• Answer the following questions:- 1×5=5

(1) Mention two fern characters of cycas. ($\frac{1}{2}+\frac{1}{2}=1$)

(2) What is shower of sulphur? (1)

(3) Name one smallest gymnosperm. (1)

(4) What is 'Bars of Sario'? (1)

(5) What is coralloid root? Give example. (1)

• Answer any three of the following:- 3×5=15

(6) What is transfusion tissue? Comment on anatomical features of leaflet of Sago palm with diagram. (2+3=5)

(7) Mention xerophytic characters of cycas. Name the gymnosperm where winged pollen grains found. What is the scientific name of 'chilgoza pine'? (3+1+1=5)

(8) Mention the general characters of gymnosperm. Name one tallest gymnosperm. What is pro-gymnosperm? (3+1+1=5)

(9) What is polyembryony? Name one "canada-Balsam" producing gymnosperm. Mention three important angiospermic characters of Gnetum. (1+1+3=5)

• Answer any two of the following:- 2×10=20

(10) What are manoxylic and pycnoxylic woods? What is cleavage.

P.T.O.

(10) - polyembryony? Describe the male gametophyte of Pinus with neat diagram. Give a short note on anatomical features of Pinus needle with diagram. (1+1+1+4+3=10)

(11) What is ovuliferous scale? Mention three differences between Cycadales and Coniferales. Compare male cone and female cone between cycas and Pinus with diagram. (2+3+5=10)

(12) Describe the female gametophyte of cycas with neat diagram. Why endosperm is haploid (n) in gymnosperm? Name one timber producing gymnosperm. What is rosette polyembryony? (5+1+1+2=10)

(13) Describe the female gametophyte of Pinus with diagram. State the economic importance of gymnosperm in brief. (5+5=10)

Short questions on Gymnology
Paper-(X) 2nd Sem.

(1) Differentiate (with one important character) between pollen grain of Cycas and Pinus.

(2) How the xylem of Gnetum be distinguished from that of Pinus?

(3) If the somatic chromosome number of a gymnospermous plant is 2n=20 what would be the chromosome no in its endosperm tissue?

(4) Name the fused cup like bracts in the cone of Gnetum.

(5) Name the sterile upper portion of the microsporophyll of Cycas.

(6) Name the genus where girdle leaf traces found in the stem of that genus.

(7) In which period, gymnosperms belong to?

(8) Name one tallest gymnosperm. [Sequoia sempervirens]

(9) Name one oldest gymnosperm. [S. gigantea]

(10) Name one smallest gymnosperm [Zamia]

(11) Mention in which genera of gymnosperm vessels are present.
[Gnetum, Ephedra, Welwitschia]

(12) What is Polyembryony?

(13) What are manoxylic and pycnoxylic woods?

(14) Common names:-

(a) Maiden hair tree → Ginkgo biloba
(b) Christmas tree → Araucaria
(c) Sago palm → Cycas revoluta
(d) Chilgoza Pine → Pinus gerardiana
(e) Chir pine → P. roxburghii
(f) Khasi Pine → P. insularis.

What is living fossil?

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16. What is Sago?
17. What is Canada Balsam?
18. What is taxol and ephedrine?
19. What is Coralloid root?
20. What is transfusion tissue?
21. What is cleavage Polyembryony?
22. Largest ovule do you find in which gymnosperm? [Cyca
23. Where do you find tetrasporic embryosac? [Gnetum]
24. Vascular bundle in young Stem of Cycas.
[conjoint, collateral, open and endarch]
25. Vascular bundles in rachis of Cycas.
[inverted omega-shaped arrangement]
26. Mention xerophytic characters of Cycas leaflet?
27. What is spur?
28. Blue pine → Pinus wallichiana
29. Armand's pine → Pinus armandi
30. What type of germination found in Cycas and Pinus?
[Hypogeal and epigeal germinations]
31. What are xerophytic characters shown by Pinus?
32. What is 'Shower of golden dust'?
33. What is 'Bars of Sanio'?
34. What is 'Rims of Sanio'?
35. What are Ovuliferous scales?
36. How many cotyledons found in Pinus [variable upto 12]

37
38
39
40
1
2
3
4
5

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37) What are girdle traces?

38) Where do you find double fertilization in gymnosperms?
[Ephedra and Gnetum]

39) What are haplochelic and Syndetochelic stomata with examples?

40) What type of embryogeny in gymnosperm? [endoscopic]

X

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Ginkgoales and angiosp

[A] Affinities with Ferns

The cycads have several traits in common with the ferns. In both the groups, the leaves possess circinate vernation and the antherozoids are motile by means of countless cilia.

[B] Affinities with Pteridosperms

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but the pits of adjacent rows alternating.

araucarian pittings.

30. What are "Bars of Sanio"?

The tracheids of *Araucaria* (not *Pinus*), occasionally have small trabeculae extending across the lumen, called 'Bars of Sanio'. These trabeculae are made of cellulose but are subsequently lignified occurring in a few genera as well.

31. What are ovuliferous scales?

Also known as cone scales occurring in certain conifers like *Pinus* are the appendage or scale like shoot to which the ovule is attached. These are not simple megasporophylls but are entire modified determinate branch systems popularly known as seed-scale complexes. A seed-scale complex in *Pinus* consists of the ovuliferous scale that bears two ovules on its upper surface and a subtending sterile bract. In other genera the bract and ovuliferous scale remain separate.

32. How is Pine resin economically

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20. What are coralloid roots?

Some of the lateral branches of roots of cycads like *Cycas* which develop near the ground surface develop into coral like masses having the branch tips swollen into short tubercles. These roots get infected with bacteria, fungi and cyanobacteria, are not only apogeotrophic but also aerotrohic and phototrophic.

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occur in Cycadeoidales,

19. What is transfusion tissue?

Tissue surrounding a leaf vein within the endodermis in gymnospermous leaves, some of its cells thickens like xylem cells, is called transfusion tissue. It is believed to conduct materials between the mesophyll and the vascular bundles.

20. What do you understand by manoxylic and pycnoxylic wood?

Manoxylic wood is soft and relatively sparse with wide parenchymatous rays and little secondary xylem. This type of wood is commonly associated with megaphyllous leaves and radial symmetry of leaves e.g., in cycads. Pycnoxylic wood is dense with very small wood rays and profuse secondary xylem. These woods are making main bulk of the trunk and commercially useful. This type of wood is commonly associated with microphyllous leaves and bilaterally symmetrical seed e.g., in conifers.

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17. Which species of *Pinus* is known as chir?

P. roxburgii.

18. Which species of *Pinus* is known as Blue or Bhutan pine?

Pinus wallichiana.

19. Which species of *Pinus* yield 'chilgoza'?

P. gerardiana is the source of edible seeds known as chilgoza.

20. Which is the strongest conifer wood?

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1. What are progymnosperms?

This is a group of Middle Devonian to Lower Carboniferous plants that possess gymnospermous type of wood anatomy with a free sporing reproduction e.g., *Archaeopteris*. It possess eustele without leaf gaps, secondary xylem tracheids with circular bordered pits, simples leaves derived from flattened branch systems (gymnospermous feature) and have fern like frond with reproduction by dispersed spores and not seeds.

2. What are the salient features of progymnosperms?

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are called radiosperme seeds.

41. What is polyembryony? Where do you find it in gymnosperms?

Development of more than one embryo in seed is called polyembryony. It may be simple when several archegonia are fertilized by several spermatozoids e.g., in *Cycas*. But a single embryo may give rise to more than one embryo for example in *Pinus* lower most tier of the four cells of proembryo with its supporting next tier of four cells acting a suspensor often separate along longitudinal wall so that each embryo forming cell (cells of the lower most tier) develop into individual embryo. This phenomenon is called cleavage polyembryony as the embryos developed are the product of a single fertilized zygote. In both cases only one embryo survives or if survives only one usually emerges during natural germination.

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Cycadophytes have following features:
(i) Fern like pinnatifid leaves.
(ii) Weakly branched or almost unbranched columnar trunks.
(iii) Trunks with profusely developed pith and cortical zones in comparison to vascular tissue.
(iv) Wood manoxylic i.e. composed of small secondary xylem made of tracheids and abundant parenchyma.

In comparison Coniferophytes have following characteristics:
(i) Simple leaves, either needle like or laminate.
(ii) Profusely branched trunks.
(iii) Small pith and cortex in trunk.
(iv) Wood pycnoxylic i.e. consisting of massive secondary xylem having less parenchyma.

5. Compare Cycadophytes to Coniferophytes.

	Cycadophytes	Coniferophytes
Stem	Not differentiated into long and dwarf (spur) shoots.	Often differentiated into long and dwarf (spur) shoots.
Wood	Manoxylic; xylem loosely arranged with broad rays, large pith and abundant parenchyma.	Pycnoxylic, xylem compact with narrow rays, pith and mostly composed of tracheids.
Leaf bases	Persistent forming armour on the stem.	Not persistent.
Leaves	Large fern like, compound.	Small simple often scale or needle like.
Leaf traces	Numerous per leaf and complex	One or few per leaf, simple.
Ovules	Borne singly on leaves in simple strobili, on a megasporophyll or on a conical axis.	Commonly borne in a compound strobili or borne singly.

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group that female flower of cycads and conifers are actually naked ovule.

3. What are the salient features of gymnosperms?

(i) Plant body sporophytic, usually arborescent.

(ii) Branching pattern and leaves various; commonly excurrent in habit or columnar with crown of leaves on the top; in former case leaves mostly needle like.

(iii) Wood pycnoxylic or manoxylic, always with secondary vascular tissue; vascular tissue consisting of tracheids (vessels in few plants), and sieve cells.

(iv) Heterosporous.

(v) Sporangia borne on specialized structures.

(vi) Megasporogenesis in a specialized tissue nucellus that ultimately surrounded by a distinctive sheath called integument. Integument single; composite structure containing megaspore within megasporangium (nucellus) covered with integument is called ovule.

(vii) Microscopes are commonly monocolpate.

(viii) Both male and female gametophytes are nutritionally dependent on sporophyte. Female gametophyte development is intrasporic and archegonia have no neck canal cells.

(ix) Fertilization siphonogamous either through flagellate male gametes (*Cycas* and *Ginkgo*) or non-flagellate spermatozoids. Pollen tubes are primarily haustorial in nature.

(x) Embryogeny endoscopic; embryo always contained within the seed developed from ovule. Free nuclear division result in the formation of embryo and the bulk of which take part in the formation of nutritive tissue (endosperm).

(xi) Endosperm tissue formed before fertilization and therefore not equivalent to angiosperms where it is formed after fertilization. Full development of embryo may take place after shedding to the ground.

(xii) Seeds never enclosed in chamber or fruits.

4. Who introduced the groups Cycadophytes and Co[illegible] features they [illegible]

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are known in angiosperms as well.

35. What is the nature of pollen grains in *Pinus*?

It is winged, have two asymmetrically placed bladders formed by local separation of the layers of the exine.

36. How are *Cryptomeria* pollen grains unusual?

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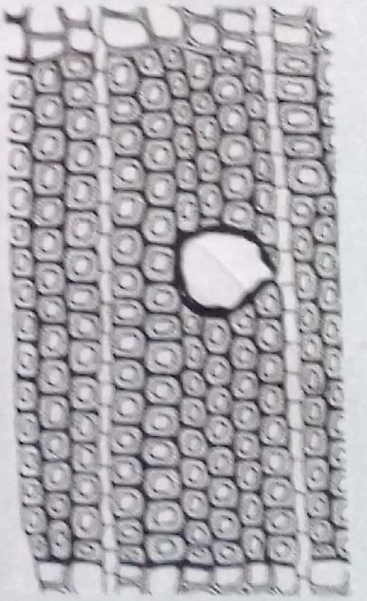
10

Economic Importance of Gymnosperms

The gymnosperms are an economically important group of plants spread all over the globe, primarily in the temperate regions and at higher elevations in the tropics. They are frequently used in landscaping of parks and grardens because of their evergreen habit and symmetrical appearance. Besides, the trees are used for timber, building construction, resin, and for the manufacture of paper and board. They are also used in medicines, perfumes, varnishes and essential oils.



