SEMESTER-II

UNIT-I

A **pteridophyte** is a vascular plant (with xylem and phloem) that reproduces by means of spores. Because pteridophytes produce neither flowers nor seeds, they are sometimes referred to as "cryptogams", meaning that their means of reproduction is hidden.

Ferns, horsetails (often treated as ferns), and lycophytes (clubmosses, spikemosses, and quillworts) are all pteridophytes. However, they do not form a monophyletic group because ferns (and horsetails) are more closely related to seed plants than to lycophytes. "Pteridophyta" is thus no longer a widely accepted taxon, but the term *pteridophyte* remains in common parlance, as do *pteridology* and *pteridologist* as a science and its practitioner, for example by the International Association of Pteridologists and the Pteridophyte Phylogeny Group.

Description

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Pteridophytes (ferns and lycophytes) are free-sporing vascular plants that have a life cycle with alternating, free-living gametophyte and sporophyte phases that are independent at maturity. The body of the sporophyte is well differentiated into roots, stem and leaves. The root system is always adventitious. The stem is either underground or aerial. The leaves may be microphylls or megaphylls. Their other common characteristics include vascular plant apomorphies (e.g., vascular tissue) and land plant plesiomorphies (e.g., spore dispersal and the absence of seeds).[1][2]

Taxonomy

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Phylogeny

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Of the pteridophytes, ferns account for nearly 90% of the extant diversity.[2] Smith et al. (2006), the first higher-level pteridophyte classification published in the molecular phylogenetic era, considered the ferns as monilophytes, as follows:[3]

- Division Tracheophyta (tracheophytes) - vascular plants
  - Subdivision Lycopodiophyta (lycophytes) - less than 1% of extant vascular plants
  - Sub division Euphyllophytina (euphyllophytes)
    - Infradivision Moniliformopses (**monilophytes**)
    - Infradivision Spermatophyta - seed plants, ~260,000 species

where the monilophytes comprise about 9,000 species, including horsetails (Equisetaceae), whisk ferns (Psilotaceae), and all eusporangiate and all leptosporangiate ferns. Historically both lycophytes and monilophytes were grouped together as pteridophytes (ferns and fern allies) on the basis of being spore-bearing ("seed-free"). In Smith's molecular phylogenetic study the ferns are characterised by lateral root origin in the endodermis, usually mesarch protoxylem in shoots, a pseudoendospore, plasmodial tapetum, and sperm cells with 30-1000 flagella.[3] The term "moniliform" as in Moniliformopses and monilophytes means "bead-shaped" and was introduced by Kenrick and Crane (1997)[4] as a scientific replacement for "fern" (including Equisetaceae) and became established by Pryer et al. (2004).[5] Christenhusz and Chase (2014) in their review of classification schemes provide a critique of this usage, which they discouraged as irrational. In fact the alternative name Filicopsida was already in use.[6] By comparison "lycopod" or lycophyte (club moss) means wolf-plant. The term "fern ally" included under Pteridophyta generally refers to vascular spore-bearing plants that are not ferns, including lycopods, horsetails, whisk ferns and water ferns (Marsileaceae, Salviniaceae and *Ceratopteris*). This is not a natural grouping but rather a convenient term for non-fern, and is also discouraged, as is eusporangiate for non-leptosporangiate ferns.[7]

However both Infradivision and Moniliformopses are also invalid names under the International Code of Botanical Nomenclature. Ferns, despite forming a monophyletic clade, are formally only considered as four classes (Psilotopsida; Equisetopsida; Marattiopsida; Polypodiopsida), 11 orders and 37 families, without assigning a higher taxonomic rank.[3]

