Chapter 10

Gymnosperms

- **Gymnosperms** is derived from Greek words *Gymnos* - naked + *sperma* - seed *i.e.,* naked seed.
- Term gymnosperms was introduced by **Theophrastus**.
- Goebel defined gymnosperms as "**Phanerogams without ovary**".
- Gymnosperms are the small group of plants which constitute the subdivision of **phanerogams** or **spermatophyta.**
- Age of higher gymnosperms is **mesozoic era** though origin of order cycadofilicales of gymnosperms is in **late palaeozoic era**.
- Gymnosperms are **connecting link between pteridophytes and angiosperms**.
- Gymnosperms are **placed in** –
  - **Archegoniate** *i.e.*, having archegonium as female sex organ (bryophytes, pteridophytes, gymnosperms).
  - **Embryophyta** - Embryo is formed in life cycle (bryophyta, pteridophyta, gymnosperms and angiosperms).
  - **Tracheophyta** *i.e.* having vascular tissue or xylem and phloem (pteridophytes, gymnosperms and angiosperms).

The **reason for the extinction of gymnosperms** may be the limited means of dispersal of seeds (only by wind and man) and their failure to grow under varied habitats (*eg.*water). Absence of bisexuality provides lesser chances of self fertilization and a good amount of pollen is wasted during wind pollination.

The numerical scarcity of present day gymnosperms (14 genera and 51 species) in India is due to the fact that they are the dwellers of temperate regions and in India such climate exists only in the Himalayas, and their adjoining hills.

- In the evolutionary point of view gymnosperms are the **most primitive seed plants**.
- There are about **73 genera** and **7000 species** in subdivision gymnospermae.
- Most of the genera are **entirely extinct** and only a few are living.

General characters

- Gymnosperms generally **constitute dominant flora of temperate region**.
- Few gymnosperms, *e.g.*. *Welwitschia* are **xerophyte.**
- The gymnosperms are **predominantly woody plants** represented by trees and shrubs. Few are climbers.
- **Tallest** gymnosperm is *Sequoia sempervirens* (about 366 ft) and **oldest** gymnosperm is *S. gigantea* (about 4000-5000 yrs). **Smallest** gymnosperm is *Zamia* (25 cm).
- **Tap root** system is present. It shows **diarch** to **polyarch nature**.
- Stem are erect, branched and woody with **leaf scars** and **scale scars**.
- Vascular bundles in stem are **conjoint, collateral** and **open**. Secondary growth is present and **annual rings** are formed.
- The xylem consist of **xylem parenchyma** and **tracheids** with bordered pits.
- **Vessels are absent** in gymnosperms **but present in order** – Gnetales *(Gnetum*, *Welwitschia* and *Ephedra*). Therefore **Gnetales are considered as connecting link** between gymnosperms and angiosperms.
- Due to the absence of vessels gymnosperm wood is called **soft wood.**
- In phloem sieve cells and phloem parenchyma are present but **companion cells are totally absent.**
- Leaves may be **dimorphic** or **monomorphic** and **show xerophytic characters** like sunken stomata and thick cuticle.

- In gymnosperms, the reproductive structures are mostly in the form of **compact cones** except female organs of *Cycas*.
- Flowers are **absent**. There are two types of sporophylls – **microsporophylls** and **megasporophylls**.
- The two types of sporophylls are usually aggregated to form distinct **cones or strobili** : pollen cones (male cones) and seed cones (female cones).
- Seed do not occur inside a **fruit** due to absence of ovary. They are **naked or lie exposed** on the surface of megasporophylls.
- The megasporophylls bear ovules. The ovule is generally **orthotropous** and **unitegmic** with three layers (bigemic ovules are found in *Gnetum* and *Ephedra*).
- Endosperm is a **prefertilization product** and hence **haploid**.
- Archegonium (female gametophyte) is with reduced neck (with **no neck canal cell**).
- Pollination is **anemophilous** (by wind) and the fertilization is of **siphonogamous** type (occur by pollen tube).
- **Polyembryony** is the formation of more than one embryo inside a single seed. It occurs in *Pinus*. Pinus ovule has 2-8 archegonia.
- Wood is **manoxylic** (soft and loose), eg. *Cycas* or **pycnoxylic** (compact and hard), eg. *Pinus*.
- Fruit formation does not occur in the embryo of gymnosperms, **2 or many cotyledons** are present, eg. 2 in *Cycas* and 10 - 11 in *Pinus*.
- Seed of gymnosperm **represent three generation** –
  - **Parent sporophyte** - Represented by nucellus and integument.
  - **Gametophyte** - Represented by endosperm.
  - **Future sporophyte** - Represented by embryo.
- Gametophyte generation is **reduced and dependent** upon sporophyte generation.
- Alternation of generation is **distinct**.
- Development of oospore is **meroblastic** *i.e.,* only a part of zygote form embryo, *eg. Pinus.*