1. Cycadales

Various members of Cycadales are of considerable economic importance.

[A] Food

Young succulent leaves of various species of *Cycas*, viz. *C. circinalis, C. pectinata, C. revoluta, C. rumphii, C. siamensis)* are cooked and eaten as vegetable in some parts of India, Malaya, Phillipines and Indonesia.Stems and seeds of most cycads are used for extracting **starch (sago)** which is used as food. The starch is, however, a poor man's food, or used in terms of scarcity in several areas in southern and south-eastern Asia, New Caledonia, Indo-China, Malaya, India, Burma, Sri Lanka and Fiji. *Macrozamia spiralis* is an important source of stem starch in Australia, used as a food for poultry, dairy animals and pigs. The pith of *Encephalartos* is used to make **kaffir bread** by the aborigines of South Africa. The seeds of *Cycas media* and *Macrozamia* are regularly taken by the Australian aboriginals. The seeds of *Cycas* are made into a paste and eaten as cakes in Nicobar Islands.

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[B] Medicines

Many species of *Cycas* are widely used in indigenous systems of medicine for the treatment of various ailments. The juice of young leaves of *C. circinalis* is used as a remedy for disorders of stomach, flatulence, blood vomiting and skin diseases. A hair wash prepared from the pounded and crushed stems of *C. pectinata* is used in Assam for the treatment of diseased hair roots. Decoction of young seeds of *C. circinalis* is purgative and emetic. A tincture prepared from the seeds of *C. revoluta* is used to relieve headache, giddiness and sore throat. Pollen grains of some species of *Cycas* are strongly narcotic, and microsporophylls of *C. rumphii* and *C. circinalis* are used as anodynes. A gum obtained from *C. rumphii* is effective in healing malignant abscesses. The gum is also used as an antidote for snake and insect bites.

[C] Decorative Plantations

In tropical and sub-tropical areas, cycads are used as outdoor plantations due to their beautiful and graceful appearance. They, however, are a beauty of the green houses in temperate regions.

Fresh or dried leaves of various cycads are utilized as decorative material. The foliage of *Cycas revoluta* is used for making wreaths, floral decorations and/or artificial palm trees for window display.

[D] As Green Manure

Leaves of *Cycas revoluta* are rich in nitrogen and they are used as green manure for rice, sweet potato and sugarcane.

Cycads are poisonous in nature. Eating seed kernels can be an acute irritant and an intake of cycad leaves can affect nerves. The buds and cones of *Dioon edule* cause emaciation and partial paralysis in cattle. Several neurological disorders such as Alzheimer's syndrome, Parkinsonian disease and a wasting disease, amyotrophic lateral sclerosis (ALS) are also caused by consumption of cycads.

2. Ginkgoales

[A] Ornamentals

Ginkgo biloba is grown as an avenue tree. The male trees are preferred, as the ripened ovules (on female plants) have a disagreeable odour, like that of rancid butter. The plant is exceptionally resistant to attacks of insects and fungi and hence, can be grown successfully in modern cities.

[B] Food

Roasted seeds of *Ginkgo* are eaten at feasts in China and Japan to promote digestion and diminish the effects of drinking wine.

[C] Medicine

An extract of leaves of *Ginkgo biloba* is useful in the treatment of cerebral insufficiency and vertigo. Besides, it is also an important source of C_{20} trilactone ginkgolide compounds which antagonize platelet activating factor (PAF) in vertebrate blood systems.

3. Coniferales

The conifers are economically important for their timber, in the manufacture of paper and board, resins, tannins, essential and fatty oils, as food supplements and pharmaceuticals.

[A] Timber

Most of the commercially important gymnospermous woods are obtained from conifers and taxads. The coniferous woods are generally straight-grained, light-coloured, light-weight and strong in comparison to their weight. They can be easily worked, have good nail-taking properties, take a fine finish with sharp tools, and polish and paint well. These qualities make them suitable for a wide range of work where strength and durability are not essential. It is much valued for cabinet and furniture making, joinery work and interior decoration. Some of the taxa have scented wood or are beautifully figured and are, therefore, specially valued for making chests, cabinets, and for panelling. The wood of *Abies* is light and used for packing cases, matchwood, wood wool, aircraft work, light camp furniture, and plywood. *Cedrus* wood is very durable, oily, fragrant, insect-repellant, and rot-resistant. The wood of *Larix* is extensively used for garden furniture, and outdoor feeding racks and troughs for cattle. *Pinus* wood is much commercially important and valuable. Logs of *Araucaria cunninghamia* are used for plywood manufacture. The wood of *Cupressus sempervirens* lasts indefinitely under water. It has been a favourite wood for coffins ever since the Egyptians introduced it. *Juniperus* wood is fragrant, reddish-brown, and rarely damaged by insects. The wood of *J. virginiana* is the standard wood for pencil manufacture. The wood of *Cryptomeria japonica* is fragrant, strong, durable, coarse and variably grained. The wood of *Taxodium distichum* is particularly suitable for greenhouse construction, cooling towers and roof planks of dye houses. The wood of *Taxus* is strong, oily, elastic, close-grained and very durable. It works well, and finishes with a smooth glossy surface.

[B] Paper and Board

Paper can be made from any natural fibrous material depending on the amount, nature, softness and pliability of the cellulose present in the cell wall. At present, 85% of the wood pulp is made from coniferous wood. The important conifers used extensively for the manufacture of paper and board are : *Pinus* sp. for kraft paper; *Picea, Abies* and *Tsuga* for higher grades of writing and printing paper; *Pinus, Picea* and *Pseudotsuga* for thermal and sound insulation boards.

[C] Resins

Resins are plant exudates which make the wood resistant to decay. Conifers are amongst the major resin yielders of the world. Resins harden gradually as their oil evaporates, which makes them invaluable in industries like paints and varnish, lacquers, paper-sizing and medicine. In most conifers, the resin remains mixed with either abundant essential oil (oleo-resin) or very little of it (hard resins). In others, the resin may be mixed with gum (gum resin). Hard resins are an excellent source of varnish as they have a low oil content. The hard resins are usually used in printing inks, adhesives, fireworks, and linoleum.

Copals are hard type of resins which contain only a little essential oil. Of the copals, the most important and most valued is the kauri resin (kauri copal), obtained from the kauri pine (*Agathis australis*), which is extremely valuable for varnish and especially suited for marine and outdoor work. The other type is the Manila copal, obtained from *Agathis alba*, used as a sizing material and has numerous other applications such as preparation of plastics, driers, adhesives, oil cloth, printing inks, and water proofing compositions.

Sandarac is a hard resin obtained as a pale yellow or orange coloured exudate from the trunks of *Tetraclinis articulata* (African sandarac) and *Callitris* sp. (Australian sandarac). It is mainly used as a metal varnish giving good lustre and as paper and leather varnish. It is also used for preservation of fine paintings and as an incense.

Canada balsam resin is obtained form *Abies balsamea* which has a very high refractive index approximating that of glass. This property makes it extremely suitable as a mounting medium for microscopic objects, and as cement for lenses in optical work.

Turpentine is an oleo-resin obtained exclusively from conifers. It is a viscous, honey-like liquid which is obtained for commerical use, by tapping living trees. In India, *Pinus roxburghii* and *P. wallichiana* are two important turpentine pines. The oil of turpentine has many uses. Due to its properties as a solvent, it acts as thinner in the paint and varnish industry. It is useful for printing cloth, especially cotton and wool, in perfumery, pharmaceutical and allied industries, and as a solvent for rubber and gutta-percha. Rosin (the residue product of the process) is even more important in industry. Depending on grade and quality, it has several uses, such as in the manufacture of soap, varnishes, oil cloth, linoleum, sealing wax, adhesives, plastics, etc. Superior

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grades are used for paper sizing, enamels and ointments. Venice turpentine, obtained from *Larix decidua*, is used in varnishes, lithographic work, veterinary medicine and histology.

[D] Amber

It is a fossil, water-insoluble tree resin which was secreted by the now extinct pine, *Pinus succinifera*. It is yellow brown to black, hard and brittle with an aromatic odour. Amber was highly prized by the ancient peoples; the Greeks and Romans for jewellery, beads and other ornamental purposes. At present, it is used for the mouthpiece of pipes, and holders for cigars and cigarettes. It is also used in medicine and X-ray therapy. Human blood does not coagulate if kept in amber containers. Scientifically, amber is of interest because remains of insect or plant material are occasionally embedded in it. Since, these existed when the tree was alive and the resin was fluid, this helps in the study of evolution of life on this earth.

[E] Tannins

Small quantities of tannin are obtained from the bark of *Araucaria, Dacrydium cupressinum, Larix decidua, Picea alba, Phyllocladus trichomanoides, Sequoia sempervirens* and *Tsuga canadensis*. Tannins are mainly used in the leather and petroleum industry, in medicine and for dyeing purposes.

[F] Essential Oils

The essential oils are obtained from almost all those conifers that yield resin by steam distillation of their young branches and adherent leaves, wood, etc. The essential oils are used extensively in preparations of deodorants, room sprays, disinfectants, preparations of bath salts, perfumery and medicine. Himalayan cedarwood oil (*Cedrus deodara*) and red cedarwood oil (*Juniperus virginiana*) are used for clearing tissues in histological work, and for use with the oil immersion lens of the microscope. Oil of juniper (*Juniperus communis*) is used as an essence for flavouring several liquors (such as gin). The oil, obtained from *Cedrus atlantica*, possesses medicinal properties, used against bronchitis, tuberculosis, skin diseases and gonorrhoea. Huon-pine wood oil, obtained from *Dacrydium franklinii* has germicidal properties and is used in the treatment of tinea, cuts and wounds. It is also an excellent insect repellent and is used against wood borers.

[G] Fatty Oils

Many conifers seeds contain fatty oils. Tall oil, which is obtained as a by-product during sulphate process of cooking conifer wood for making kraft paper is used in paints, soaps, linoleum, emulsifiers, organic coating industry, etc. The fatty oil obtained from the seeds of *Cephalotaxus drupacea* is used as an illuminant whereas the oil from the seed of *Pinus cembra* and *Torreya nucifera* is edible and also used for paints.

[H] Food Supplements

Pine seeds have been used as a food item for a long time. The roasted seeds of *Pinus gerardiana* (the chilgoza pine) is edible. In Italy, the seed kernels are largely used for making confectionery. The aborigines in Queensland depend on the ripe seeds of *Araucaria bidwilli* for food. Similarly, *Araucaria araucana* seeds are used by the natives of Chile, and *A. angustifolia* in Brazil. The seeds of *Torreya nucifera* are an important article of food in Japan.

[I] Pharmaceuticals

The leaves of *Taxus baccata* are used in asthma, bronchitis, hiccough, epilepsy and for indigestion. Taxol (from *Taxus brevifolia*) is found effective against ovarian cancer, breast cancer, melanoma and colon cancer.

[J] Decoration

The one single item that heightens the beauty of any hill resort/forest is the conifers, be it a pine, cedar, fir, spruce, juniper or hemlock. Their stately appearance, asymmetrical growth and evergreen habit are a treat to the eye. Species of *Abies, Araucaria* and *Picea* are ceremoniously used as christmas trees. Several conifers are the suitable material for developing 'Bonsai' plants. *Cupressus*

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funebris is generally planted around tombs and religious buildings. Articles carved out of wood of many conifers are also used as decorative pieces.

