GYMNOSPERMS

- A separate subdivision of seed bearing plants.
- Gymnos = naked & Sperma = seed
- Plants with naked seeds.
- Ovules – mature into seeds – borne exposed on megasporophylls.
- Theophrastus – plants with unprotected seeds.
- Goebel – Phanerogams without ovary.
- 722 species of gymnosperms present today.
- Many are extinct & fossilized.
- Connecting link bet. Pteridophytes & Angiosperms.

CYCAS

CYCAS

ZAMIA

PODOCARPUS

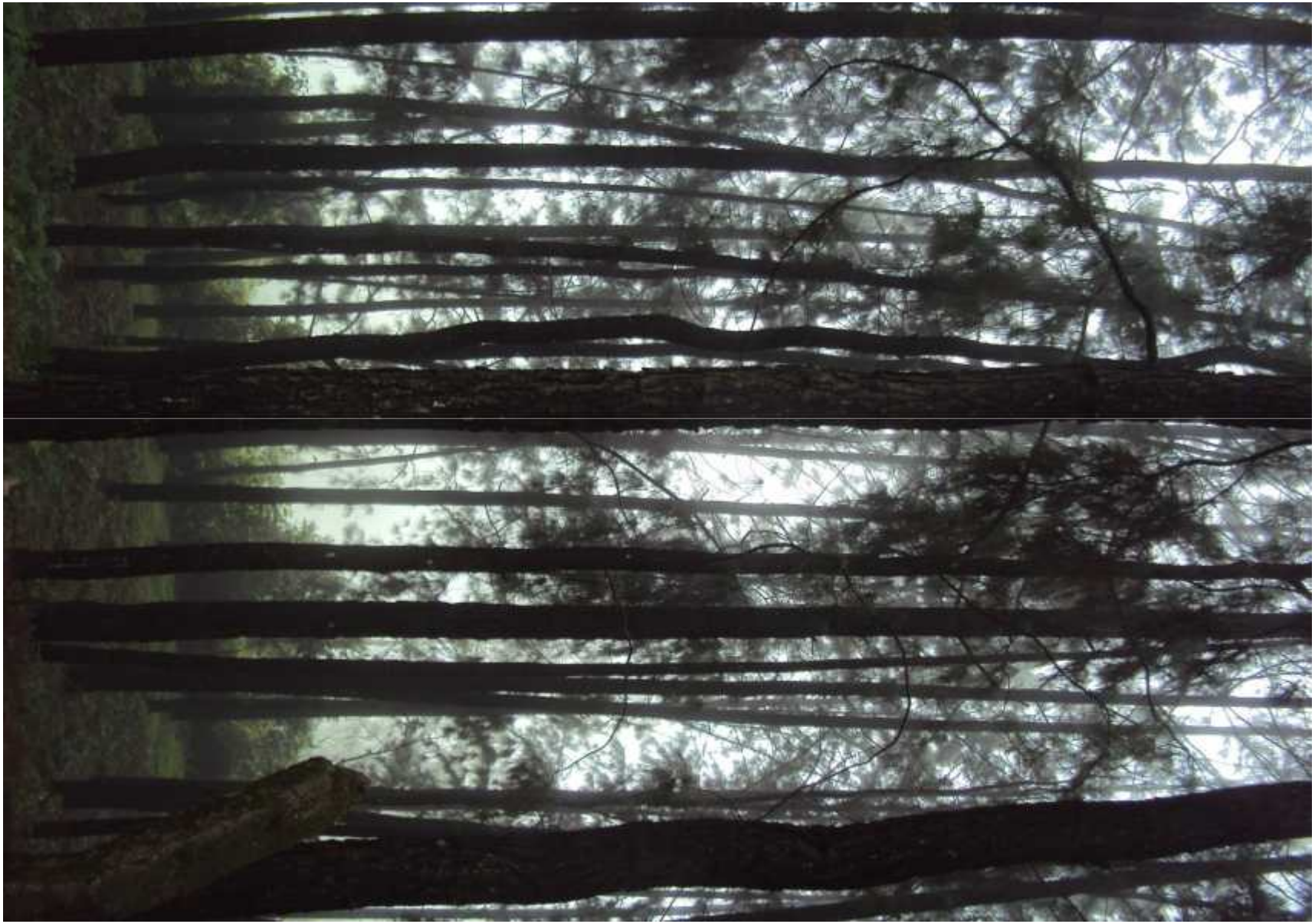
CUPRESSUS

THUJA

ARAUCARIA

PINUS

PINUS



CRYPTOMERIA

CRYPTOMERIA

- **Most primitive set of plants that produce seeds.**
- **Do not bear any flowers or fruits.**
- **Plant is sporophyte – produces reproductive structures – cones.**
- **Plants are heterosporous – 2 types of cones – 2 types of sporophylls – 2 types of spores.**
- **Male cones – microsporophylls – microsporangia – microspores.**
- **Female cones – megasporophylls – megasporangia (ovule) – megaspores.**
- **Female gametophyte formed - endosperm.**