Classification of gymnosperms

- Gymnosperms are further classified into three classes. **(Sporne, 1965).** They are **cycadopsida**, **coniferopsida** and **gnetopsida**.

Cycadopsida

- Cycadopsida is **represented by small plants** and are **comparatively primitive**.
- The stems are **erect**, **unbranched** and **stumpy**.
- The wood is **manoxylic**.
- Male cones are **large** and with compactly arranged microsporophylls.
- The megasporophylls are loosely arranged and **does not form a cone**. The megasporophyll **bears large ovule**.
- The seeds are **radially symmetrical**. E.g., *Cycas* (**described in details**), *Microcycas*, *Zamia* etc.

Coniferopsida

- Coniferopsida includes widely distributed **larger dominant gymnosperms** on the earth at present.
- The plants possess profusely branched shoot system which appears in the form of a cone.
- The leaves are **simple** and show many **xerophytic adaptations**.
- The wood is **pycnoxylic**, pith is small.
- Sporophylls form cones. They are **dioecious**, hard and woody.
- The seeds show **bilateral symmetry**, *eg*., *Pinus* (**described in details**), *Ginkgo*, *Taxus*.
- Conifers are **evergreen** in the sense that they do not shed their leaves as compared to deciduous plants which become bare by leaf shedding in winter (autumn).

Gnetopsida

- Gnetopsida includes **advanced gymnosperms** represented by climbers, shrubs or small trees.
- The stems are **branched**.
- Leaves are broad, simple, ovate, or **scaly**.
- Secondary xylem **shows vessels**.
- Sexual structures are **unisexual** situated in compound cones.
- Male sex organs are with **perianth members** and the female sex organs shows single straight ovule.
- The ovules are of **orthotropus type** and show **long tubular micropyle**.
- The embryo is with **two cotyledons**.
- The class **Gnetopsida** includes single order namely *Gnetales*, eg. *Gnetum*.

Table : Common name of some gymnosperms

Ginkgo biloba	–	Maiden hair tree
Sequoia	–	Red wood tree
Araucaria	–	Christmas tree/ Monkey's puzzle
Cycas revoluta	–	Sago palm
Pinus gerardiana	–	Chilgoza pine
P. roxburghii	–	Chir pine
P. insularis	–	Khasi pine

- **Largest egg, sperm and ovule** is found in *Cycas*.
- The fertilization in *Pinus* is **siphonogamous** *i.e.,* by pollen tube. In ferns it is **zooidogamous** *i.e.,* by multiciliated sperm. In *Cycas* both the events occur at the **same time**.
- *Cycas revoluta* and *Gingko biloba* considered as **living fossils**. *Ginkgo biloba* is the single living genus in a big fossilized order **Ginkgoales**. Hence it is called living fossil. *Cycas revoluta* show the primitive characters hence it is also considers as living fossil.