4. Gnetales

Ephedra is the source of a valuable drug, **ephedrine,** obtained from species like *E. equisetina, E. gerardiana, E. major, E. sinica, E. intermedia* and *E. nebrodensis*. It is used against cold, respiratory disorders, asthma and hay fever. *E. antisyphilitica* is used in the treatment of syphilis. An aromatic beverage, known as **Mormon tea,** is also brewed from the species of *Ephedra* in south western United States. The rhizomes of *E. gerardiana* are utilized as fuel in Tibet.

Young leaves, inflorescences, fruits and seeds of *Gnetum gnemon* are edible; the bark yields a fibre of high tensile strength, suitable for paper pulp and fishing nets, and the wood is used for junks and rafts. Seed-kernels of *G. ula* yield an oil used for illumination and cooking and massage in rheumatism. The kernels of *G. latifolium* are edible and the bark is used for making nets and ropes. *G. montanum* possesses piscicidal properties.

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Female gametophyte: Cycas	Pinus
(i) It is monosporic and the development takes place extremely within the megasporian given	(i) Same as Cycas
(ii) The functional megaspore enlarges and its nucleus divides and re divides freely forming numerous free nuclei which are distributed in the cytoplasm of the megaspore.	(ii) Same as Cycas
(iii) Then a vacuole appears in the centre and the free nuclei get distributed in the peripheral cytoplasm.	(iii) Same as Cycas
(iv) Then cell wall formation takes place within the free nuclei from the periphery towards the centre. Until the vacuole is filled by a cellular tissue. Thus a haploid solid mass of endosperm tissue is developed.	(iv) Same as Cycas (Cycas)
(v) The gametophytic tissue then shows differentiation into two regions: → Region of larger cell near the chalaza and the region of smaller cell towards the micropyle	(v) No distinction of the gametophytic tissue
(vi) Several cells in the micropylar region develop into archegonial initials (2 to 8), each of which divides transversely to form a neck initial and a central cell. The neck initial divides transversely to form two neck cells	(vi) (2-3) cells of the endospermic tissue towards the micropylar end differentiate as archegonial initials, each of which divides transversely to form an upper neck initial and a lower central cell. The neck initial divides to form 8 cells.

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while the central cell divides to form a ventri canal nucleus and an egg nucleus.

(vii) In a mature female gametophyte, a depression called archegonial chamber is formed above the archegonia by the degeneration of the top nucellar tissue at this region.

which arranged in 2 tiers of 4 cells each, to form the neck. Neck canal cells are absent. The central cell divides just before fertilization into a upper venter canal cell and a lower, larger egg cell. The venter canal cell soon degenerates.

(vii) No archegonial chamber is developed

by free nuclear

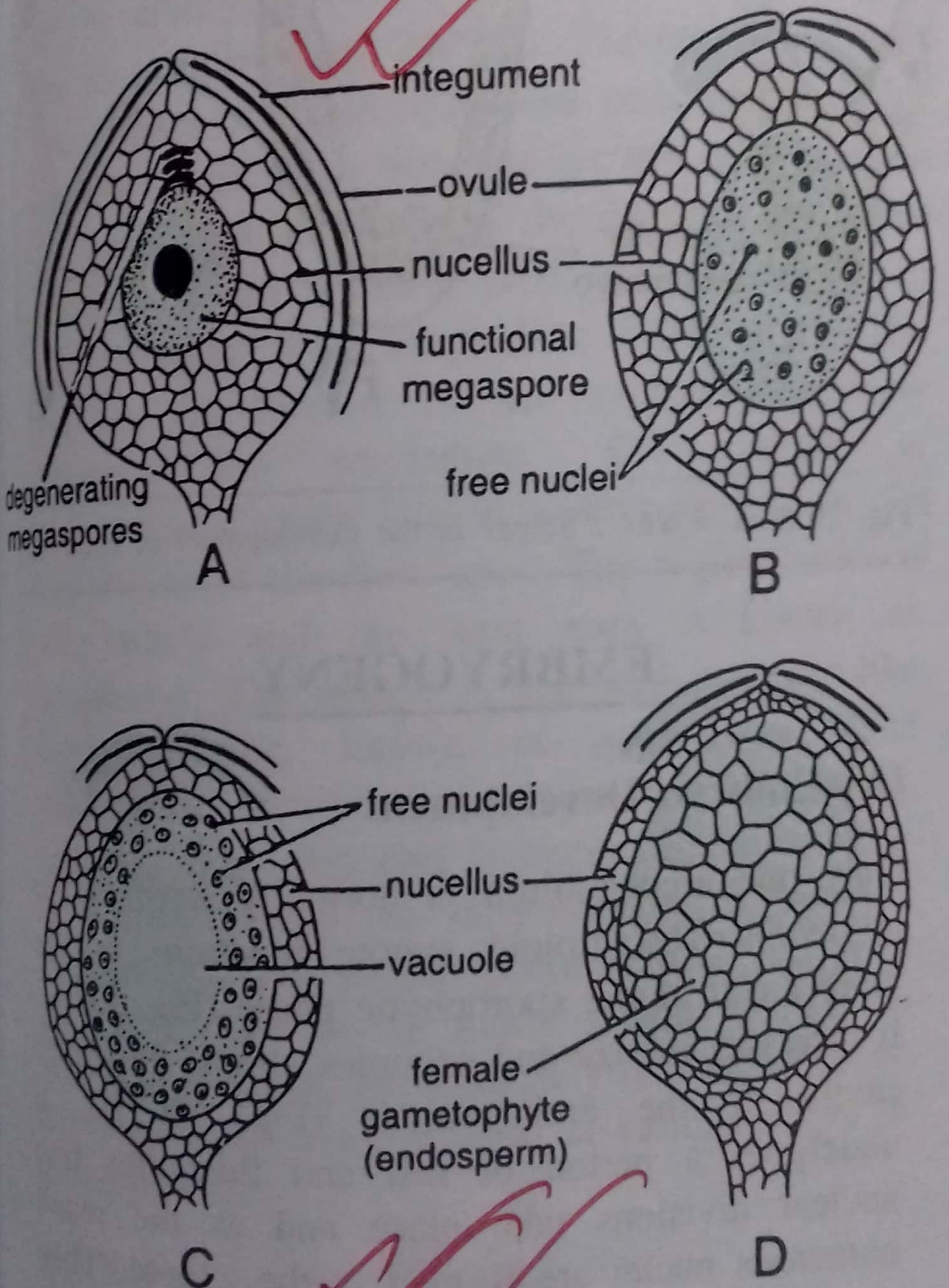

Fig. 27 A-D *Cycas* : Stages in the development of female gametophyte.

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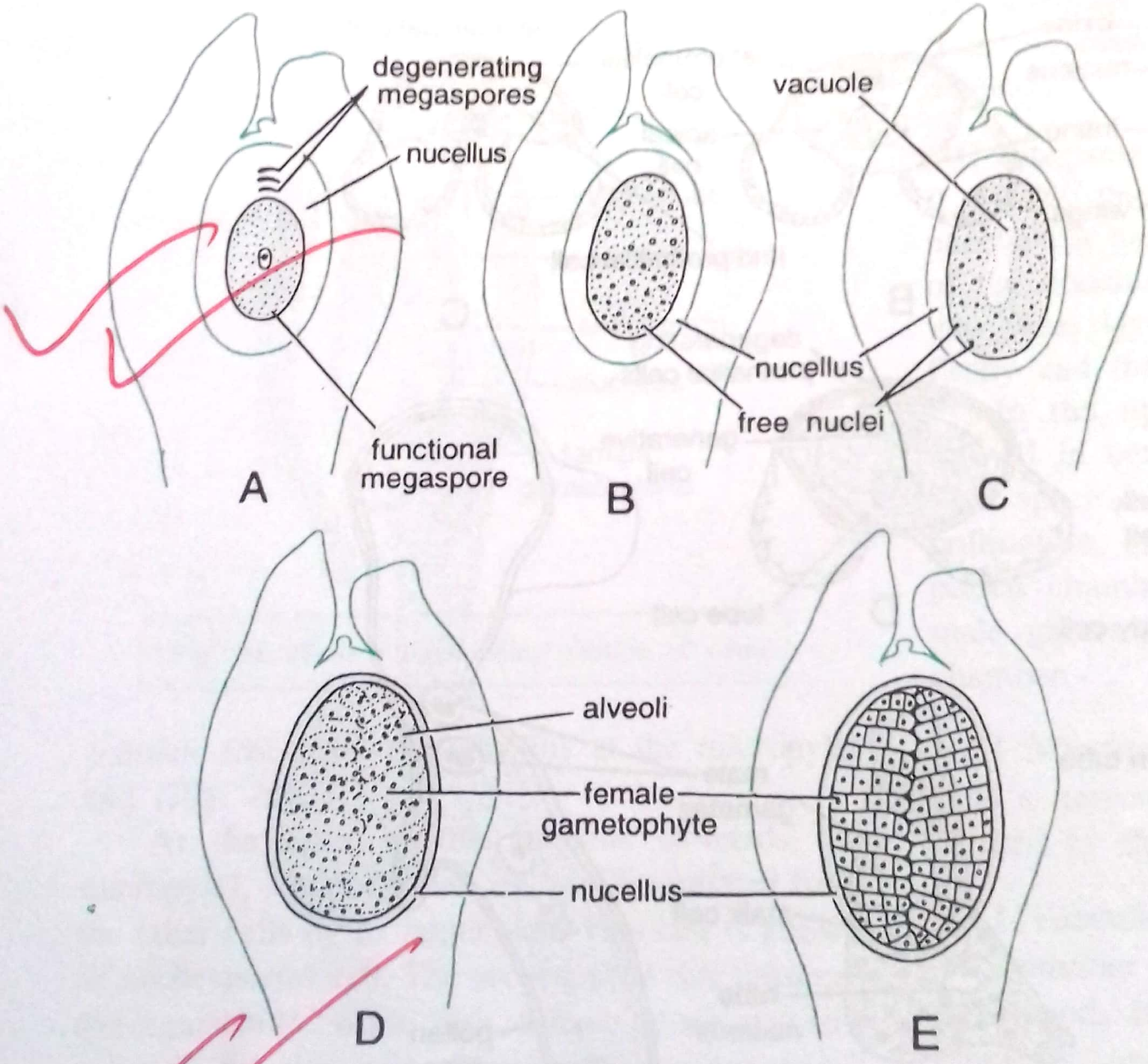

Fig. 22 A-E. *Pinus* : Development of female gametophyte.

penetrating the nucellar tissue. It is rich in starch. As in other g

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Structure of Ovule/ [illegible] | Internal" of Leaf. Leaf.

