Unit 9 · Gymnosperms

STUDY NOTES

WHAT NEB'S GRADE 11 EXAM ASKS

- **CDC's grid (2077):** Floral Diversity (Units 4–10 together): 18 of 75 marks; with Ecology and Vegetation a combined 26, at least 3 MCQs, 2 short and 1 long from them
- **The paper:** 11 MCQs × 1 · 8 short × 5 · 3 long × 8; 3 hours; 1 mark per expected point
- **CDC's model paper:** short (5): "Gymnosperms are more advanced than Pteridophyta. Give five points." (OR a Unit 10 question)
- **MCQ (1 mark)**
  - seeds and pollen tube: first in gymnosperms
  - haploid part of a pine seed (food store)
  - ephedrine → asthma; taxol → cancer
- **Short and long (in parts)**
  - mycorrhizal vs coralloid roots; long vs dwarf shoots
  - general characteristics
  - scale leaves vs foliage leaves of *Pinus*
  - mycorrhiza and nutrient uptake
  - male vs female cones
  - economic importance
  - reproduction in *Pinus* with diagrams

Key terms

Gymnosperms (*gymnos* naked + *sperma* seed): seed plants with **naked** ovules and seeds; no ovary, no fruit.

Strobilus (cone): short shoot with spiral scales bearing sporangia or ovules.

Heterosporous: two kinds of spore, **microspores** and **megaspores**.

Microsporophyll: scale with two **microsporangia** (pollen sacs); **ovuliferous scale**: carries two ovules.

Ovule (megasporangium): **nucellus** + one **integument** + **micropyle**.

Spur (fascicle): dwarf shoot with its needles.

Mycorrhiza: root + fungus, both gain; **coralloid root**: *Cycas* root with N_2-fixing cyanobacteria.

Pollination drop: sticky fluid from the micropyle that catches pollen.

Polyembryony: several embryos start in one ovule.

General

- *gymnospermos*: Theophrastus (~300 BCE)
- first seed plants ~360 million years ago; dominant in the **Mesozoic** (Jurassic, Cretaceous)
- ~1,000 kinds today (flowering plants ~300,000)
- temperate, tropical; most in **cold** climates: **taiga**, Himalayan forests
- perennial, evergreen, woody; *Gnetum* climbers; **xerophytic** features; **no herbs, no aquatic** ones
- records: tallest *Sequoia sempervirens* (~116 m); largest *Sequoiadendron giganteum*; bristlecone pines > 4,800 years; *Ginkgo biloba*: living fossil

Characteristic features

1. **evergreen** woody trees, shrubs (deciduous: *Ginkgo*, larch)
2. **perennial**; **xerophytic** features
3. plant body = **sporophyte**: root, stem, leaves
4. **tap root**; **coralloid roots** (*Cycas*, cyanobacteria); **mycorrhizal** roots (*Pinus*, fungus)
5. stem tall, woody, branched, scaly **bark** (*Cycas* unbranched)
6. conifers: **long shoots** (unlimited) + **dwarf shoots** (limited)
7. leaves **dimorphic**: green **foliage** + brown **scale** leaves
8. **secondary growth** (cambium), **annual rings**; xylem **tracheids, no vessels** (except *Gnetum*, *Ephedra*); phloem **no companion cells**
9. **heterosporous**
10. **microsporophylls** (pollen sacs), **megasporophylls** (ovules)
11. sporophylls in **cones**, usually **unisexual**
12. pollination mostly by **wind** (anemophilous); some insects (cycads, *Ephedra*)
13. **pollen tube**: no water for fertilization; **no double fertilization**
14. **ovules naked**, no fruit; food store = **female gametophyte** (**haploid**)
15. alternation of generations, **sporophyte dominant**; gametophytes tiny, inside the sporophyte
    - e.g. *Pinus*, *Cycas*, *Ginkgo*, *Taxus*, *Ephedra*, *Juniperus*

More advanced than pteridophytes

- **seeds** (embryo with food store, coat)
- **pollen tube**: fertilization without water
- **secondary growth**, woody trees
- gametophytes reduced, **dependent**, inside the sporophyte
- always **heterosporous**; spores in **cones**
- male gametes non-motile (most)