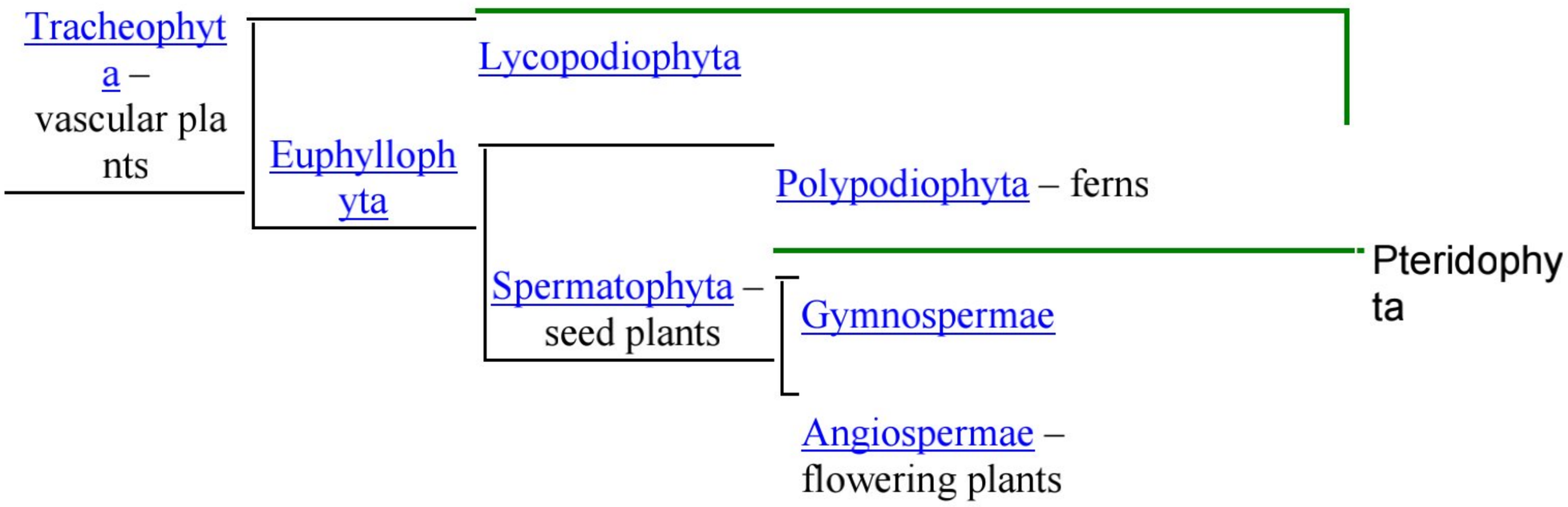
Furthermore, within the Polypodiopsida, the largest grouping, a number of informal clades were recognised, including leptosporangiates, core leptosporangiates, polypods (Polypodiales), and eupolypods (including Eupolypods I and Eupolypods II).[3]

In 2014 Christenhusz and Chase, summarising the known knowledge at that time, treated this group as two separate unrelated taxa in a consensus classification;[7]

- Lycopodiophyta (lycopods) 1 subclass, 3 orders, each with one family, 5 genera, approx. 1,300 species
- Polypodiophyta (ferns) 4 subclasses, 11 orders, 21 families, approx. 212 genera, approx. 10,535 species
  - Subclass Equisetidae Warm.
  - Subclass Ophioglossidae Klinge
  - Subclass Marattiidae Klinge
  - Subclass Polypodiidae Cronquist, Takht. & Zimmerm.

These subclasses correspond to Smith's four classes, with Ophioglossidae corresponding to Psilotopsida.

The two major groups previously included in Pteridophyta are phylogenetically related as follows:[7][8][9]



Subdivision

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Pteridophytes consist of two separate but related classes, whose nomenclature has varied.[3][10] The system put forward by the Pteridophyte Phylogeny Group in 2016, PPG I, is:[2]

- Class Lycopodiopsida Bartl. – lycophytes: clubmosses, quillworts and spikemosses; 3 extant orders
  - Order Lycopodiales DC. ex Bercht. & J.Presl – clubmosses; 1 extant family
  - Order Isoetales Prantl – quillworts; 1 extant family
  - Order Selaginellales Prantl – spikemosses; 1 extant family
- Class Polypodiopsida Cronquist, Takht. & W.Zimm. – ferns; 11 extant orders
  - Subclass Equisetidae Warm. – horsetails; 1 extant order, family and genus (*Equisetum*)
    - Order Equisetales DC. ex Bercht. & J.Presl – 1 extant family
  - Subclass Ophioglossidae Klinge – 2 extant orders
    - Order Psilotales Prant – whisk ferns; 1 extant family
    - Order Ophioglossales Link – grape ferns; 1 extant family
  - Subclass Marattiidae Klinge – marattioid ferns; 1 extant order
    - Order Marattiales Link – 1 extant family
  - Subclass Polypodiidae Cronquist, Takht. & W.Zimm. – leptosporangiate ferns; 7 extant orders
    - Order Osmundales Link – 1 extant family
    - Order Hymenophyllales A.B.Frank – 1 extant family
    - Order Gleicheniales Schimp – 3 extant families
    - Order Schizaeales Schimp. – 3 extant families
    - Order Salviniales Link – 2 extant families

- Order Cyatheales A.B.Frank – 8 extant families
- Order Polypodiales Link – 26 extant families

In addition to these living groups, several groups of pteridophytes are now extinct and known only from fossils. These groups include the Rhyniopsida, Zosterophyllopsida, Trimerophytopsida, the Lepidodendrales and the Progymnospermopsida.