- **Plants possess archegonia – with no neck canal cells.**
- **Pollination by wind – pollination drop.**
- **Pollen – microspores received by ovule.**
- **Germinate in pollen chamber of ovule.**
- **Produces pollen tube that carries male gametes.**
- **Fusion of male & female gametes – zygote.**
- **Zygote – embryo – meroblastic development.**
- **Sporophytic generation is diploid, dominant & independent.**
- **Gametophyte is haploid, reduced & dependent.**

CYCAS

DIVISION : GYMNOSPERMS

CLASS : CYCADOPSIDA

ORDER : CYCADALES

FAMILY : CYCADACEAE

25 sps world wide, 6 sps in India

C. circinalis

C. pectinata

C. revoluta

C. siamensis

C. beddomei

C. rumphii

- **Evergreen, slow growing, long living, palm-like.**
- **1.5 to 3 meters tall.**
- **Sporophyte - roots, stem & leaves.**
- **Sago palm – starch – sago starch.**
- **Roots – normal tap roots & coralloid roots.**
- **Stem - tuberous & subterranean when young.**

  old – unbranched.
- **Leaves – dimorphic – scale leaves & photosynthetic leaves.**
- **Foliage leaves – green, photosynthetic, large, compound with circinate vernation.**

- Circinate vernation
- Rachis & leaflets coiled

- **Scale leaves - small, brown, non-photosynthetic, covered with ramenta, protective in function.**
- **Rachis & leaflets show circinate vernation.**

ROOT ANATOMY

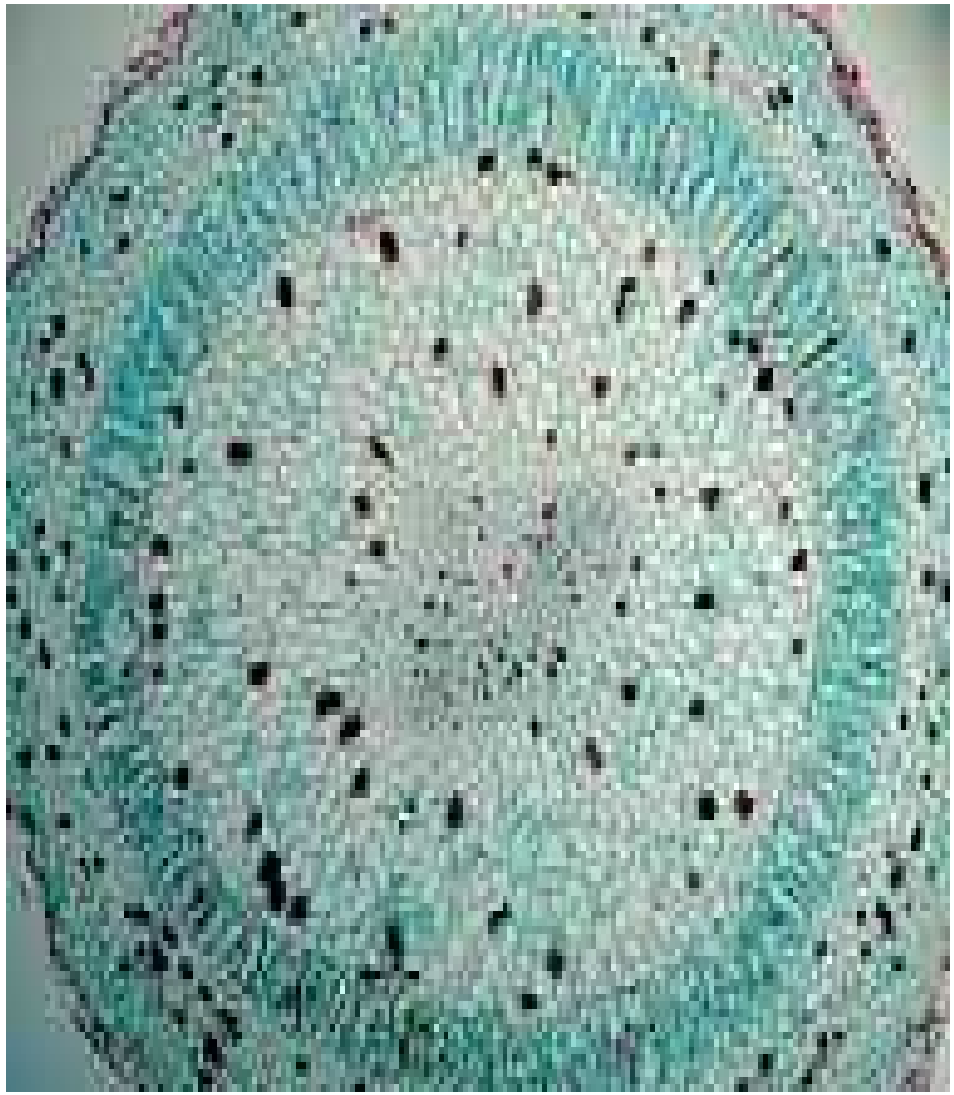
- **Similar to structure of dicot roots.**
- **Epidermis with root hairs.**
- **Cortex – many layered, parenchymatous, thin walled cells.**
- **Starch cells, tannin cells & mucilage canals.**
- **Innermost layer of cortex – endodermis – one layered with casperian thickening.**