Economic importance

- Some of the gymnosperms like *C. revoluta, C. circinalis, Thuja, Taxus* etc. are used for **ornamental purpose**.
- Stem portion of *C. revoluta*, is a **good source of sago,** a kind of starch **used in making bread by poor people mainly in Japan**.
- *Zamia* is **rich is starch** and is **used by many Indian as food**.
- Seeds and seed kernals of some species are roasted and taken as food.
- Young succulent leaves of some species are **used as vegetables**.
- Seeds and stem of *C. revolula* are **used in making wine in Japan**.
- The leaves *C. circinalis* are medicinally very important. The fresh juice extracted from the leaves is used as medicine in stomach disorders, blood vomitting and other skin diseases.
- Pollen grains of some *Cycas* plants are reported to have some narcotic effect.
- Seeds and crushed bark of *Cycas* and its megasporophylls when mixed with coconut oil are used as poultice for sores and wounds in South India.
- *Thuja*, *Araucaria*, *Abies*, *Cryptomeria*, *Pinus*, *Taxus* are grown in parks.
- **Seeds** of *P. gerardiana* (Chilgoza)*, Ginkgo biloba, Gnetum gnemon* are edible.
- **Manila copal** an important varnish resin is obtained from *Agathis sp.*
- **Canada Balsam** (Turpentine), a well known turpentine is obtained from *Abies balsamea* (used as mounting medium for biological preparation).
- *Pinus marittima* is a good source of **bordeus turpentine.**
- **Turpentine oil used in paint industries** is mainly obtained from resin of *Pinus* species.
- Timber is obtained from of *Pinus, Abies, Cedrus, Sequoia*.
- Fossil resin (Amber) is obtained from extinct pine *Pinus succinifera*, used in jewellery and carvel object.
- Wood gas, wood tar and wood alcohol are obtained from various species of *Pinus*. *eg*. *Pinus sylnestris*.
- Drug **ephedrine** is obtained from *Ephedra* which is used in curing respiratory ailments including asthma.
- A medicine of cancer called "**taxol**" is obtained from the bark of *Taxus*.
- *Gnetum ula* is a common source of edible oil. It is also used as massage in rheumatic pain. A volatile oil extracted from the shoots and leaves of biota (*Thuja*) is used as vermifuge. Oil of *Juniperus* is medicinally important.
- *Gnetum latifolium* yields fibre used in making ropes and nets.

CYCAS

Systematic position

–	Phylum	:	Tracheophyta
–	Class	:	Gymnospermae
–	Subclass	:	Cycadophytae
–	Order	:	Cycadales
–	Family	:	Cycadaceae
–	Genus	:	*Cycas*.

External morphology

- *Cycas* is an **evergreen palm-like plant**. It is the **only genus of family Cycadaceae** represented in India. Hence **also called as living fossil**.
- In India, **four** *Cycas* species are common in Orissa, Bengal, Assam, Tamilnadu, Karnataka and Andaman.

Cycas revoluta	:	Sago palm in India, Tesso in Japan and China.
Cycas circinalis	:	Jangli madan mast-ka-phul.
Cycas rumphii	:	Kama, Paiyindu.
Cycas beddomei	:	–

- Dominant stage in *Cycas* is **sporophyte**.
- Plant body is differentiated into **roots, stem and leaves**.

- Type of root system in *Cycas* is **tap root system**. These roots are **not green**, **positively geotropic with no root hairs**.
- From the lateral branches of the normal roots are formed **dichotomously branched, apogeotropic, bluish green roots** called **coralloid roots**.
- Rough texture of coralloid roots is due to the presence of **lenticels**.
- Coralloid roots show symbiotic association with **blue-green algae** *Anabaena cycadacearum, Nostoc punctiformae***.**
- Young stem of *Cycas* is **underground** and **tuber like**.
- Stem in *Cycas* is **caudex**, an unbranched columnar stem, with a crown of leaves at the top.
- Leaves are of **two kinds** – scale leaves and foliage leaves.
- A **single scale leaf** is a brown, dry, woody, triangular structure, covered with brown hairs or **ramenta.**
- Foliage leaves are **unipinnately compound.** Leaves are leathery and thick, some leaflets at the base of the rachis are reduced to spines.
- Leaves of *Cycas* are **megaphylls** (each leaflet contains a single midvein).
- Leaflets of young leaf show **circinate vernation**.