Q:13(Q8)

Cycas	Pinus
Male cone:-	
(i) These are compact cylindrical, or ovoid structure large, solitary or few and apparently terminal at the growing apex of the male stem.	(i) These are compact, oval structures measuring about (2-3) cm in length, occuring singly in the axils of scale leaves of long shoot. At the base of young shoot they appear to grow in cluster.
(ii) Each cone consists of a central axis upon which numerous microsporophylls are arranged acropetally.	(ii) Each cone consists of a short and elongated axis upon which numerous microsporophylls are arranged spirally.
(iii) Each microsporophyll is a flattened woody structure, narrow below and widen above into an expanded sterile disc. On the under surface (abaxial) of fertile portion numerous microsporangia are borne in sori.	(iii) Each microsporophyll is scaly and consists of a short stalk and a leaf-like expanded structure, the apex of which bends upwards. On the under surface of each microsporophyll there are 2 microsporangia.
(iv) Each microsporangium is sessile and oval and consists of a wall of several layers of cells	(iv) Each microsporangium is sessile and oblong in shape and consists of a wall of several layers of cells.
(v) Pollen grains i.e microspores are many in each sporangium. These are simple and without wings.	(v) Pollen grains are many in each sporangium and provided with two wing like projections.
(vi) Dehiscence of microsporangium is longitudinal	(vi) Dehiscence is also longitudin

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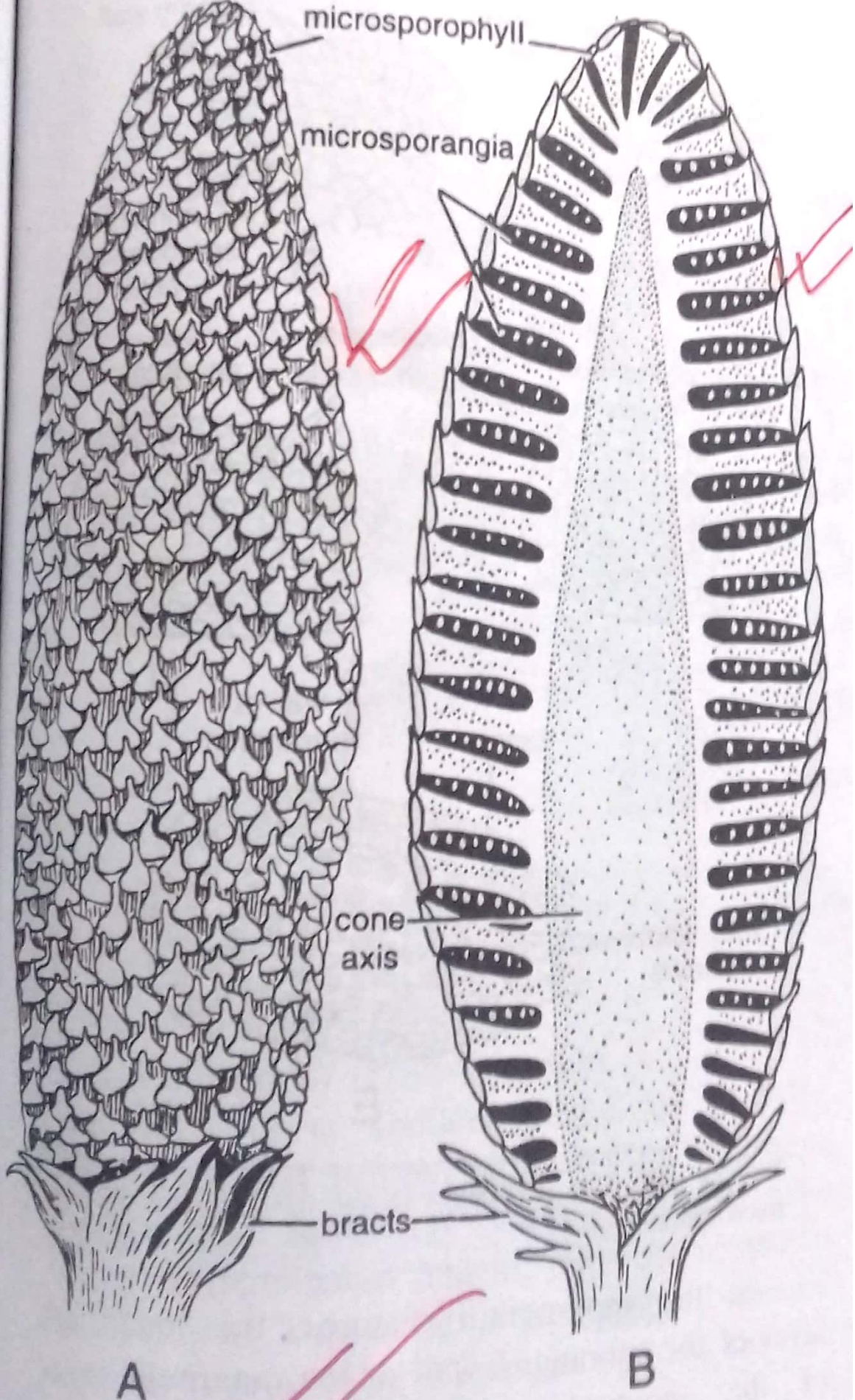

Fig. 19 A-B. *Cycas* : Male cone; **A.** Entire, **B.** Longitudinal section.

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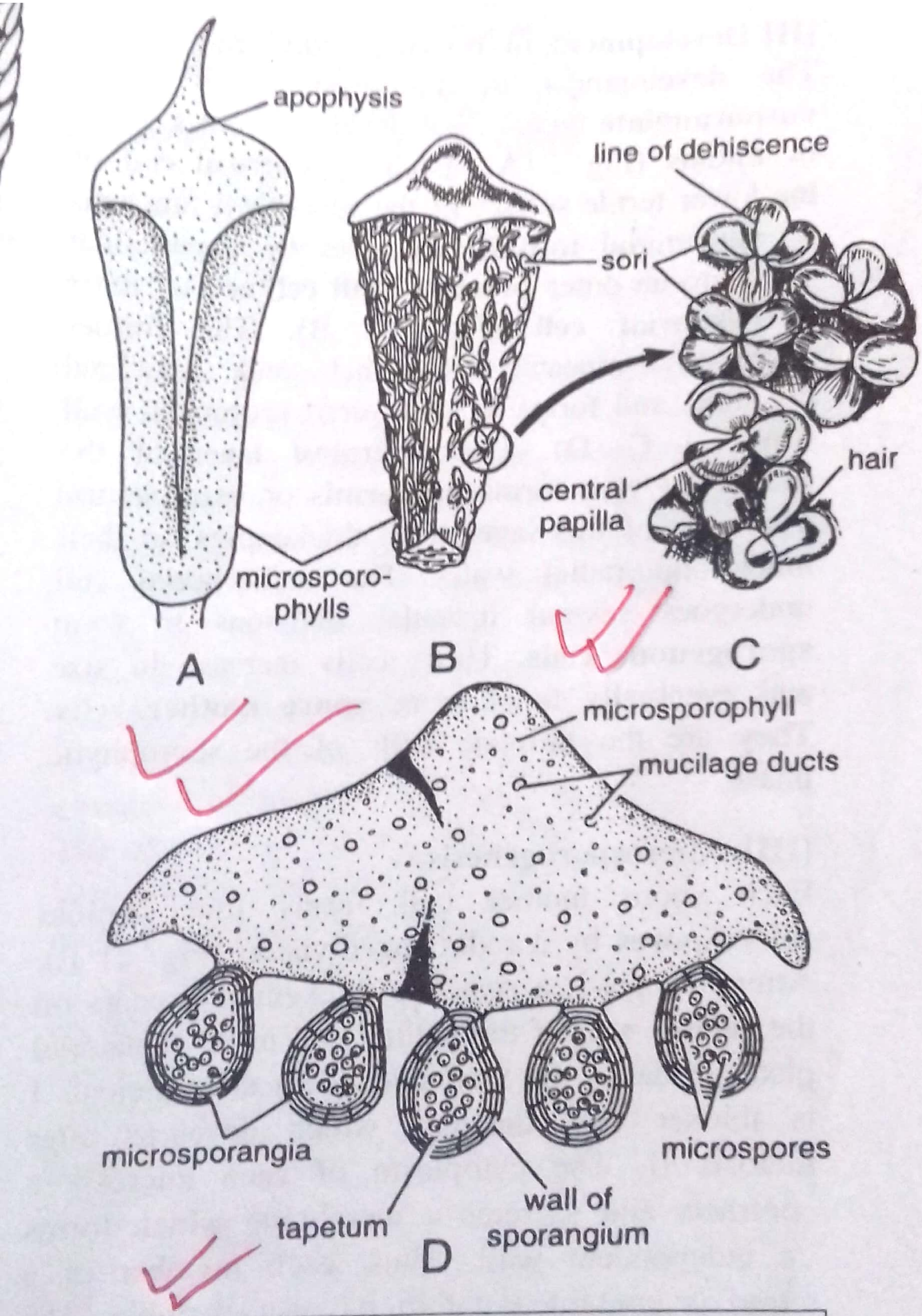

Fig. 20 A-D. ***Cycas*** **: Microsporophyll; A.** Adaxial surface, **B.** Abaxial surface, **C.** Sori, **D.** Transverse section of microsporophyll.

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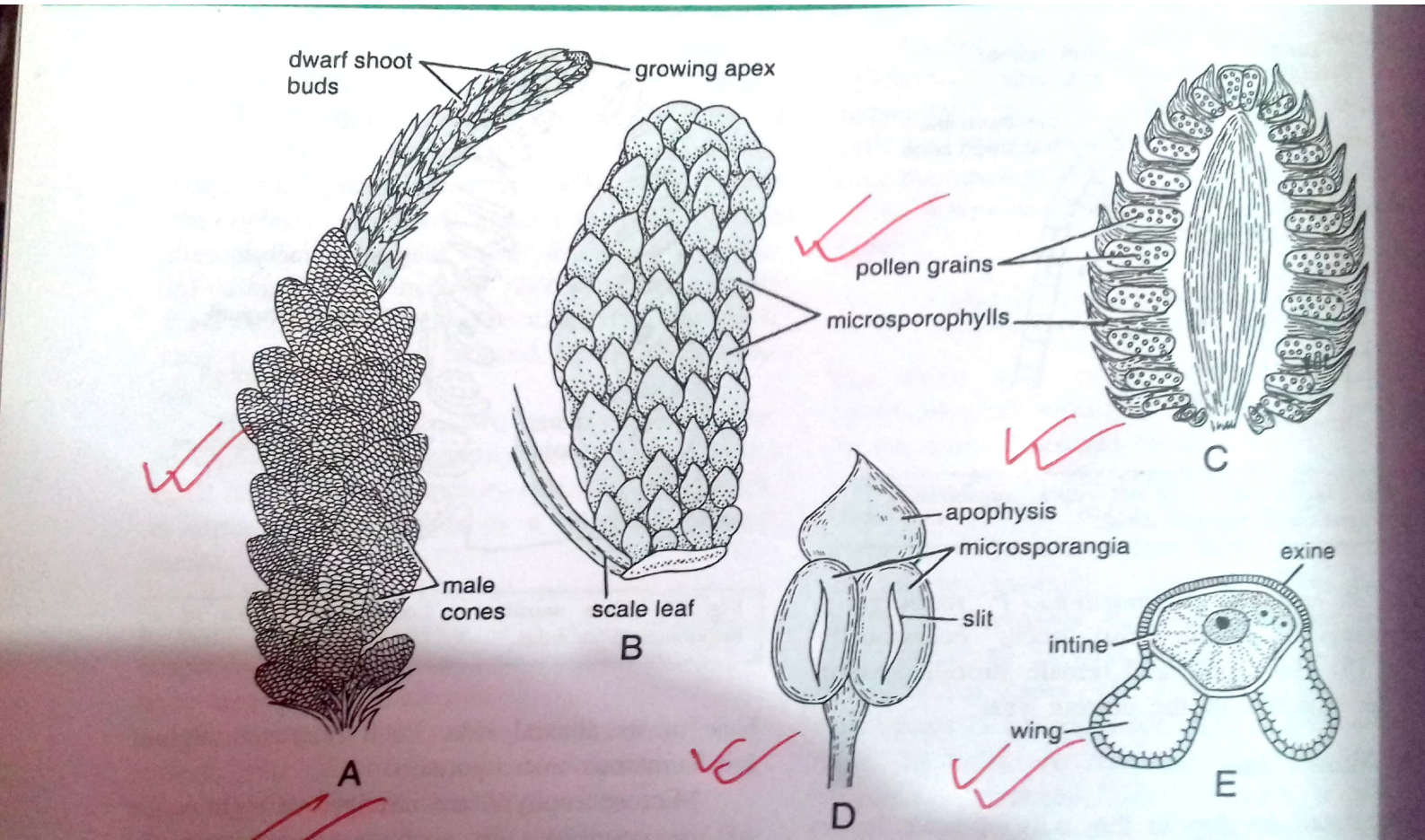

Fig. 16 A-E. *Pinus* : Male cone; A. A group of male cones, **B.** A single male cone, **C.** Longitudinal section of male cone, **D.** Microsporophyll, **E.** Pollen grain.