- **Pericycle several layered.**
- **Triarch – with radially arranged xylem & pholem.**
- **Xylem is exarch.**
- **Sec. thickening as in dicot roots.**

COROLLOID ROOT

- **Similar to normal root.**
- **Cortex – three zones – outer, middle & inner.**
- **Middle zone – radially elongated cells – algal zone – with *Nostoc* & *Anabaena* colonies.**
- **Symbiotic association**

CYCAS CORALLOID ROOT



STEM ANATOMY

Pri. structure – similar to dicot stem.

Outer region irregular - with leaf bases.

Epidermis hardly visible – broken due to leaf bases.

Cortex broad – cells thin walled – with starch, calcium oxalate crystals & mucilage ducts.

Cortex & pith communicated by parenchymatous medullary rays.

Pericycle & endodermis indistinct.

Vas. bundles conjoint, collateral, open, endarch & arranged in the form of a ring.

- **Pri. phloem – sieve tubes, phloem parenchyma & albuminous cells – no companion cells.**
- **Pri. cambium – bet. Xylem & phloem - short lived.**
- **Pith - large – big cells - with starch grains.**
- **Cortex – leaf traces – 2 direct & 2 indirect.**
- **Indirect traces – girdle traces.**

SECONDARY THICKENING

- **Interfascicular cambium produced.**
- **Produces sec. phloem externally & sec. xylem internally.**

- **Sec. stem with plenty of parenchyma cells.**
- **Xylem – tracheids with bordered pits.**
- **Phloem – sieve tubes & parenchyma.**
- **Companion cells absent.**
- **Sec. thickening abnormal with polycyclic xylem.**
- **First formed cambium active only for short period.**
- **New cambial ring formed peripherally.**
- **Active only for short period – after producing sec. xylem & phloem.**
- **Several successive cambia are formed.**

- **Vas. tissues appear to be polycyclic.**
- **Periderm formed in cortex.**
- **Several concentric layers of phellogen arise in centripetal manner.**
- **Cork formed in successive layers.**
- **Lenticels are also formed.**

RACHIS ANATOMY

- **Epidermis – single layered, small cells, thick walled & with thick cuticle.**
- **Followed by 2 layers of chlorenchyma.**
- **Hypodermis – 2 to 3 layered & sclerenchymatous.**