Pinus: structure

- tall, evergreen; mostly **northern hemisphere**, temperate, mountains
- **chir pine** (खोटे सल्लो, *P. roxburghii*): 500–2,000 m; needles 20–35 cm, **three** per spur; **resin**
- **blue pine** (गोब्रेसल्लो, *P. wallichiana*): higher; soft blue-green, **five** per spur
- Scots pine: two per spur
- sporophyte (2n); **pyramid-like** (conical) outline

Root

- **tap root**, wide laterals; older laterals: root hairs replaced by **mycorrhizal roots** (symbiosis)

Mycorrhizal root	Coralloid root
with a **fungus**	with **cyanobacteria** (*Anabaena*, *Nostoc*)
Pinus (most trees)	*Cycas*
short, branched, covered with hyphae; replaces root hairs	short, thick, coral-like clusters, up to soil surface
fungus absorbs water, **phosphate**, minerals; plant gives sugars	cyanobacteria fix **nitrogen**; plant gives shelter, food

- mycorrhiza: hyphae far thinner, reach far more soil; phosphate (moves slowly), nitrogen, zinc, copper; enzymes free nutrients; protect against harmful fungi, toxic metals, drought; pines grow on poor rocky soil; forest soil added to new plantations

Stem: cylindrical, woody, thick scaly **bark**; branches in whorls

Long shoot	Dwarf shoot
unlimited growth	**limited** growth
terminal bud	no functional apical bud
grows on year after year	a few mm
only scale leaves	scale leaves + needles (spur)

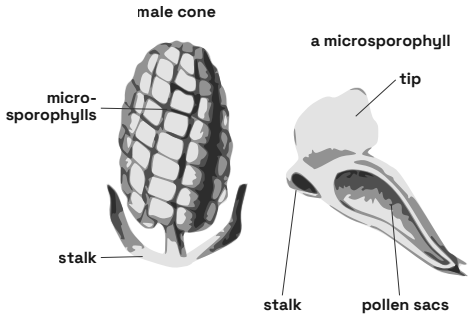
Scale leaves	Foliage leaves
small, thin, brown, papery	green **needles**
on long and dwarf shoots	**only on dwarf shoots**
protect buds, young shoots	**photosynthesis**

- needle saves water: long, narrow, **thick cuticle**, **sunken stomata**, resin canals; kept through cold, dry winters (frozen soil)

Pinus: reproduction

- **monoecious**: male and female cones on **different branches** of one tree

Male cone	Female cone
small, 1.5–2.5 cm	larger; young: small, upright, reddish
in **clusters** at base of young long shoots, **lower branches**	1–4 near **tips** of long shoots, **upper branches**
microsporophylls spiral on axis	**bract scales** + **ovuliferous scales** spiral on axis
each: **2 microsporangia** below	each ovuliferous scale: **2 ovules** above, near base
meiosis → **microspores** (pollen)	meiosis → **megaspores**
makes and sheds pollen	catches pollen; seeds ripen in it

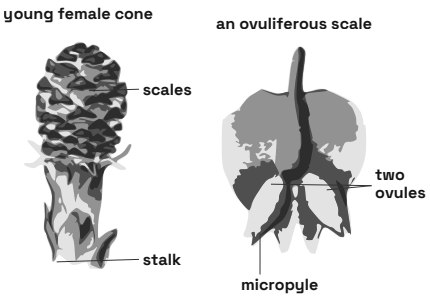


Male cone: microsporophylls spiral round the axis; one microsporophyll with two pollen sacs.

- **pollen grain**: yellow, **uninucleate** at first; **intine** + **exine**; **two wings** (air sacs) for wind
- male cones low, female high → own pollen blows past

Ovule

- **nucellus**, one **integument**, **micropyle**
- **inverted**: micropyle faces the **cone axis** (often called anatropous; nucellus, integument, micropyle in one straight line)
- megaspore mother cell → meiosis → **linear tetrad**; upper 3 degenerate; **lowest functional**
- → **female gametophyte** (haploid "endosperm")



Young female cone; one ovuliferous scale with two ovules, micropyles towards the axis.