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Cycas	Pinus
Female cone:→	
(i) Female cones are not true cones but simple structures. The megasporophylls are large, generally leafy and loosely arranged spirally around the stem apex of the female plant. Acropetally forming a loose crown leaving the apical growing point free.	(i) Female cones form true cones and are compound. These are borne in the axils of scale leaves of the long shoots taking the position of dwarf shoots. Each cone is hard, woody, dry and consists of a long central axis bearing spirally arranged megasporophylls.
(ii) Each megasporophyll is brown in colour and is covered with hairs. (1-5) pairs of big ovules are borne on both sides of lower stalk (like part.	(ii) Each megasporophyll is shortly stalked and consists of a large ovuliferous scale and a bract scale, attached on the lower side of the ovuliferous scale. Ovuliferous scale bears two inverted megasporangia (ovules) on the upper surface near the base.
(iii) Each megasporangium i.e. ovule consists of a massive nucellus tissue and is surrounded by a thick, single integument, which is three layered - Outer fleshy layer, Middle stony layer and Inner fleshy layer. Nucellus tissue is fused with the integument except at the micropylar region, where it forms a beak like structure called nucellar beak. In this region the pollen chamber is situated.	(iii) Each ovule consists of a massive nucellus surrounded by a single integument. The nucellus is fused with the integument at the basal region. Nucellar beak and pollen chambers are absent.
(iv) One megaspore mother cell is diff within the nucellus tissue which by meiosis gives rise to a linear tetrad of 4 megaspores, Of these 4 megaspores only lower most one is the functional megaspore while other 3 degenerate.	(iv) One megaspore mother cell is diff within the nucellus tissue which by meiosis gives rise to a linear tetrad of 4 megaspores. Of these 4 megaspores, only lower most one is the functional while other three degenerate.

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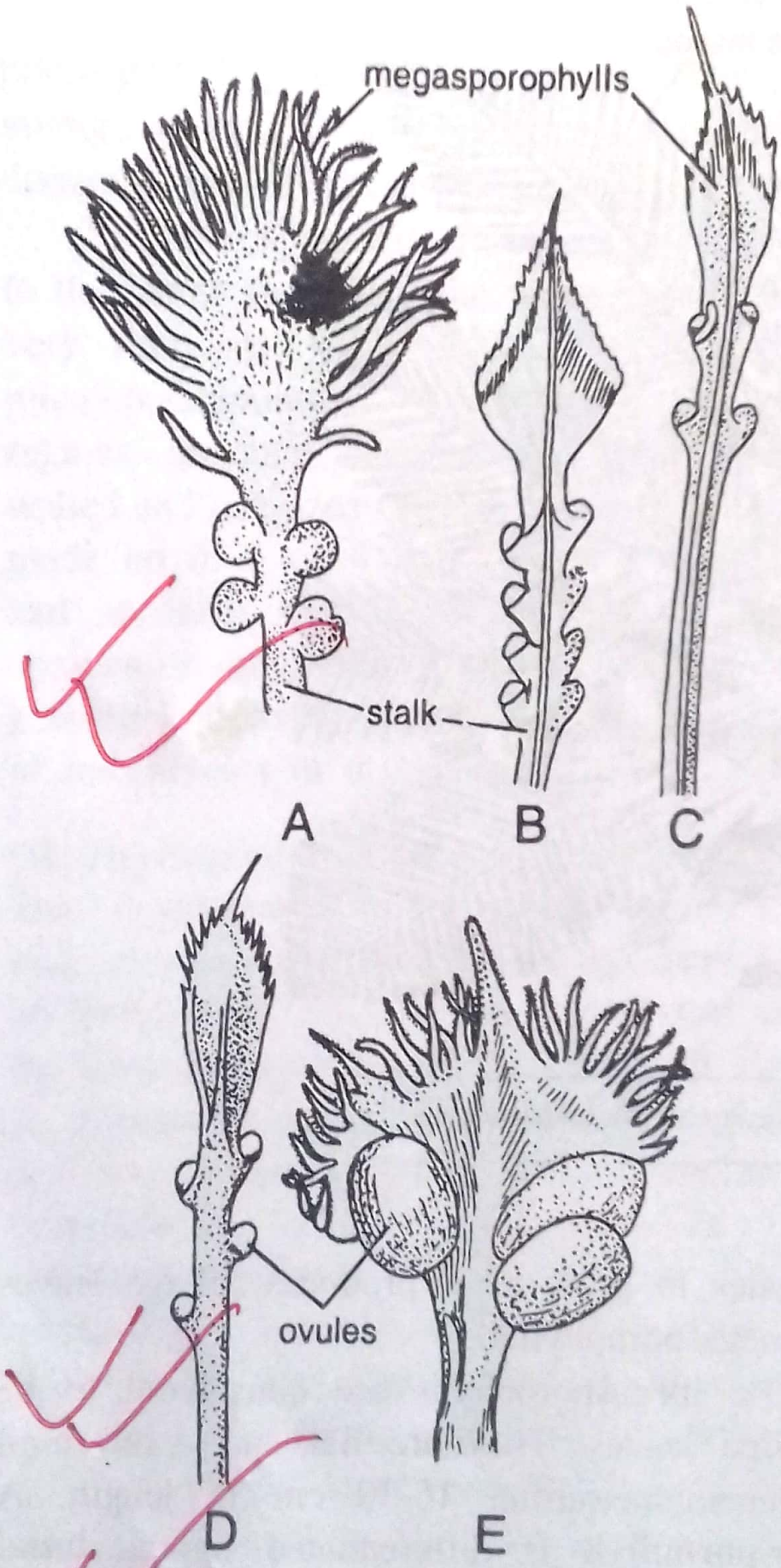

Fig. 23 A-E. *Cycas* : Megasporophylls; **A.** *C. revoluta*, **B.** *C. circinalis*, **C.** *C. rumphii*, **D.** *C. beddomei*, **E.** *C. pectinata.*

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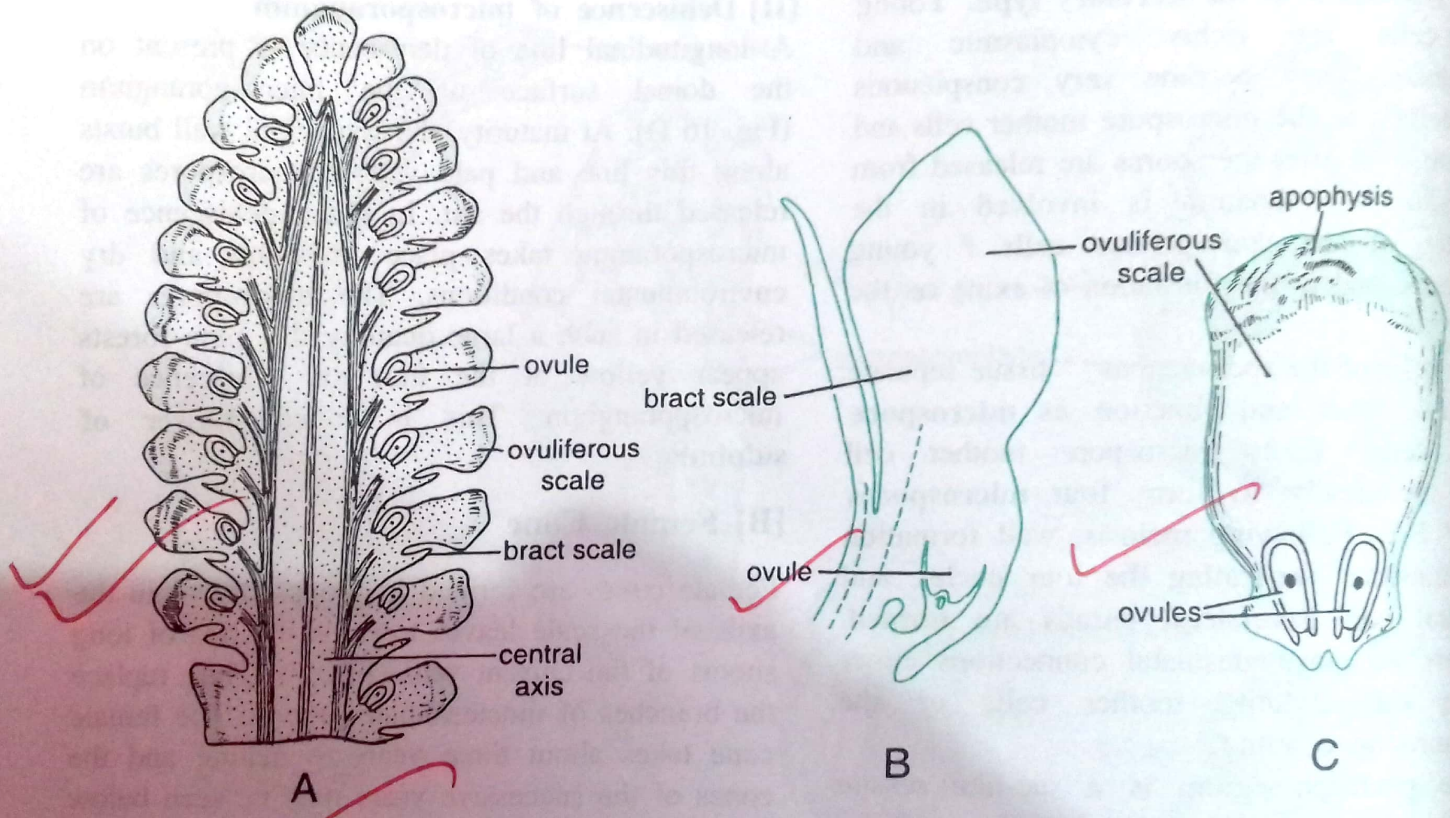

Fig. 19 A-C. *Pinus* : Female cone; A. Longitudinal section, **B.** Megasporophyll, **C.** Ovuliferous scale.

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divide into three equal parts.

[D] Foliage Leaf (Pinus needle)

In transection the outline of the foliage leaf varies in different species depending on the number of leaves in a spur. For example, it is circular in *P. monophylla* (with one needle in a spur); semicircular in *P. sylvestris* (with two needles in a spur) and triangular in *P. longifolia* (Fig. 13) and *P. gerardiana* (with three needles in a spur).

1. Epidermis. The single layered epidermis consists of heavily cutinised thick-walled cells. It has many deeply sunken haplocheilic stomata. The stomata are arranged in axial rows. Each stoma consists of two guard cells surrounded by 6-9 subsidiary cells. It opens internally into a substomatal cavity.

2. Hypodermis. The epidermis is followed by 2-3 layers of thick-walled sclerenchymatous hypodermis. The hypodermis is interrupted by the

stoma

Scanned by CamScanner

presence of sub-stomatal cavities. In *P. longifolia*, the hypodermis is more developed at the corners.