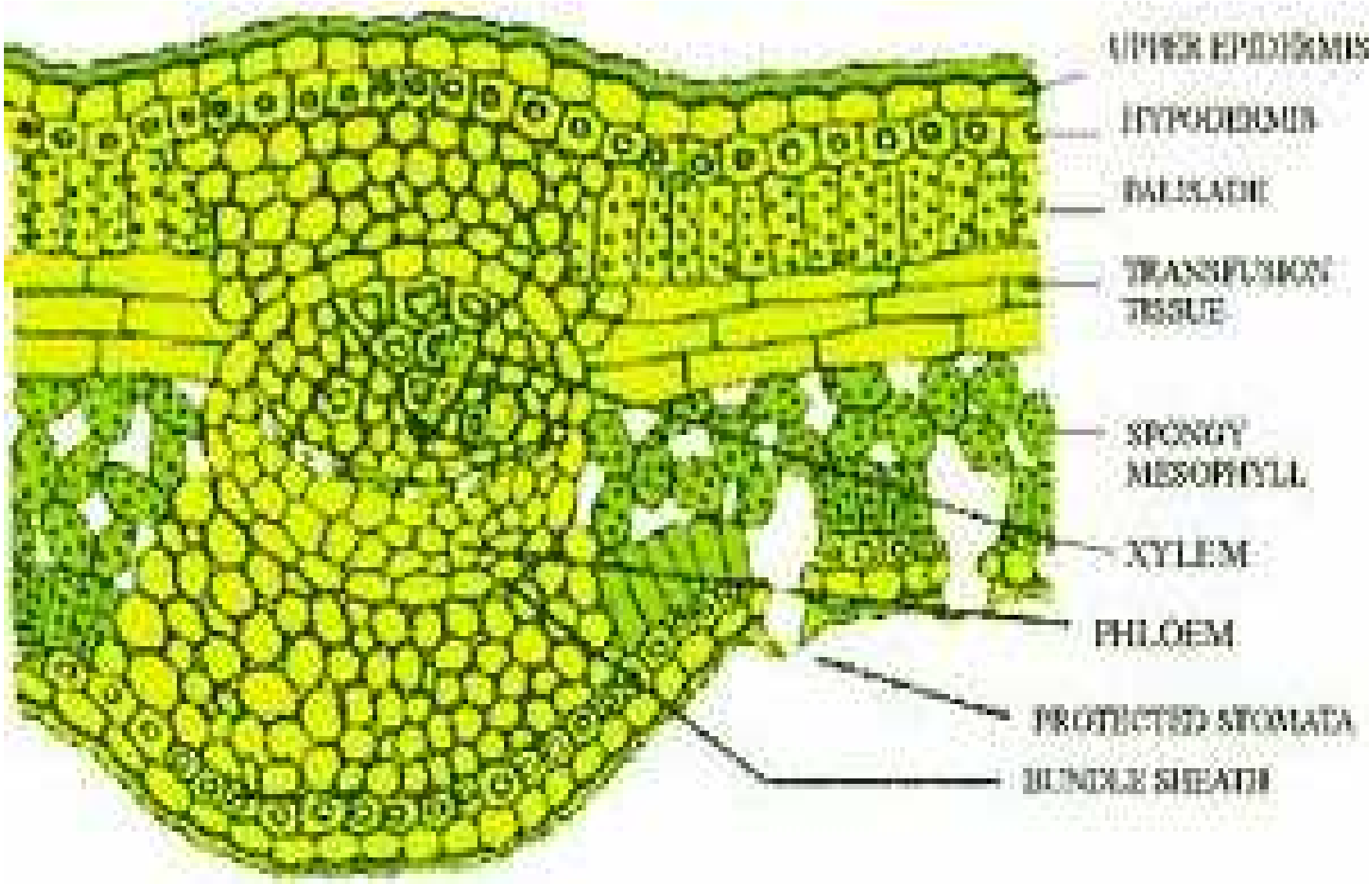
- **Followed by parenchymatous ground tissue.**
- **8 to 12 vas. bundles – "inverted omega" fashion.**
- **Bundles mesarch & diploxylic.**
- **2 groups of xylem - centripetal & centrifugal.**
- **Phloem seen bet. xylem tissue.**
- **Cambium absent – no sec. growth.**

