

PLANT MORPHOLGY: CONIFEROPHYTA: three orders: Coniferales (extant), Voltziales & Cordaitales (both of the latter are extinct)

Coniferales:

- * known from Mesozoic; families distinguished from Late Triassic or Early Jurassic; extant genera known from Middle Jurassic
- * 7 families; 51 genera; ca. 550 spp.
- * widespread in Northern & Southern Hemispheres; particularly diverse in western N. America & eastern Asia; few in tropical regions (in contrast to cycads)
- * current systematics based primarily on 1) form, phyllotaxy and anatomy of lvs, 2) organization of strobili & 3) mature pollen grains
- * most conifers prod. seeds in seed cones (except Taxaceae: where seeds are terminal on short shoots and enclosed (*Torreya*) or partially so (*Taxus*) by a fleshy aril (cuplike structure).

Families within Coniferales and their characteristics:

Pinaceae: Monoecious trees with spirally arranged linear or needlelike lvs; each microsporophyll has two microsporangia; ovules borne in pairs on woody cone scales subtended by more or less free bracts; pollen grains usu. w/ 2 wings

Taxodiaceae: Monoecious trees with spirally arranged or opposite needle-like or linear lvs; microsporophylls with two to nine microsporangia; ovuliferous scale joined with its bract and bearing two to nine ovules; pollen grains lacking wings

Cupressaceae: Monoecious or dioecious trees or shrubs; lvs opposite or whorled, usu. scalelike in form; microsporangia with three to six (sometimes more); ovulate cones woody or somewhat fleshy at maturity; ovuliferous scale united with its bract and bearing two to many ovules; pollen grains w/out wings

Araucariaceae: Dioecious or monoecious trees; lvs linear to broad, opposite or spirally arranged; microsporophylls with five to twenty pendant microsporangia; ovuliferous scale fused with its bract and having a single median ovule; pollen grains w/out wings

Podocarpaceae: Trees or shrubs, most dioecious with scalelike, linear or broad spirally arranged lvs; microsporophylls w/ 2 microsporangia; megasporangiate strobili conelike or greatly modified; usu. only one ovule matures and may be supported on a fleshy "receptacle"; pollen grains usu. with two or more wings

Cephalotaxaceae: Trees or shrubs, most dioecious; lvs needlelike and spirally arranged to two-ranked; microsporophylls with three to eight pollen sacs; ovulate cones with decussately arranged bracts, each bract subtending two ovules, only one of which generally develops into an ovelike seed; pollen grains w/out wings.

Taxaceae: Dioecious trees or shrubs; lvs linear or needlelike, spirally arranged; microsporophylls peltate with two to eight microsporangia; ovuliferous branch with a single terminal ovule partly or entirely enclosed at maturity by a fleshy aril; pollen grains w/out wings

GENERAL CHARACTERISTICS OF CONIFERS:

HABIT:

- * mostly tall trees w/ persistent central trunk
- * mostly evergreen (exceptions: *Larix*, *Pseudolarix*, *Taxodium*, & *Metasequoia*)
- * many are long-lived: ex. *Sequoiadendron giganteum* (>3000 yrs), bristlecone pine, *Pinus longavea* (several older than 4,000 yrs),

LEAVES:

- * all *living* conifers have simple lvs.; needle-like (*Pinus*, *Picea*, *Abies*), scale-like (*Thuja*, *Juniperus*, *Calocedrus*, *Cupressus*), broad lvs (*Agathis*, *Araucaria*, *Podocarpus*)
- * vascular tissue derived sympodial bundles of a eustele