3. Mesophyll. Next to hypodermis there are 3-5 layers of mesophyll tissue, composed of polygonal parenchymatous cells with dense chloroplasts and starch grains. The walls of the mesophyll cells give rise to many peg-like infoldings which increase photosynthetic area of these cells. The structural peculiarity of mesophyll cells compensates the reduced area of the needle leaves.

There are usually two resin canals in the mesophyll, just below the hypodermis. Each resin canal has a layer of secretory epithelial cells which is surrounded on outside by a sclerenchymatous sheath.

4. Endodermis. Inner to mesophyll, there is a layer of barrel-shaped cells with prominent casparian thickenings on their radial walls. This layer represents endodermis.

5. Pericycle. A multilayered pericycle is present next to endodermis. It consists of the following three types of cells.

(*a*) ***Parenchymatous cells.*** Most of the pericycle is composed of parenchymatous cells which are densely filled with starch grains.

(*b*) ***Albuminous cells.*** These cells occur in close contact with the phloem cells. They are also parenchymatous cells which are packed with proteins and starch grains. They do not possess pits and probably help in translocation of nutrients from mesophyll to phloem cells.

(*c*) ***Tracheidal cells.*** These are tracheid- like cells which occur close to xylem cells. These cells possess pits and help in conduction of water and minerals to mesophyll. They form transfusion tissue.

Besides the above three types of cells, some sclerenchymatous cells also occur in the pericycle which form a T-shaped girdle above the two vascular bundles in *P. roxburghii*.

6. Vascular bundles. The number of vascular bundles varies in different species of *Pinus*. There is only a single vascular bundle in *P. monophylla* and two in *P. roxburghii*. The vascular bundles are conjoint, collateral and open with abaxial phloem and adaxial xylem.

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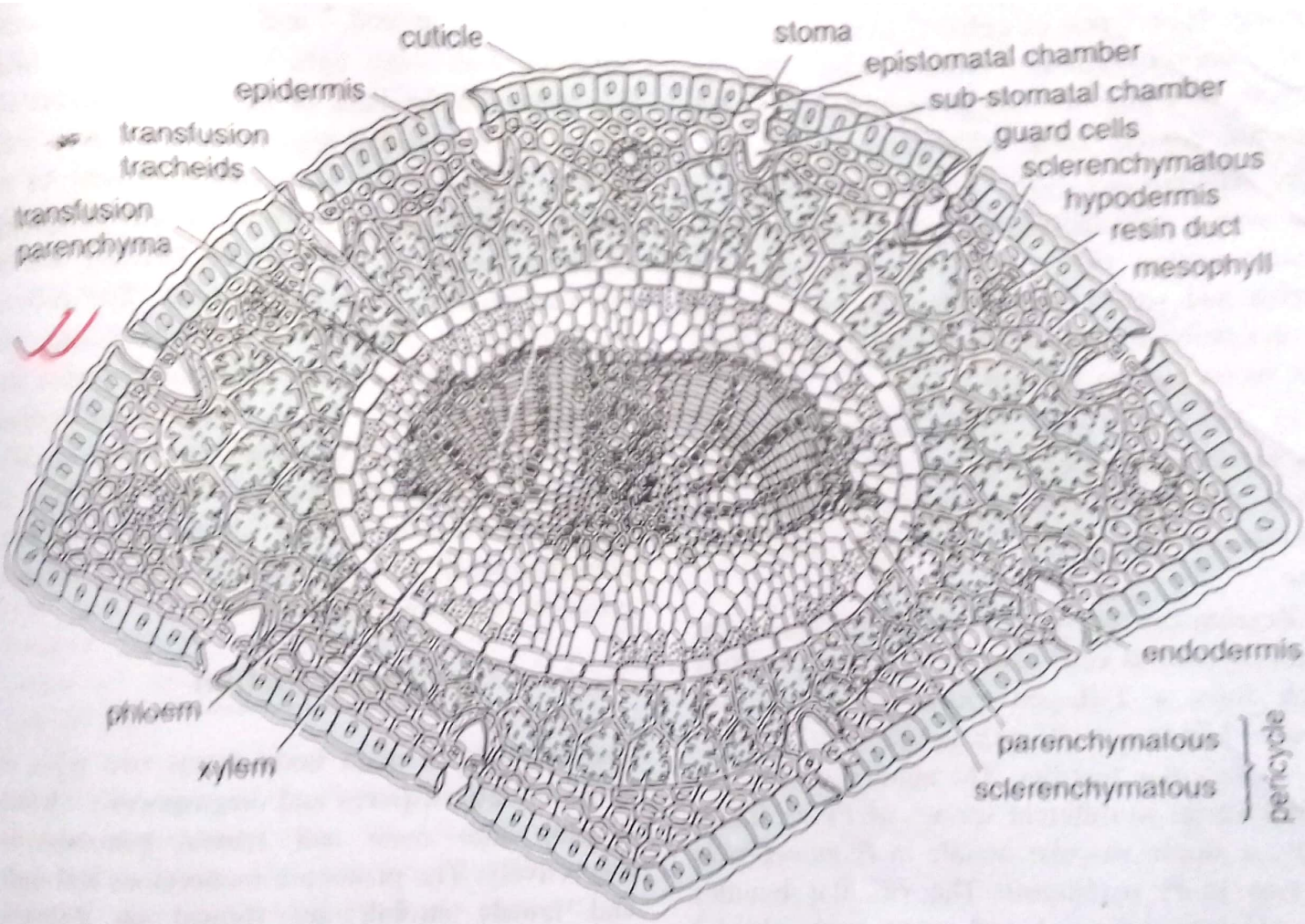

Fig. 13. Pinus : Transverse section of needle.

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grammatic representation of vertical section

secondary growth.

[II] Leaflet

There is a single midrib in the leaflet; lateral veins are absent. The leaflet is swollen in the mid-rib region. The margins of the wings are revolute in *C. revoluta* and *C. beddomei* and straight in *C. circinalis*, *C. pectinata* and *C. rumphii*. The following regions are discernible in a transverse section of the leaflet (Figs. 14,15).

The outermost layer forms one-celled thick **epidermis**, which is covered by a thick layer of cuticle. The upper epidermis is continuous, whereas the lower epidermis is interrupted by

Scanned by CamScanner

sunken haplocheilic stomata, which are confined to the wings. The stomata possess a crater-like appearance. The two guard cells lie at the bottom of the crater and between them is the slit-like pore. The guard cells are bordered by 8-10 subsidiary cells arranged in a ring-like manner. In later stages these are not easily distinguishable from the rest of the epidermal cells.

The epidermis is followed by a layer of sclerenchymatous **hypodermis**. The hypodermis forms a continuous layer on the dorsal surface but on the ventral surface it is confined only to the mid-rib region. In *C. revoluta,* however, hypodermis is also present in the wings. The hypodermis serves as a screen and protects the plant from over-heating and excessive transpiration.

Next to hypodermis, there is a well developed **mesophyll** which is differentiated into palisade and spongy parenchyma. The **palisade** is a single continuous layer of columnar cells. The **spongy parenchyma** consists of several layers of loosely arranged oval or irregular cells that are confined to the wings. The cells of both the palisade and spongy parenchyma are rich in chloroplasts.

There are groups of tracheid-like cells on the lateral sides of the vascular xylem in the mid-rib region. These cells are small and broad and have reticulate thickenings or bordered pits on their walls. They represent **transfusion tissue**. In the wing region long colourless and transversely elongated parenchyma cells are present in between palisade and spongy parenchyma. They represent **secondary** or **accessory transfusion tissue.** The secondary transfusion tissue is connected with centripetal xylem, abutting on the bundle sheath. Since lateral veins are lacking in *Cycas,* accessory transfusion tissue helps in lateral conduction of water and nutrients.

A single **vascular bundle** is present in the midrib region. It is surrounded by a parenchymatous bundle sheath. The vascular bundle is conjoint, collateral, open and diploxylic. It has a large and triangular centripetal xylem and two small groups of centrifugal xylem, one on either side of the centripetal protoxylem. Phloem is present on the adaxial side of the xylem. It is composed of parenchyma and sieve

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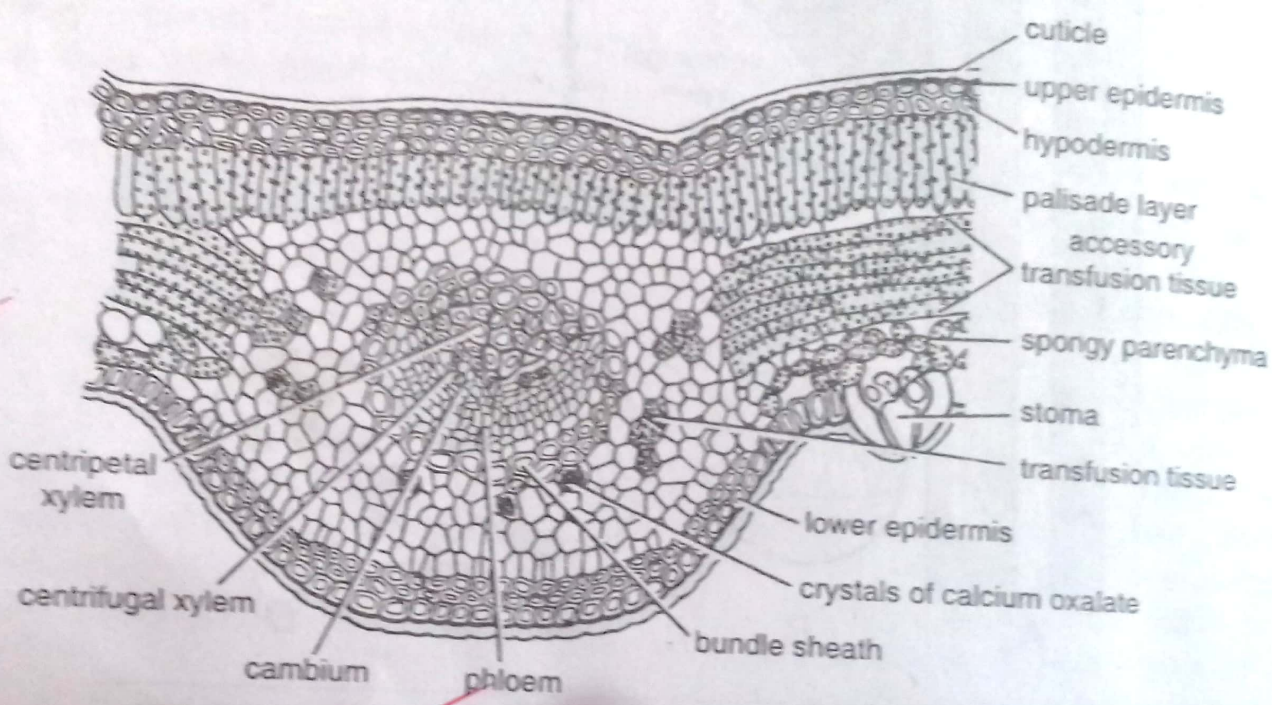

Fig. 15. *Cycas* : Vertical section of leaflet.

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Learning objectives:

- Understand Phanerogams
- What are Gymnosperms?
- General Characteristics of Gymnosperms
- How Gymnosperms differ from Angiosperms?