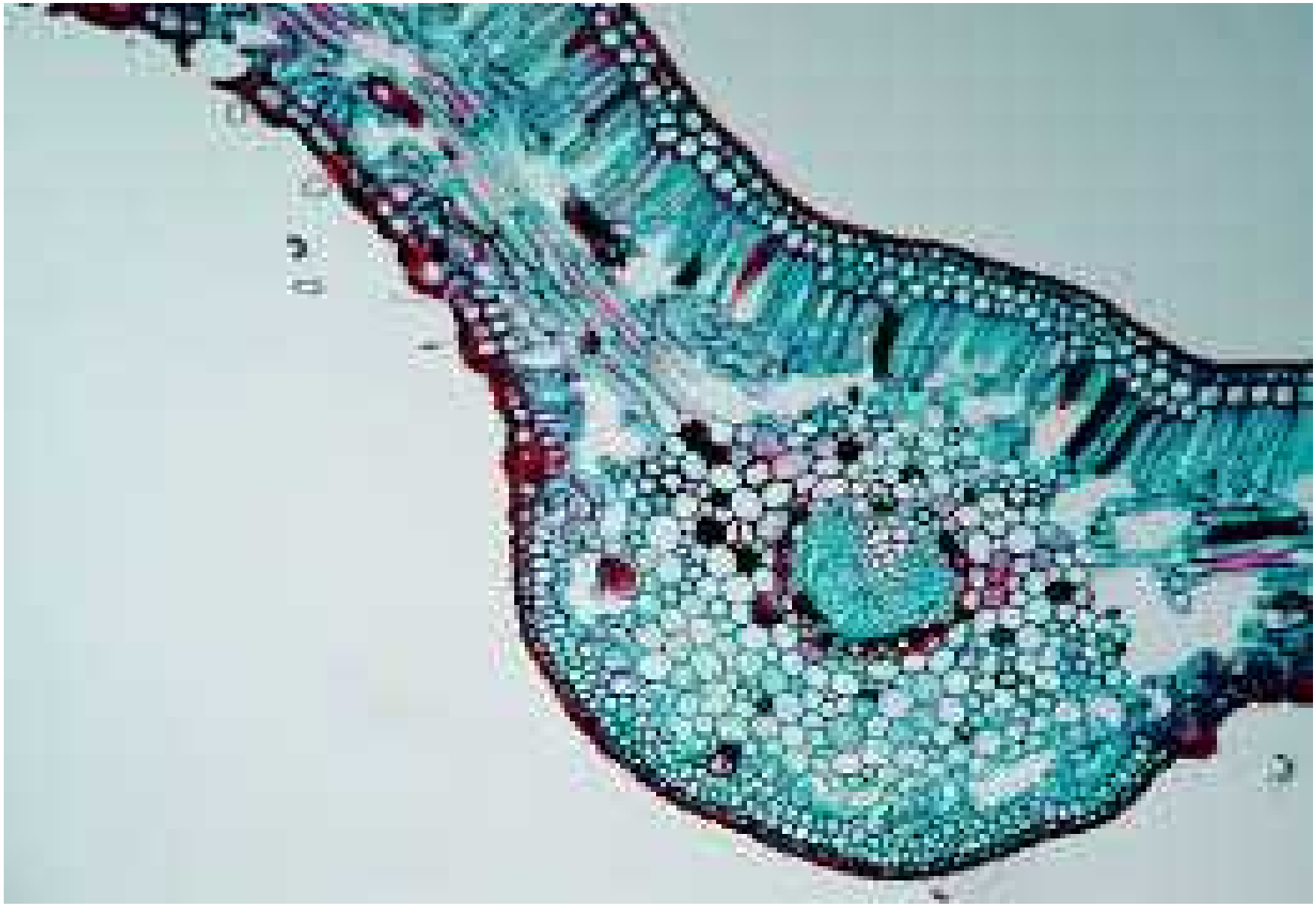
LEAFLET ANATOMY

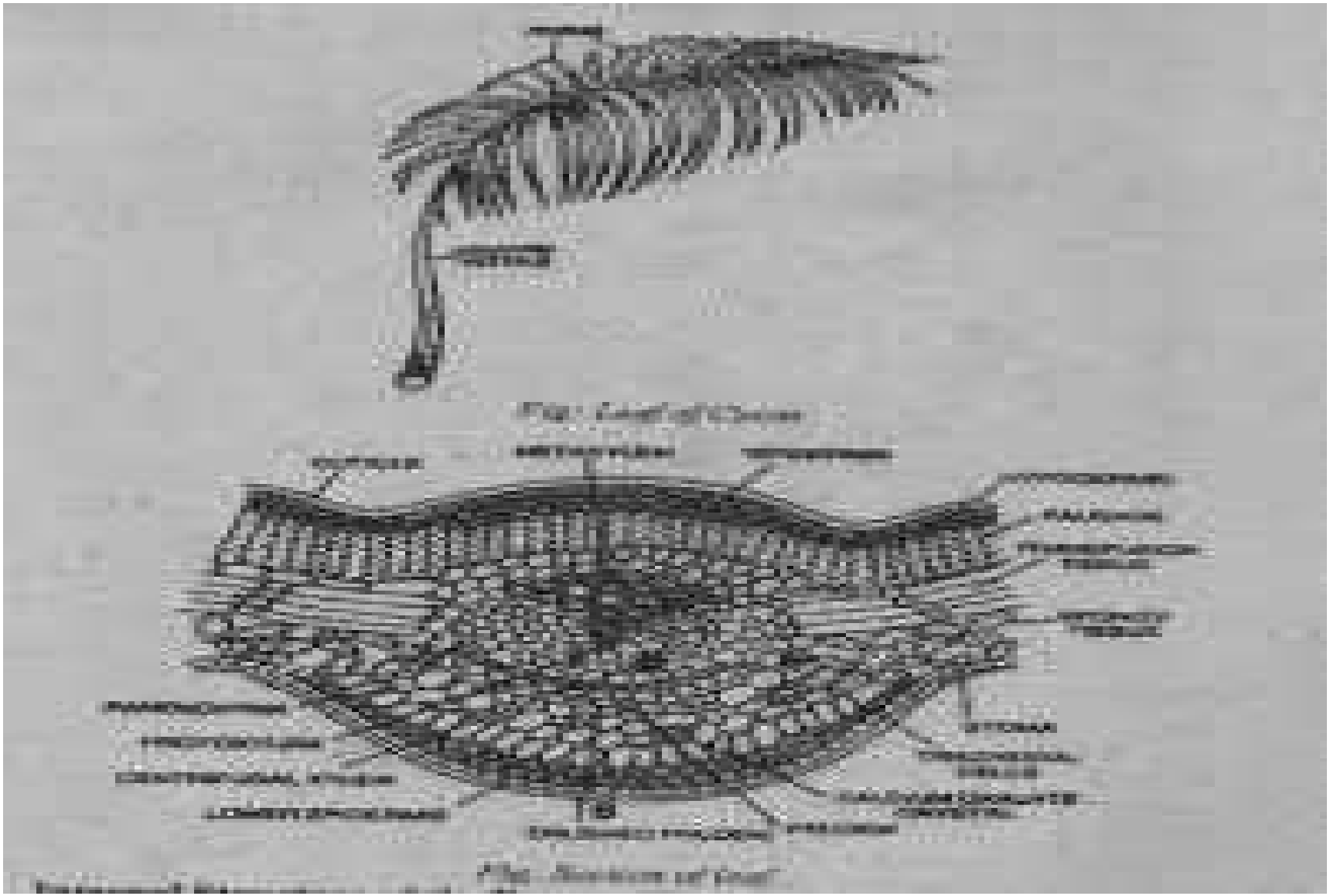
Epidermis covers entire leaflet.