- * arrangement (phyllotaxy) is spiral and alternate in most (Cupressaceae w/ decussate or whorled arrangement)
- * lvs on spur shoots in a few genera (*Larix*, *Cedrus*, *Pseudolarix*) similar to *Ginkgo biloba*
 - * growth of spur shoots have aided in the interpretation of the ovuliferous scales of the megasporangiate strobili
- * speculation on primitive lvs: progymnosperms w/ simple, dichotomously branched segments to deeply dissected, very narrow types to more broad lamina with numerous veins (similar in many respects to current *Araucaria*)
 - * heterophylly in certain early groups: needlelike and others that were dichotomously lobed & dichotomously veined.
 - * from above arose needle-like lf early in the phylogeny of Coniferales
- * vascularization of lvs.: single median bundle in most conifer genera (*Abies*, *Picea*, *Pseudotsuga*, Cupressaceae (as a whole), & certain *Pinus* spp.)
 - * *Pinus*: 2 subgenera recognized based on # of median veins present: *Haploxyton* (for single-veined spp.), *Diploxyton* (spp. w/ 2 median veins/lf)
 - * broad-leaf'd genera (*Araucaria*, *Agathis*, *Podocarpus*) have series of dichotomously branched veins similar to Cycads)

HISTOLOGY:

- * epidermal, fundamental, & fascicular tissue systems are well-defined, but cellular structure varies widely among genera & spp.
- * epidermis: thick-walled & w/cuticle of varying thickness
- * stomata: sunken w/ overarching subsidiary cells
- * hypodermis: 1+ layers of cells; not always present
- * mesophyll: differentiated either into palisade and spongy parenchyma or palisade layers on both sides of leaf
- * endodermal sheath: cells w/ casparian strips often w/ secondary walls w/ suberin on anticlinal walls only, while other spp. the endodermis consists only of parenchyma
- * "transfusion tissue" & vascular tissue w/in endodermis (in older texts often referred to as pericycle)
- * STOMATA:
 - * amphistomatic: stomates on all sides of lvs.
 - * hypostomatic: stomates on lower " " "
 - * *haplocheilic*: 2 guard cells arise from single epidermal initial
 - * *syndetocheilic*: protodermal initial divides twice to produce 2 subsidiary cells then the initial (remaining between the subsidiary cells) divides to produce 2 guard cells
 - ** these two types of stomatal types traceable thru fossil record & define major groups of gymnosperm taxa
 - * Haplocheilic: 1) living & extinct conifers, 2) Pteridospermales, 3) Cordaitales, 4) Cycadales, 5) Ginkgoales, & 6) Ephedra
 - * Syndetocheilic: *Welwitschia*, & *Gnetum*
- * Transfusion tissue: transfusion tracheids & transfusion parenchyma @ periphery of lf veins; conduction of material between vascular tissue and mesophyll
 - arises from outer region of procambium
 - matures basipetally and centripetally

STEM ANATOMY:

- * Eustelic; comprised of 5, 8, 13, or 21 vascular sympodia: "open system" except in plants w/ opposite phyllotaxy where leaf trace is derived from two adjacent sympodia
- * primary xylem is endarch (a condition that we have seen since ?)
- * prominent secondary xylem (unlike cycads) of tracheids, xylem rays of parenchyma & resin ducts; distribution of resin ducts varies from simple alignment w/ sympodial bundles to complex (*Araucaria*)
 - * tracheids w/ circular bordered pits (fig. 17-17)
- * phloem of sieve cells, phloem parenchyma and rays (fibers and sclereids may also develop)
- * pith & cortex of parenchyma with large resin ducts in cortex

- * epidermis w/ thickened outer walls & thick cuticle which is later sloughed and replaced by periderm

STROBILI & SPORANGIA:

- * separation of microsporangiate (pollen-bearing) cones & megasporangiate (seed) cones; this true of Paleozoic & Mesozoic fossils representatives
- * dioecious condition found in species of Taxaceae, most Auracariaceae, *Podocarpus*, and various genera of Cupressaceae
- * *Microsporangiate strobili*: simple strobilus; small relative to cycads; subterminal in *Pinus* (in axils of scale lvs), solitary in *Cedrus* (at tips of spur shoots)...
- * microsporangia develop on *lower* surface of sporophylls; number of sporangia varies (two in Pinaceae, 2-7 in other families; 13-15 in certain spp. of *Auracaria* & *Agathis*; in Taxaceae, peltate, *sporangiphores* bear 3-9 microsporangia)
 - * eusporangiate in final form, but originates from periclinal division of series of hypodermal cells (i.e., not from superficial initials as in lower vascular plants), except in *Pseudotsuga*, *Cedrus deodara*, *Pinus*, *Picea*, & *Larix*
- * *Megasporangiate cones*: compound strobilus; each ovuliferous scale subtended by a small bract; each scale bears two inverted ovules on the adaxial (upper) surface
- * Origin of ovuliferous scale (Voltziales): ovuliferous scale represents a highly-condensed, fertile shoot (i.e., not a simple sporophyll); under this interpretation, early precursors of this scale would be found in 2 genera of Voltziales (*Lebachia* & *Ernestiodendron*; fig. 17-28) from the Upper Carboniferous-Permian.

REPRODUCTIVE CYCLE (of *Pinus*) (fig. 17-30)

- * 12-14 months pass between pollination & fertilization in *Pinus* (vs. other conifers where pollination & fertilization occur in same season)
- * incl. initiation & development of strobili, whole life cycle of *Pinus* occurs over a three year period (normally two years for most other conifers);
- * *microsporogenesis*: development and maturation process takes nearly a year: initiated in the spring (early summer) and well-defined sporogenous tissue is formed by winter followed by meiosis and formation of winged pollen grains in the spring.
 - * microsporocyte → 4 microspores (retained w/in wall of microsporocyte for an indefinite period of time); wings of pollen grain formed by separation of exine & intine layers of microspore wall
 - * endosporic male gametophyte develops from 3 successive nuclear divisions --> *two prothallial cells, a generative cell & a tube cell*; in this form = *pollen grain*; pollen grains adhere to pollination drops at the open ends of inverted ovules (*pollination*) and begins development of *pollen tube* before entering period of dormancy (winter).
- * *megasporogenesis*: ovule w/ single integument & nucellus w/ single megasporocyte embedded within nucellus.
 - * megasporocyte → 3 or 4 megaspores (the one furthest from the micropyle becomes the functional megaspore); at time of pollination, megaspore undergoes a series of free nuclear divisions before entering a period of dormancy (winter)
 - * development of female gametophyte (endosporic): during spring, more free nuclei are formed before cell wall formation is initiated; cell wall formation is similar to cycads & *Ginkgo* w/ centripetal development of tubular alveoli; archegonia formed (when gametophyte is completely cellular or not) in manner very similar to that of cycads (fig. 15-25 & notes on Cycadophyta)
- * *fertilization*: sterile cell & spermatogenous cell move down the pollen tube from which are secreted pectinase and cellulase that dissolve cell walls of nucellus; ca. a week before fertilization, the spermatogenous cell divides forming *two, unequal, male gametes* (flagella are absent in contrast to cycads & *Ginkgo*); *fertilization*: fusion of larger of two male gametes w/ nucleus of egg cell.

- * embryogeny: initiated w/ series of *free nuclear divisions* (4 (*Pinus*)-64 nuclei prod.) before the start of wall formation; proembryo: 4 walled cells + 4 free nuclei → further divisions & wall formation --> 16 celled arrangement in 4 tiers located at lower end of archegonium (this precise stratification of cells is different from what is found in cycads & *Ginkgo*)
- * *polyembryony*: development of 4-8 embryos from a single egg cell. Development from lower cell tiers (see above) through their separation into 4 filamentous embryos (= cleavage polyembryony). This formation of multiple embryos followed by the elongation of *embryonal suspensor cells* which force the apical tier of cells (= potential embryo(s)) into the female gametophyte. [Subsequent divisions of apical cells form new layers of suspensor cells followed by the cleavage of apical cells into 4 distinct embryos; yet more divisions occur to form embryonal masses, but competition is such that only one embryo continues to develop]
- * fully developed embryo: ca. 8 cotyledons, shoot apex, short hypocotyl, & primary root or radicle.
- * wing of seed from adaxial surface of ovuliferous scale (i.e., morphologically not part of seed)

[Read: Comparisons between *Pinus* and other conifers]