Anatomy

- Internal structure of normal root of *Cycas* resembles dicot root. Stele of normal root of *Cycas* is **diarch/ tetrarch** and **exarch**.
- Old coralloid root of *Cycas* consists of **periderm in the place of epidermis**. Periderm is **formed from cork cambium**.
- Cortex of coralloid root is divisible into – outer **cortex, middle cortex** (algal zone) and **inner cortex**.
- Tips of coralloid roots are **degenerated due to infection by bacteria**.
- Some of the cells of outer and inner cortex contain **tannins**, **sphaeraphides** and **starch materials**.
- Stele of coralloid root is **triarch and exarch**.
- Presence of **girdle leaf traces** is a characteristic feature of *Cycas* stem.
- **Mucilage canals** (of schizogenous nature) are present both in the cortex and the pith.
- Vascular bundles in young stem of *Cycas* are **conjoint, collateral, open** and **endarch**.
- Phloem is devoid of companion cells instead **albuminous cells** are present in phloem.
- **Anomalous secondary growth** is present in *Cycas* stem. Formation of **more than one cambial ring is an anomaly**.
- Large amount of parenchymatous cells are present with secondary xylem tracheids, so the wood is called **soft wood** or **manoxylic wood.**
- Secondary xylem in *Cycas* is **polyxylic** (formation of several rings of xylem).
- In *C. pectinata,* **14 rings** have been reported.
- **Transfusion tissue** (tracheid like and colourless) extends from the vascular bundle to the margin of the leaflet.
- Rachis has epidermis with sunken stomata, chlorenchyma, sclerenchyma, and ground tissue with mucilage ducts.
- Vascular bundles in rachis of *Cycas* **show inverted omega-shaped arrangement**.
- Vascular bundle in rachis and leaflet is **diploxylic** (presence of centripetal xylem and centrifugal xylem is in the same vascular bundle) and **pseudomesarch**.

Xerophytic characters of *Cycas* leaflet
Leaflets are thick and leathery.
Thick cuticle.
Epidermis with thick-walled cells.
Sclerenchymatous hypodermis.
Presence of transfusion tissue.
Absence of lateral veins.
Hypostomatous condition, sunken stomata.

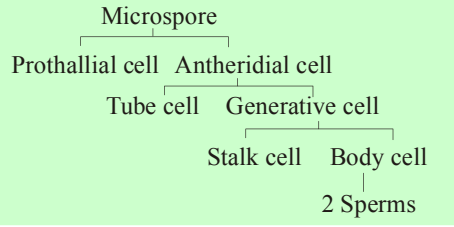
Reproduction

- The *Cycas* plants reproduce both by **vegetative** and **sexual methods**.
- Vegetative reproduction in *Cycas* **takes place by bulbils formed on stem**.
- *Cycas* plant is dioecious *i.e* separate male and female plants.
- Plant of *Cycas* is **sporophyte** (2*n*) and the sexual reproduction is of **oogamous type**, *i.e.,* takes place by the fusion of distinct male and female gametes.
- The male and female gametes are formed by the germination of micro and megaspores which are borne on **microsporophylls** and **megasporophyll**.
- Microsporophylls unite to form a cone.
- Type of growth present in male plant of *Cycas* is

sympodial. *i.e.,*the cone is later pushed to lateral side and the stem continues to grow.