Single layered, thick walled & with thick cuticle.

Lower epidermis interrupted by stomata.


UPPER EPIDERMIS
HYPODERMIS
PALISADE
TRANSFUSION TISSUE
SPONGY MESOPHYLL
XYLEM
PHLOEM
PROTECTED STOMATA
BUNDLE SHEATH





- **Stomata placed in sunken pits.**
- **Hypodermis – sclerenchymatous – both sides.**
- **Mesophyll - upper palisade & lower spongy tissues.**
- **Mesophyll – with chloroplasts – photosynthetic tissue.**
- **Transfusion tissue – transversally elongated cells – bet. palisade & spongy.**
- **Helps in lateral conduction.**
- **Vas. bundle - single – midrib region – surrounded by thick walled bundle sheath.**

- **Xylem - diploxylic – centripetal & centrifugal.**
- **Phloem in the lower side.**

REPRODUCTION

Plants dioecious – male & female repro. structures produced on separate plants – male plant & female plant.

Reproductive structures - cones – after 10 yrs.

Male plant – male cone – sympodially.

Female plant – female cone - monopodially.

MALE CONES

- Terminal meristem of plant – used for production of cone.
- Growth continues – lateral bud – sympodially.
- Cone – 25 to 65 cm long.
- Central cone axis bears numerous microsporophylls – spirally arranged.
- Sporophyll – distally broad & tapers at tip.
- Basal portion narrow & thick.
- Microsporangia – abaxial side - in sori.
- Each sorus – with 2 to 6 sporangia.