Modern studies of the land plants agree that seed plants emerged from pteridophytes more closer to ferns than lycophytes. Therefore, pteridophytes do not form a clade but constitute a paraphyletic grade.

Life cycle

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Pteridophyte life cycle

Just as with bryophytes and spermatophytes (seed plants), the life cycle of pteridophytes involves alternation of generations. This means that a diploid generation (the sporophyte, which produces spores) is followed by a haploid generation (the gametophyte or prothallus, which produces gametes). Pteridophytes differ from bryophytes in that the sporophyte is branched and generally much larger and more conspicuous, and from seed plants in that both generations are independent and free-living. The sexuality of pteridophyte gametophytes can be classified as follows:

- Dioicous: each individual gametophyte is either male (producing antheridia and hence sperm) or female (producing archegonia and hence egg cells).
- Monoicous: each individual gametophyte produces both antheridia and archegonia and can function both as a male and as a female.

  Protandrous: the antheridia mature before the archegonia (male first, then female).

  Protogynous: the archegonia mature before the antheridia (female first, then male).

These terms are *not* the same as monoecious and dioecious, which refer to whether a seed plant's sporophyte bears both male and female gametophytes, i. e., produces both pollen and seeds, or just one of the sexes.

The **gymnosperms** (/ˈdʒɪmnəˌspɜːrmz, -noʊ-/ ⓘ *JIM-nə-spurmz, -noh-*; lit. 'revealed seeds') are a group of seed-producing plants that includes conifers, cycads, *Ginkgo*, and gnetophytes, forming the clade **Gymnospermae**. The term *gymnosperm* comes from the composite word in Greek: γυμνόσπερμος (γυμνός, *gymnos*, 'naked' and σπέρμα, *sperma*, 'seed'), literally meaning 'naked seeds'. The name is based on the unenclosed condition of their seeds (called ovules in their unfertilized state). The non-encased condition of their seeds contrasts with the seeds and ovules of flowering plants (angiosperms), which are enclosed within an ovary. Gymnosperm seeds develop either on the surface of scales or leaves, which are often modified to form cones, or on their own as in yew, *Torreya*, and *Ginkgo*.[2] The life cycle of a gymnosperm involves alternation of generations, with a dominant diploid sporophyte phase, and a reduced haploid gametophyte phase, which is dependent on the sporophytic phase. The term "gymnosperm" is often used in paleobotany to refer to (the paraphyletic group of) all non-angiosperm seed plants. In that case, to specify the modern monophyletic group of gymnosperms, the term **Acrogymnospermae** is sometimes used.

The gymnosperms and angiosperms together constitute the spermatophytes or seed plants. The spermatophytes are subdivided into five divisions, the angiosperms and four divisions of gymnosperms: the Cycadophyta, Ginkgophyta, Gnetophyta, and Pinophyta (also known as Coniferophyta). Newer classification place the gnetophytes among the conifers.[3] Numerous extinct seed plant groups are recognised including those considered pteridosperms/seed ferns, as well other groups like the Bennettitales.[4]

By far the largest group of living gymnosperms are the conifers (pines, cypresses, and relatives), followed by cycads, gnetophytes (*Gnetum*, *Ephedra* and *Welwitschia*), and *Ginkgo biloba* (a single living species). About 65% of gymnosperms are dioecious,[5] but conifers are almost all monoecious.[6]

Some genera have mycorrhiza, fungal associations with roots (*Pinus*), while in some others (*Cycas*) small specialised roots called coralloid roots are associated with nitrogen-fixing cyanobacteria.