- The arrangement of microsporophylls on cone axis of male cone is **spiral.**
- Each microsporophyll is 5 – 6 cm long, wedge shaped woody structure.
- The terminal sterile part of microsporophyll is called **apophysis**.
- **Microsporangial sori** are **present on the abaxial surface** (**under surface**) of the microsporophyll (**fern character**).
- The number of microsporangia on a single microsporophyll are **900 - 1000**. In *C. media* there are about **1160 sporangia**.
- Microsporangia are shortly stalked, oval or oblong structure and dehisce by longitudinal slits.
- Reduction division occurs in **microspore mother cells**.
- Pollen grains are boat shaped.
- Female cone is **absent** as megasporophylls do not aggregate instead are **loosely arranged round stem tip**.
- Type of growth in female plant of *Cycas* is **monopodial**. Megasporophylls of *Cycas* consist of basal sterile stalk ovule bearing middle part and upper sterile part or apophysis.
- Megasporophyll of *Cycas* is equivalent to the **carpel of angiosperms.**
- **Ovule** of *Cycas* is naked, orthotropous and 2 – 12 reddish brown ovule borne laterally in two rows.
- The ovules of *Cycas* are **largest in nature**, can be seen by naked eyes. In *C. circinalis*, the ovules are largest in size *i.e.,* about **6 cm in length** and **4 cm in diameter**.
- The ovule consists of a micropylar beak, three layered integument, a nucellus and female gametophyte.
- Integument of *Cycas* is divisible into **three layers**– outer fleshy layer (sarcotesta), middle stony layer (sclerotesta) and inner fleshy layer.
- **Number of vascular bundles** that enter into the ovule of *Cycas* is **three**.
- Female gametophyte in *Cycas* acts as **endosperm** with 2 – 8 archegonia.
- Chromosomal condition of endosperm in *Cycas* is **haploid** as it is **formed before fertilization**.
- A pollen chamber is present at the micropylar end of nucellus.
- Ripe ovule secretes **pollination drop** through the micropyle, which trap pollen grain.
- Pollination in *Cycas* is **anemophilous** and **direct**.
- Pollen grains which are at **3-celled stage** (tube cell, generative cell and prothalial cell) reach the pollen chamber due to the **drying of the pollination drop**.
- A large **pollination drop** comes out of micropylar end of ovule by disorganization of **nucellar beak** (The apex of the nucellus develop beak like process. This is called nucellar beak).

Development of male gametes



- The **male gametes of Cycas are largest** (300 m) in nature, visible to naked eye oval in form and are **multiciliate** (multiflagellate).
- Water is essential for **fertilization** in *Cycas*.
- **Free nuclear divisions** occur in the zygote of *Cycas*.
- **Proembryo** is formed first from the zygote.
- Proembryo is **divided into 3 regions** –
  - **Haustorial region** for **absorption of food materials** from the endosperm.
  - **Suspensor region** for **pushing the embryo into the endosperm**.
  - **Embryonal region** that **gives rise to proper embryo**.
- Embryo consists of **suspensor**, **radicle**, **two unequal cotyledons** and **plumule**.
- Ovule is converted into seed having 3 layered seed coat (outer, middle and inner).
- Seed in *Cycas* is **naked**, **endospermic** and **perispermic**.
- **Type of germination** in *Cycas* is **hypogeal**, cotyledons remain underground.
- Alternation of generations is **heteromorphic** and life cycle is diplohaplontic.
- The time gap between pollination and fertilization is about 5 – 6 **months**.

PINUS

Systematic position

– Phylum : Tracheophyta

- Class : Gymnospermae
- Subclass : Coniferophytae
- Order : Coniferales
- Family : Pinaceae
- Genus : *Pinus*.

- Only **six species** are found in India.

Scientific name	Common name
Pinus gerardiana	Chilgoza pine
Pinus wallichiana	Blue pine or kail
P. roxburghii (P. longifolia)	Chir pine
P. merkusii	Teenasserim pine
P. insularis (P. khasya)	Khasi pine
P. armandi	Armand's pine

- In addition to above, **some exotic species have also been introduced in India**, *e.g.*, *P. sylvestris*, *P. laricia, P. montana* and *P. strobus* (white pine).

