas. A, Abaxial surface of a microsporophyll; B, Groups of sori enlarged.

Microsporophylls, Microsporangia and Microspores:

Separate a microsporophyll from the male cone and observe the shape and arrangement of microsporangia on its lower surface.

1. Microsporophylls are flat, leaf-like, woody and brown-coloured structures with narrow base and expanded upper portion.
2. Upper expanded portion becomes pointed and called apophysis.
3. Narrow base is attached to the cone axis with a short stalk.

Each microsporophyll has two surfaces: an adaxial or upper surface and an abaxial or lower surface.

4. On the adaxial surface is present a ridge-like projection in the middle and an apophysis at the apex (Fig. 20).
5. On the abaxial surface are present thousands of microsporangia in the middle region in groups of 3 to 5. Each such group is called a sorus (Fig. 21 A).
6. In between these groups are present many hair-like structures (Fig. 21B).
7. Each microsporangium is an oval or sac-like structure with a short stalk. It encloses many microspores or pollen grains.
8. Each pollen grain is a rounded, uninucleate structure, surrounded by an outer thick exine and inner thin (or thick on lateral sides) intine.

T.S. Microsporophyll: Cut transverse section of microsporophyll, shows the following :

1. Many microsporangia (Fig. 22) are present on abaxial side.

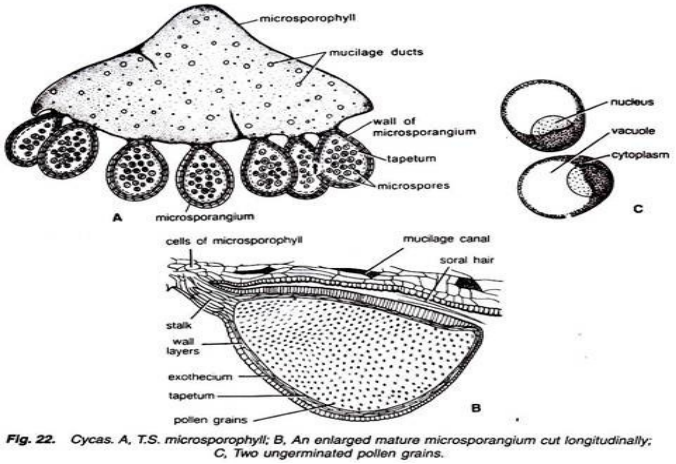

Fig. 22. Cycas. A, T.S. microsporophyll; B, An enlarged mature microsporangium cut longitudinally; C, Two ungerminated pollen grains.

2. Each shortly-stalked sporangium is surrounded by many layers with the innermost layer of tapetum. Many pollen grains are present in each sporangium.
3. Many mucilaginous canals and vascular bundles are present in the microsporophyll.

6. Development of male gametophyte in Cycas :

Each microspore is unicellular, unicelled structure with two layered wall. Outer wall is known as exine while inner is known as intine. **The development of male gametophyte takes place in two stages:**

Stage I: Development of male gametophyte before pollination: Development of male gametopheyte or germination of pollen grains starts in situ i. e., they are still inside the microsporangium. First its nucleus divides into two, one of them goes towards the lower side and is separated from the other by a cresent shaped wall resulting in the formation of two unequal cells. The lower smaller cell is called as prothallial cell and the upper bigger one as antheridial cell (Fig. 25 A, B). The prothallial cell does not divide further but the antheridial cell divides to form a generative cell (Fig. 25C) which is in close contact with the prothallial cell and distal tube cell with a large nucleus. This stage is called 3-celled stage consisting of a prothallial cell, generative cell and tube cell. At this stage microsporangia dehisce and the shedding of the pollen grains takes place, (tapetum disintegrates, sporangium becomes dry, cells shrink, sporangial wall ruptures radially at the line of dehiscence). Further development of the pollen grains (II stage) takes place after pollination.

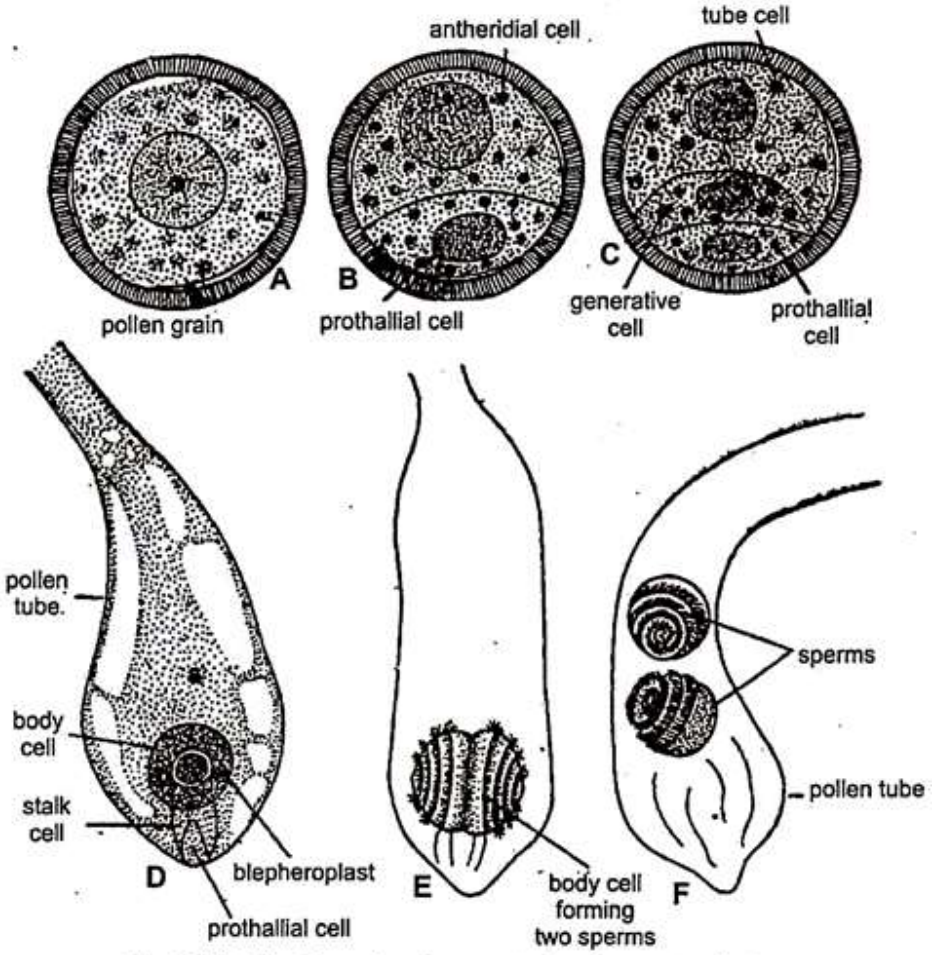

Fig. 25 (A–E). *Cycas*. Development of male gametophyte.