GYMNOSPERMS: CHARACTERISTICS

- ***Naked Seed Plants***
- ***'Gymnos'*** = naked; ***'sperma'*** = seeds
- Primitive seed plants of spermatophyta (Phanerogams)
- Characterized by **naked ovules** (ovule without ovary)
- Ovules borne on the surface of **megasporophylls** (unprotected)
- Seeds are **NOT** enclosed in fruit (unlike Angiosperms)
- Also known as "*Phanerogams without ovary*"

Gnetum

Cycas

Naked seeds of Gymnosperms

GYMNOSPERMS: CHARACTERISTICS

Cycas

Pinus

Gnetum

GYMNOSPERMS: CHARACTERISTICS

Cedrus

Araucaria

Zamia

Thuja

Ephedra

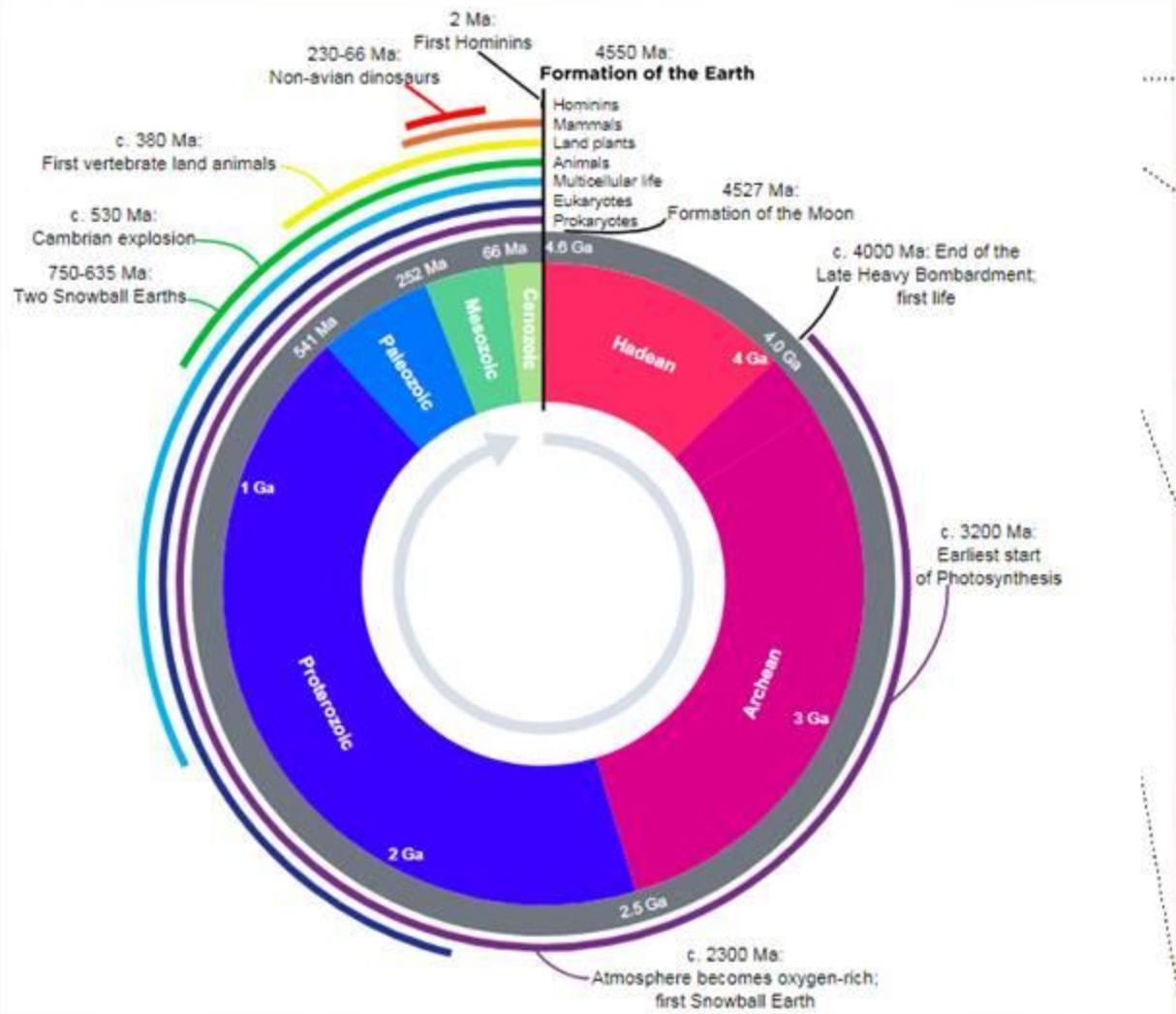
Welwitschia mirabilis

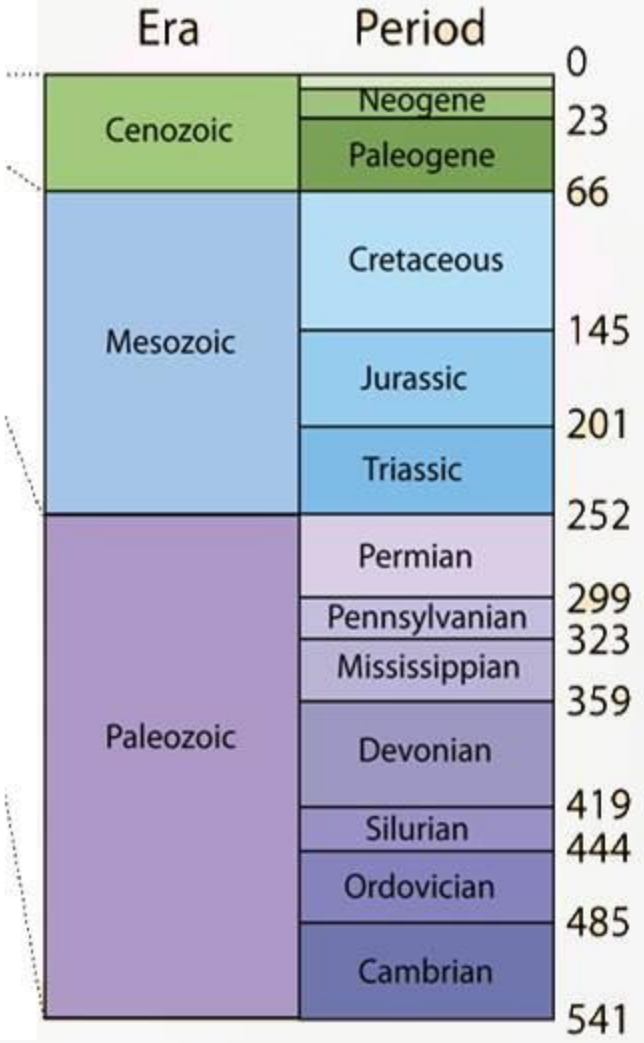
GYMNOSPERMS: CHARACTERISTICS

- A **Small** group of plants
- 70 Genera: 70 and Species: 725
- **Distribution**: Temperate and Tropical regions
- **Ancient** group of seed plants
- Originated in the **Paleozoic era** (541 – 252 million years ago)
- Dominant plants of **Jurassic** and **Cretaceous** periods of Mesozoic era
- Many primitive Gymnosperms were **extinct**
- Extinct: *Cycadofilicales, Bennettitales, Cordaitales*

Fossil of a Gymnosperm

GYMNOSPERMS: CHARACTERISTICS





Geological Time Scale
(Years in Million)

GYMNOSPERMS: CHARACTERISTICS

- Living forms are usually **evergreen trees** or **shrubs**
- Usually show **xerophytic** characters
- Plant body is **sporophytic** – diploid
- Differentiated into **roots**, **stem** and **leaves**
- Plant possesses well developed **vascular system**
- Vascular system consists of **xylem** and **phloem**

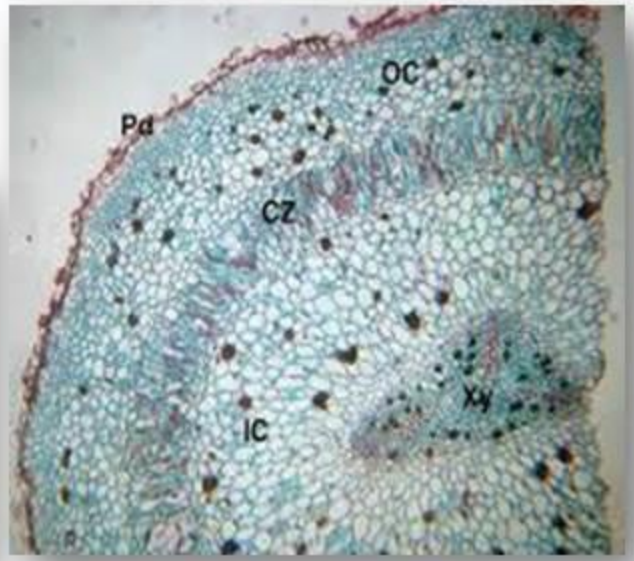
Pinus Trees

GYMNOSPERMS: CHARACTERISTICS

- Roots show **symbiotic** association with **fungi** or **cyanobacteria**
- Fungi: *Mycorrhizal* association of ***Pinus*** roots
- Fungi helps in absorption of minerals
- Algae: **Coralloid** roots of *Cycas* with *Nostoc* and *Anabaena*
- Algae helps in nitrogen fixation

Mycorrhia

Coralloid roots



Algal zone in Coralloid roots

GYMNOSPERMS: CHARACTERISTICS

- Stem: usually **erect**, **branched** and woody
- Stem usually un-branched in *Cycas*
- Stem underground in *Zamia*

- Presence of **Leaf scar** is a characteristic feature of Gymnosperms

Pinus

Cycas

Zamia

GYMNOSPERMS: CHARACTERISTICS

- Leaves usually **dimorphic**: (**Foliage** leaves and **Scale** leaves)
- **Foliage leaves:** green; simple or needle shaped or pinnately compound
- **Scale leaves:** minute and deciduous
- Leaves have thick cuticle
- Stomata usually **sunken**
- *Cycas* show ***circinate vernation***

Circinate vernation - Fern

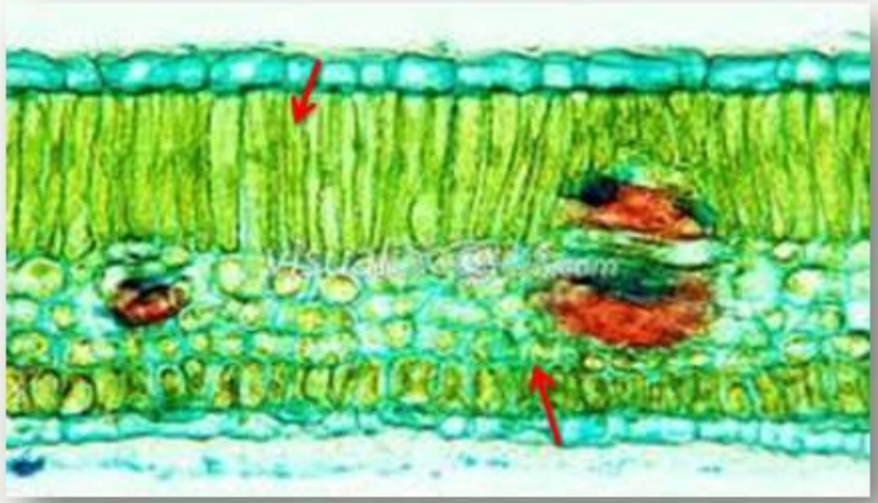
Cycas leaves

Pinus Leaves

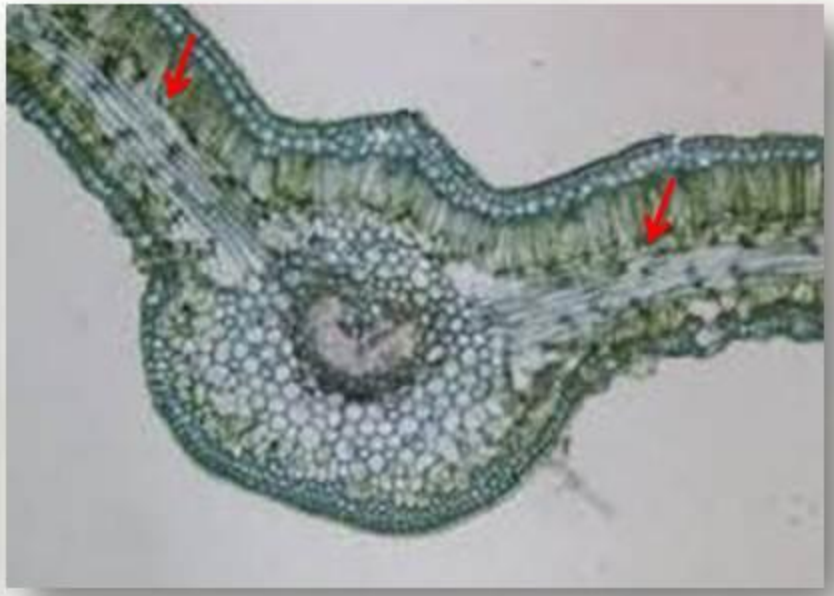
Pinus leaves

GYMNOSPERMS: CHARACTERISTICS

- Mesophyll differentiated into **palisade** and **spongy** tissue
- Mesophyll undifferentiated in *Pinus*
- Leaves do **NOT** have lateral veins
- Lateral translocation of nutrients takes place by **transfusion tissue**