External morphology

- The **plant body is sporophyte** and the plants are **monoecious**.
- The plant body is differentiated into **roots, stem** and **leaves**.
- *Pinus* is an **evergreen, perennial plant of xerophytic nature**. Mostly the species are tall and straight.
- The **whorled branching** gives a typical conical or **excurrent appearanc**e to the plant (due to apical dominance).
- Predominantly **tap root system** is present where primary roots are less developed and lateral roots are well developed.
- The root hairs are poorly developed and hence **ectotrophic mycorrhiza** (symbiotic association of fungal hyphae with the branches of roots) is of common occurrence in *Pinus* **for absorption of water**.
- The stem is tall, erect, cylindrical and the branching is **monopodial type**.
- The stems are branched and the branches are **dimorphic** - (i) **Branches of unlimited growth** or **long shoots** or long laterals and (ii) **Branches of limited growth or dwarf shoots or spur shoots** or short laterals.
- The **dwarf shoots** are **borne on the axis of scale leaves of long shoots**.
- The leaves are also **dimorphic, scaly and foliage**.
- Scale leaves are **green when young** but at maturity they become **brown**.
- **Foliage leaves** are present only at the apex of dwarf shoots. They are long, **needle-like** (acicular) green structures, present for 3 or more years and thus the plants are evergreen.
- The dwarf shoot with needles is called a **'spur'**.
- The number of needles per dwarf shoot is variable – **monofoliar** (with one needle), **bifoliar** with two needles), **trifoliar** (with four needles) and **pentafoliar** (with five needles).

Anatomy

- The primary root is distinguishable into **epidermis, cortex, endodermis, stele** and **pith**.
- Pericycle is multilayered.
- The **cortex** is infected with ectotrophic mycorrhiza.
- Vascular bundles are radial.
- The xylem is **Y-shaped** in T.S. being forked at the protoxylem end.
- There is a **resin canal** in the fork of xylem.
- The xylem is made up of **tracheids only**, vessels are absents.
- The phloem is made up of sieve cells but there are **no companion cells**.
- In young roots, cambium is absent but at maturity below the phloem patches, arches of cambium are formed. It cuts off **secondary xylem on the inner side and secondary phloem on the outer side**.
- In a T.S. the young stem of *Pinus* appears to be a ribbed structure due to the presence of **leaf bases and dwarf shoots.**
- Epidermis of stem is provided with thick cuticle and hypodermis is sclerenchymatous, **resin canal is present in cortex**, some cells contain tannins.
- The vasculature of stem comprises a **eustele** and vascular bundles are **conjoint, collateral** and **open bundles** resembles dicot stem. It is described as an **eustele**.
- Xylem is endarch devoid of vessels after secondary growth and form **non-porous wood**.
- Protoxylem consists of annular and spiral trachieds, metaxylem has uniseriate bordered pits on tracheids.
- Presence of bars of sanio.
- The wood is **pycnoxylic** (compact and hard). Phloem is made up of **sieve cells and albuminous cells**.
- The albuminous cells **are analogus to** companion cells of angiosperms but **not homologous**.
- **Intrafascicular cambium** is **present in between**

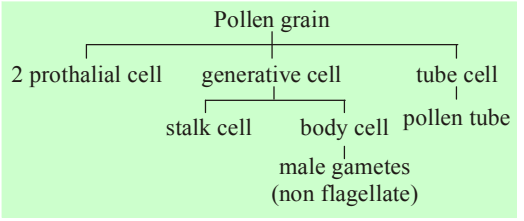
xylem and phloem, presence of parenchymatous medullary rays.

- Secondary growth is observed consisting of distinct annual ring containing spring wood and autumn wood.
- Autumn wood is formed during autumn and cells are smaller squarish and thick.
- Spring wood is formed during spring and cells are thinner, larger and polygonal. This is called **pycnoxylic**.
- **Resin canals** are **present in cortex and xylem** and are schizogenous cavities.
- Needles have sunken stomata throughout the surface *i.e.*, **amphistomatic**.
- The stomata comprises of two guard cells surrounded by **6-8 subsidiary cells**. The subsidiary cells enclose a supra stomatal space called as **vestibule**.
- Mesophyll is undifferentiated into palisade and spongy parenchyma.
- Vascular bundles are obliquely placed, collateral, open, endarch.
- Vascular cylinders were surrounded by single-layered endodermis having barrel-shaped cells with **casparian strips**.
- Pericycle is multilayered and composed of four types of cells - **parenchymatous cells, sclerenchymatous cell, albuminous cells, tracheidal cells**.
- **Transfusion tissue** is **composed of 2 types of cells - tracheidal cells** and **albuminous cells**.
- **Tracheidal cells** are tracheid-like cells having pits, **found close to the xylem elements** of the bundles. This is generally referred to as **transfusion tissue**.
- **Albuminous cells** are **living cells** without pits and **help conduction**.