Male gametophyte

- microspore = first cell; at shedding **4 cells**: **2 prothallial** (shrivel), **1 antheridial (generative)**, **1 tube cell**

Pollination (wind)

1. female cone scales part
2. **pollination drop** at micropyle catches pollen
3. drop drawn back → pollen into **pollen chamber**
4. scales close; pollen **inactive for months**

Pollen tube (next spring)

- tube cell → **pollen tube** through nucellus
- antheridial cell → **stalk cell + body cell → 2 male gametes** (unequal; **non-motile**)
- swimming sperm only in *Cycas*, *Ginkgo*

Archegonia

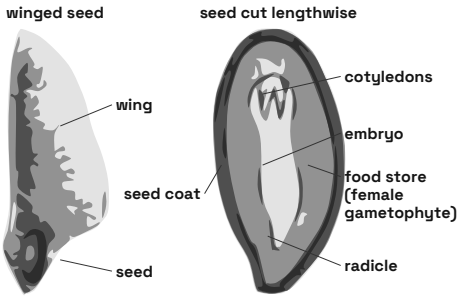
- functional megaspore = first cell of female gametophyte
- **2–4 archegonia** at micropylar end: venter with large **egg** + venter canal cell; **short neck**, **no neck canal cells**

Fertilization (**~1 year** after pollination)

- one male nucleus + egg → **zygote** (first cell of sporophyte); other degenerates
- **polyembryony**: several archegonia fertilized; usually one embryo survives

Seed (**~2 years** from pollination)

- embryo: **radicle** (to micropyle), **plumule**, **several cotyledons**
- integument → **seed coat**; ovule → **seed**; female gametophyte → **food store**
- thin layer of scale → papery **wing** (wind)
- cone opens, seeds spin away; germinate → seedling



Winged seed; seed cut: seed coat, food store (female gametophyte), embryo with cotyledons and radicle.

Life cycle

- tree = **sporophyte** (2n), dominant
- **microspores** (male cone), **megaspores** (ovule) by meiosis
- gametophytes tiny, **never independent**: male = pollen + tube; female inside the ovule
- no water: pollen tube carries gametes
- **ploidy of the seed**: embryo 2n; food store **n**; seed coat, wing 2n (parent)

Economic importance

1. **ornamental**: *Cycas*, *Araucaria*, *Thuja*, junipers, cypresses; Christmas trees, hedges
2. **food**: **sago** from cycads (soak, wash: poisonous); **chilgoza** (*Pinus gerardiana*) seeds; *Ginkgo* seeds
3. **wood** (**softwood**): building, furniture, packing, matchsticks, pencils (cedar), sleepers, fuel, paper pulp; salla, deodar doors, beams
4. **medicine**
   - *Ephedra* → **ephedrine**: asthma, coughs, colds, bronchitis (*E. gerardiana* in Nepal)
   - *Taxus* → **taxol**: anti-cancer; Himalayan yew (*T. wallichiana*, lauth salla) down ~90 %, **endangered** (IUCN)
5. **industry**
   - gums (*Cycas*): adhesive
   - **tannin** (*Araucaria* bark): tanning leather
   - cycad leaves: baskets, mats, hats, brooms
   - plywood (*Podocarpus*)
   - **resin** (chir pine) → **turpentine** (~⅕) + **rosin** (~¾): paints, varnish, soap, ink, violin bows

COMMON MISTAKES

✗ Gymnosperms bear fruits
✓ **no ovary, no fruit**; seeds naked.

✗ The pine seed's food store is triploid endosperm
✓ it is the **female gametophyte**, **haploid**.

✗ Pine needles grow on long shoots
✓ **only on dwarf shoots**; long shoots bear scale leaves.

✗ Gymnosperms have double fertilization
✓ **absent**; one male nucleus degenerates.

✗ Pine male gametes swim
✓ **non-motile**, carried by the pollen tube.

✗ Pine archegonia have neck canal cells
✓ **none**.

✗ Fertilization follows pollination at once
✓ about **a year** later.