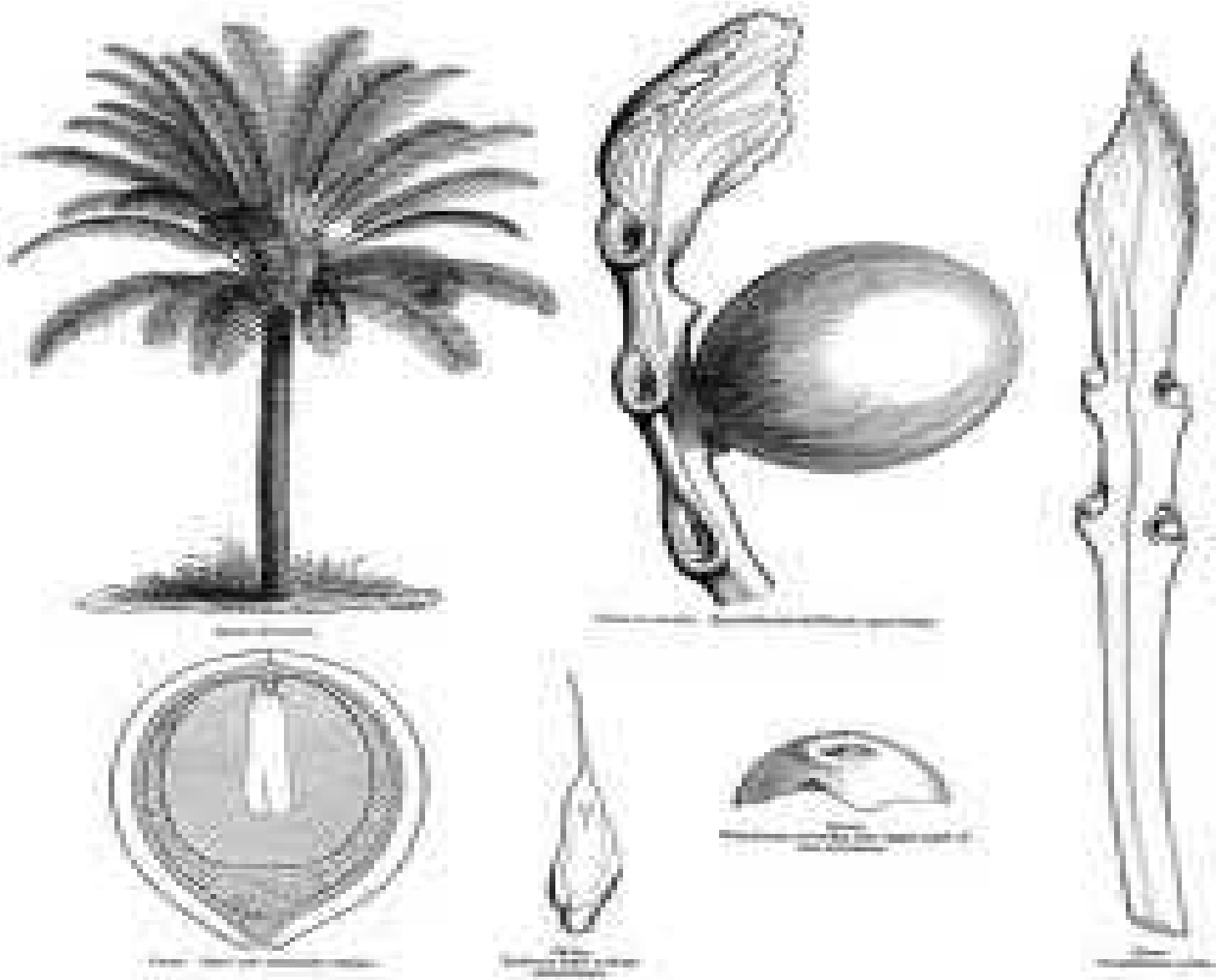
C. revoluta - Male cone

- **Soral hairs intermixed with sporangia.**
- **Help in dehiscence.**
- **Sporogenous cells in sporangium produces microspores or pollen by meiosis.**
- **Mature sporangium – oval sac – with short stalk.**
- **Mature – wall breaks longitudinally – spores liberated.**

MEGASPOROPHYLLS

- **At apex of stem - female plant – in close spiral.**
- **Sporophyll – basal narrow stalk, middle fertile region & terminal sterile portion.**
- **Fertile region - bears ovules.**

MEGASPOROPHYLL



Cycadales (cycads) - Cycas spp. megasporophylls ("carpels").
From: Zimmermann (1930), Die Phylogenie der Pflanzen, Verlag von Gustav Fischer, Jena. Drawing: Karsten; Colorization: Leubner.

STRUCTURE & DEV. OF OVULE

- Dev. starts as a soft tissue called nucellus.
- Nucellus ensheathed by a single integument.
- Integument – 3 layers – outer fleshy, middle stoney & inner fleshy.
- Ovule – Megasporangium – protected by integument.
- Integument free from nucellus at apical region – opening – micropyle.
- Nucellus – deep seated enlarged cell – megaspore mother cell.

- **MMC divides reductionally – linear tetrad – 4 megaspores.**
- **Upper three degenerate & lowermost one functional.**
- **Functional cell – female gametophyte.**
- **FC enlarges – nucleus divides without wall formation – free nuclear division.**
- **Followed by wall formation from periphery to center.**
- **Cellular mass – female gametophyte – endosperm.**

- **At peripheral zone near micropyle – few cells enlarge – forms archegonia.**
- **Archegonium – neck & venter.**
- **Venter contains egg or female gamete.**