Xerophytic characters shown by *Pinus* are – (i) reduced leaf surface (acicular), (ii) presence of thick cuticle, (iii) thick walled hypodermis, (iv) presence of sunken stomata, (v) special type of mesophyll (arm palisade), (vi) sclerenchymatous sheath inbetween the bundles.

Reproduction

- Vegetative reproduction is **absent** in *Pinus*.
- *Pinus* is a heterosporous, monoecious plant producing micro and megaspores in **micro and megasporangia** respectively.
- The **microsporangia** are borne on microsporophyll which constitutes the **male cone**.
- A male cone consists of a central axis bearing 60-135 microsporophylls in spiral manner. It is, therefore, comparable to **male flower of angiosperms**.
- Each microsporophyll is small, brown, scaly and triangular having a short stalk and leaf-like sterile expansion called **apophysis**.
- Microspores are produced in such a large number that at the time of their dispersal, yellow clouds of pollen grains are produced, which is called **"shower of sulphur"** or **"shower of golden dust"**.
- The **megasporangia** are produced on ovuliferous scales formed along with a bract. The ovuliferous scales and bracts constitute the **female cone.**
- Each female cone **matures in three years**. In the third year it matures with ovules.
- Each female cone is an oval or somewhat elongated structures with an elongated central axis around which a large number of megasporophylls are arranged in an **acropetal and spiral manner**.
- The female cone **represents an inflorescence** because the ovule bearing ovuliferous scales are borne on the bract scales which are directly formed on the central axis.
- A megasporangium or ovule of *Pinus* is **orthotropous**. Ovule has an oblique micropyle, nucellus and female gametophyte having 1 – 8 archegonia.
- Archegonia has 2 – 4 celled neck, ventral canal cell and egg.
- The ventral canal cell **disorganizes before fertilization**. Neck canal cells are absent.
- Integument is differentiated into **3 layers** : **outer fleshy** layer, **middle fleshy layer**, **inner fleshy layer**.
- The pollination in *Pinus* is **anemophilous** (brought out by wind).
- There is a long interval of **about a year** between pollination and fertilization.
- Endosperm of *Pinus* differs from angiosperms as it is a **pre-fertilization structure**, while in angiosperms it is a post-fertilization structure.
- The micropyle of each ovule contains mucilage or pollen drop to catch pollen grains.



- The zygotic nuclei divide to **form four nuclei**. These four cells divide simultaneouly **thrice** to form **four tiers of four cells each**.
- **Embryonal tier (4 cells)** is the lowermost tier, which **forms the embryo**.
- **Suspensor tier (4 cells) :** Above the lower tier which elongates and gives rise to long **suspensors**.
- **Rossette tier (4 cells) :** Above the suspensor tier and mediates between the suspensor tier and nutritive tier.
- **Nutritive tier (4 cells) :** The cells remain open above and provide nutrition to the remaining proembryo.
- Since **only a part of the oospore** is involved in the formation of the embryo, the development is said to be **meroblastic**.
- All the four cells of the embryonal tier separate from each other and develop independently into four embryos. The formation of more than one embryos from one oospore is called **cleavage polyembryony**.
- **Simple polyembryony** is also found in *Pinus* (where more than one embryos are formed as a result of fertilization of different archegonia).
- Inspite of having polyembryony only **one embryo** is found at maturity.
- The mature embryo consist of **9 – 14 cotyledons**, **plumule** (embryonic shoot) and **radicle** (embryonic root).
- The mature ovule with embryo constitutes seed.
- As the seed of *Pinus* is winged it is **anemochorous** (dispersed by wind).
- These seeds show three generation -
  - **Old sporophytic generation** by testa, tegmen and nucellus.
  - **Gametophytic generation** by endosperm.
  - **Future sporophytic generation** by embryo.
- The germination of seed is of **epigeal type**, *e.g.,* the cotyledons come above the ground by the elongation of hypocotyl.

End of the Chapter