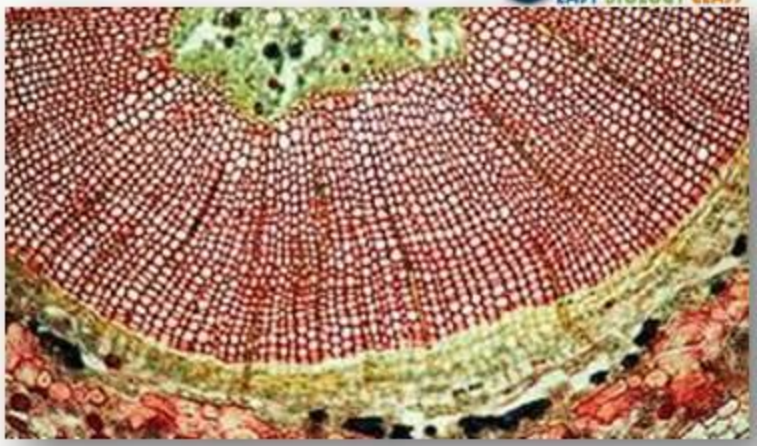
CS of Leaf (Palisade and Spongy Tissue)



CS of Cycas Leaflet (Transfusion Tissue)

GYMNOSPERMS: CHARACTERISTICS

- Roots **diarch** to **polyarch**
- Tanniniferous cells present in cortex
- Vascular bundles: **collateral** and **open**



Wood of Gymnosperm

Xylem:

- Xylem consists of **Tracheids** and **Parenchyma**
- Vessels **absent** in the xylem
- **Vessels present in *Gnetum***

Gnetum

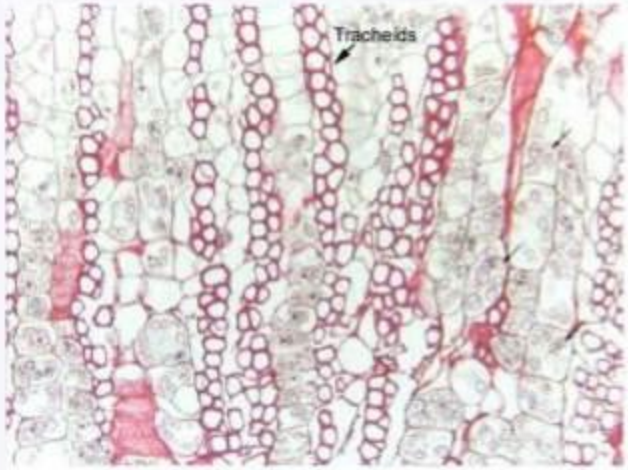
Wood of Gnetum with Vessels

GYMNOSPERMS: CHARACTERISTICS

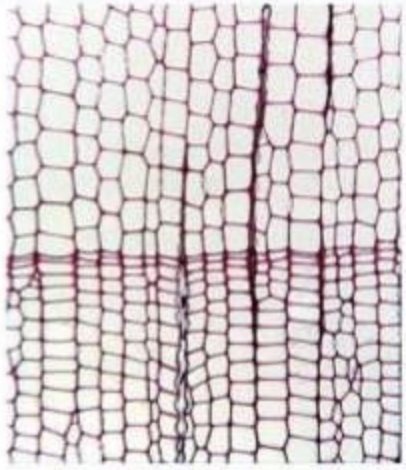
Phloem:

- Phloem consists of **sieve tubes** and **phloem parenchyma**
- **Companion** cells absent

- Stem shows **secondary growth**
- Wood may be **manoxylic** (*Cycas*) or **pycnoxylic** (*Pinus*)



MANOXYLIC WOOD



PYCNOXYLIC WOOD

GYMNOSPERMS: CHARACTERISTICS

- Plants are **heterosporous**
- **Megasporangia** produced on **megasporophyll**
- **Microsporangia** produced on **microsporophyll**
- Sporophylls aggregated to form **cones** or **strobili**
- Cones/strobili are **mono-sporangiage**

Cycas: Male cone

Cycus Microsporophyll

Cycas Megasporophyll

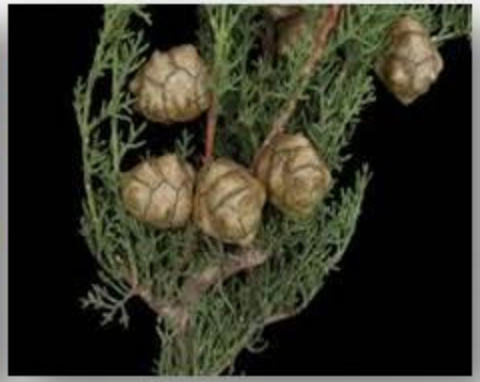
Cycas: Male cone

GYMNOSPERMS: CHARACTERISTICS

Cycas
(Male cone)

Cycas
(Female cone)

Cupressus
(Male cone)



Cupressus
(Female cone)

Pinus
(Male cone)

Pinus
(Female cone)

Gnetum
(Male cone)

Gnetum
(Female cone)

GYMNOSPERMS: CHARACTERISTICS

Male and Female Cone:

- Males cones **short lived**
- Female cones lives for many **years**
- Microsporangia formed on **abaxial** side of microsporophyll
- Microsporangia development: **eusporangiate**

Pinus (Soft Male and Hard Female cone)

Cycas (microsporophyll)

Cycas (Sporangia)

Cycas (Sporangia)

GYMNOSPERMS: CHARACTERISTICS

Female cone:

- Female cone formed by the aggregation of **megasporophylls**
- Megasporophylls may be **foliar** (*Cycas*) or **cauline** (*Pinus*)
- Megasporangium is better known as **ovule** (naked)
- Ovules **orthotropous** and unitegmic
- Ovular integument is differentiated into **three** layers

Cycas
Megasporophyll

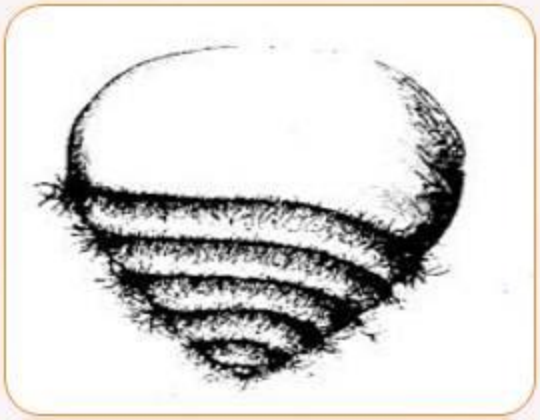
Pinus
Megasporophyll

Orthotropous Ovule

Anatropous Ovule

GYMNOSPERMS: CHARACTERISTICS

- Microspores are liberated at various stages of the **gametophyte**
- Male gametes are **non motile** except in *Cycas* and *Ginkgo*
- Number of archegonia in female gametophyte varies
- Several archegonia in *Cycas*, only one in *Pinus*



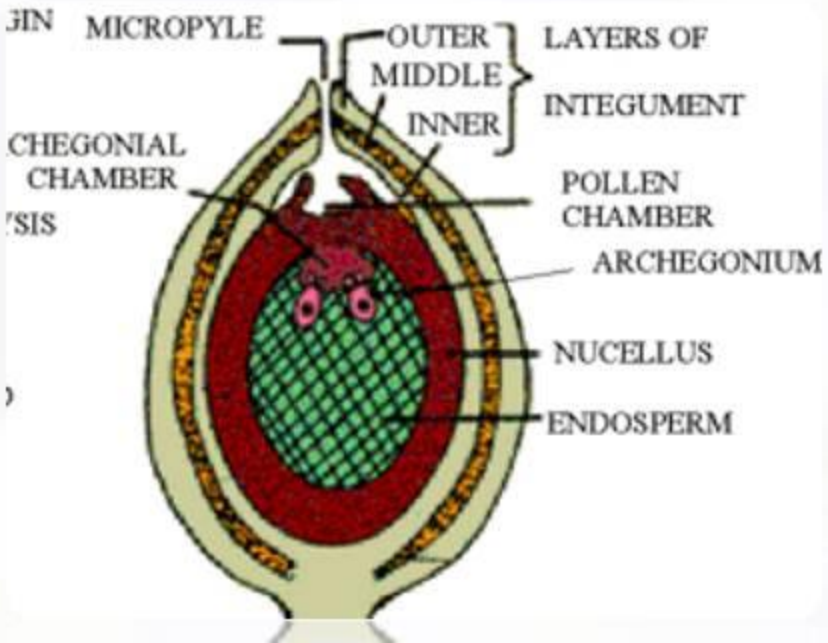
Cycas (Sperm)

Ginkgo (Sperm)

Ginkgo (Sperm)

GYMNOSPERMS: CHARACTERISTICS

- Archegonium has a **single egg** and a **venter canal** cell
- Archegonium in *Gnetum* is represented by ovum only
- **Neck canal cell absent in *Gnetum***
- Pollination: all gymnosperms are **wind** pollinated (*Anemophily*)
- Pollens deposited in the wet **pollen chamber**



GYMNOSPERMS: CHARACTERISTICS

- Fertilization **siphonogamic** (with the help of pollen tube)
- Pollen tube functions as the **sperm carrier**
- Embryo development: **meroblastic** (embryo develops from some part of zygote. Angiosperms are also shows meroblastic development)
- Endosperm present
- Development of endosperm takes place **before fertilization**
- *Endosperm is **haploid***
- ***Double fertilization** and **triple fusion** absent in Gymnosperms*

GYMNOSPERMS: CHARACTERISTICS

- Poly-embryony is very common
- Poly-embryony may arise by:
  - Fertilization of more than one eggs
  - Division of zygote (**Cleavage poly-embryony**)
- Seed coat **present**
- **Integument** of ovule forms the seed coat
- Seeds winged in *Pinus*

Pinus (Winged seeds)

Cycas (seeds)

Cycas (seeds)

GYMNOSPERMS: CHARACTERISTICS

- Number of cotyledons may be **one** or **two** or **many**
- Seeds usually have a **resting** period
- Distinct alternation of generation
- Diploid **sporophytic generation** is dominant
- Haploid gametophytic stage is reduced
- Gametophytic phase is **depended** on sporophytic phase