MALE GAMETOPHYTE

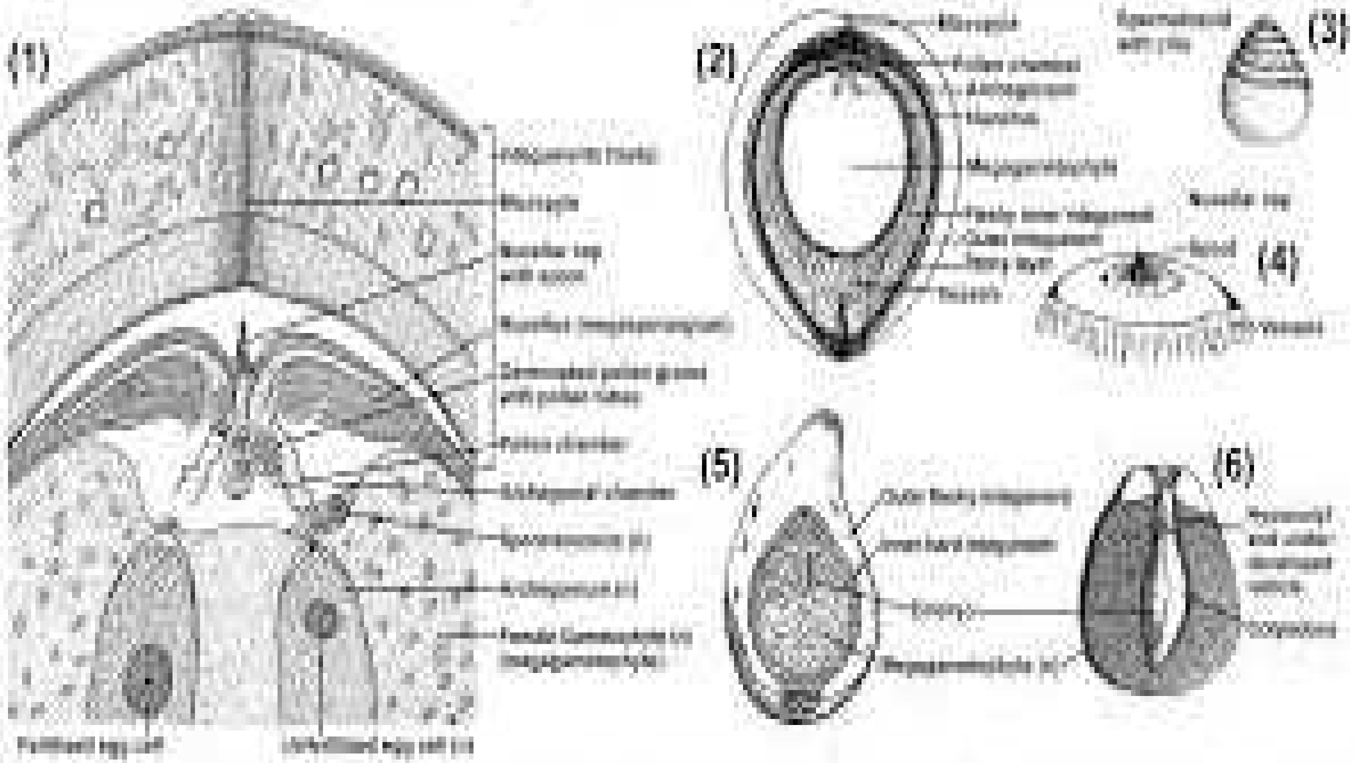
- **Microspore first cell of gametophyte.**
- **Divides – prothalial cell below & antheridial cell above.**
- **AC divides – generative cell & tube cell.**
- **3-celled stage – pollination occurs.**
- **Pollen received by micropyle – reaches pollen chamber – near to female gamete.**

- **Pollen – two coverings – intine & exine.**
- **After pollination – pollen tube formed by intine – opposite to prothalial cell.**
- **Generative cell – stalk cell & body cell.**
- **Body cell – 2 male gametes formed.**
- **Gamete – top shaped & multiciliate.**

FERTILIZATION

- **Male gametes discharged into archegonial chamber (a cavity above archegonium).**
- **Male gamete enters through neck – into venter – to reach the egg.**

Cycadales (cycads, "Palmfarne"): Ovules and seeds of extant ancient gymnosperms



- **Both gametes fuse to form diploid zygote.**
- **Zygote divides to form embryo.**
- **Embryo - dicotyledonous – with suspensor & haustorium.**
- **Haustorium – absorbs food from endosperm.**
- **Suspensor – pushes embryo deep into endosperm.**
- **Embryo gets nourishment from endosperm.**
- **Mature embryo is straight.**
- **Embryo well protected inside the seed.**

STRUCTURE OF SEED

- Seed – fleshy – orange-brown in colour.
- Outermost layer - testa.
- Inner nucellus protects embryo – embedded in endosperm.
- Embryo - 2 cotyledons, plumule & radicle.
- Seed germination epigeal – cotyledons remain inside seed.
- Radicle enclosed in hard covering – coleorrhiza.
- Radicle comes out through micropyle – produces primary root.
- Plumule – produces shoot – leaves.

LIFE CYCLE

- **Alternation bet. sporophyte & gametophyte.**
- **Plant is sporophyte – produces cones.**
- **Microsporophyll – sporangia – in male plant.**
- **Megasporophyll – ovule – in female plant.**
- **Gametophytic generation starts with formation of microspore & megaspore.**
- **Gametes produced – fertilize to form zygote.**
- **Zygote – first cell of sporophyte.**
- **Zygote – develops into embryo.**
- **Embryo – develops into sporophytic plant.**

ECONOMIC IMPORTANCE

- **Ornamental value.**
- **Stem & seeds rich in “sago” starch.**
- **Endosperm also rich in proteins.**
- **Young shoots edible.**