Diversity and origin

[edit]

Encephalartos sclavoi cone, about 30 cm long

Over 1,000 living species of gymnosperm exist.[2] It was previously widely accepted that the gymnosperms originated in the Late Carboniferous period, replacing the lycopsid rainforests of the tropical region, but more recent phylogenetic evidence indicates that they diverged from the ancestors of angiosperms during the Early Carboniferous.[7][8] The radiation of gymnosperms during the late Carboniferous appears to have resulted from a whole genome duplication event around 319 million years ago.[9] Early characteristics of seed plants are evident in fossil progymnosperms of the late Devonian period around 383 million years ago. It has been suggested that during the mid-Mesozoic era, pollination of some extinct groups of gymnosperms was by extinct species of scorpionflies that had specialized proboscis for feeding on pollination drops. The scorpionflies likely engaged in pollination mutualisms with gymnosperms, long before the similar and independent coevolution of nectar-feeding insects on angiosperms.[10][11] Evidence has also been found that mid-Mesozoic gymnosperms were pollinated by Kalligrammatid lacewings, a now-extinct family with members which (in an example of convergent evolution) resembled the modern butterflies that arose far later.[12]

Zamia integrifolia, a cycad native to Florida

All gymnosperms are perennial woody plants,[13] Unlike in other extant gymnosperms the soft and highly parenchymatous wood in cycads is poorly lignified,[14] and their main structural support comes from an armor of sclerenchymatous leaf bases covering the stem,[15] with the exception of species with underground stems.[16] There are no herbaceous gymnosperms and compared to angiosperms they occupy fewer ecological niches, but have evolved both parasites (*Parasitaxus*), epiphytes (*Zamia pseudoparasitica*) and rheophytes (*Retrophyllum minus*).[17]

Conifers are by far the most abundant extant group of gymnosperms with six to eight families, with a total of 65–70 genera and 600–630 species (696 accepted names).[18] Most conifers are evergreens.[19] The leaves of many conifers are long, thin and needle-like, while other species, including most Cupressaceae and some Podocarpaceae, have flat, triangular scale-like leaves. *Agathis* in Araucariaceae and *Nageia* in Podocarpaceae have broad, flat strap-shaped leaves.[*citation needed*]

Cycads are the next most abundant group of gymnosperms, with two or three families, 11 genera, and approximately 338 species. A majority of cycads are native to tropical climates and are most abundantly found in regions near the equator. The other extant groups are the 95–100 species of Gnetales and one species of *Ginkgo*.[4]

Today gymnosperms are the most threatened of all plant groups.[20]

Classification

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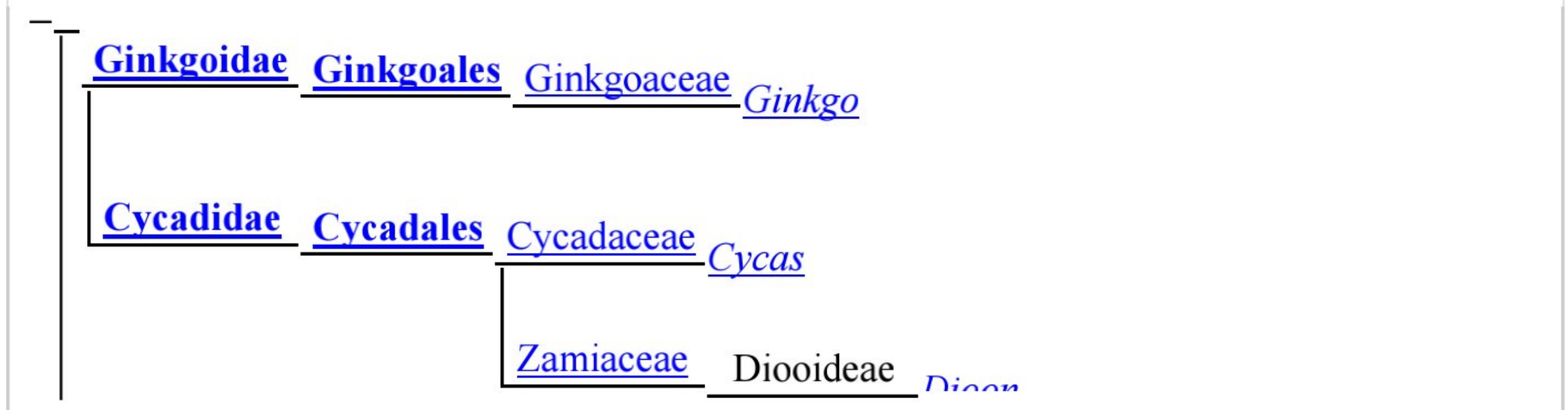
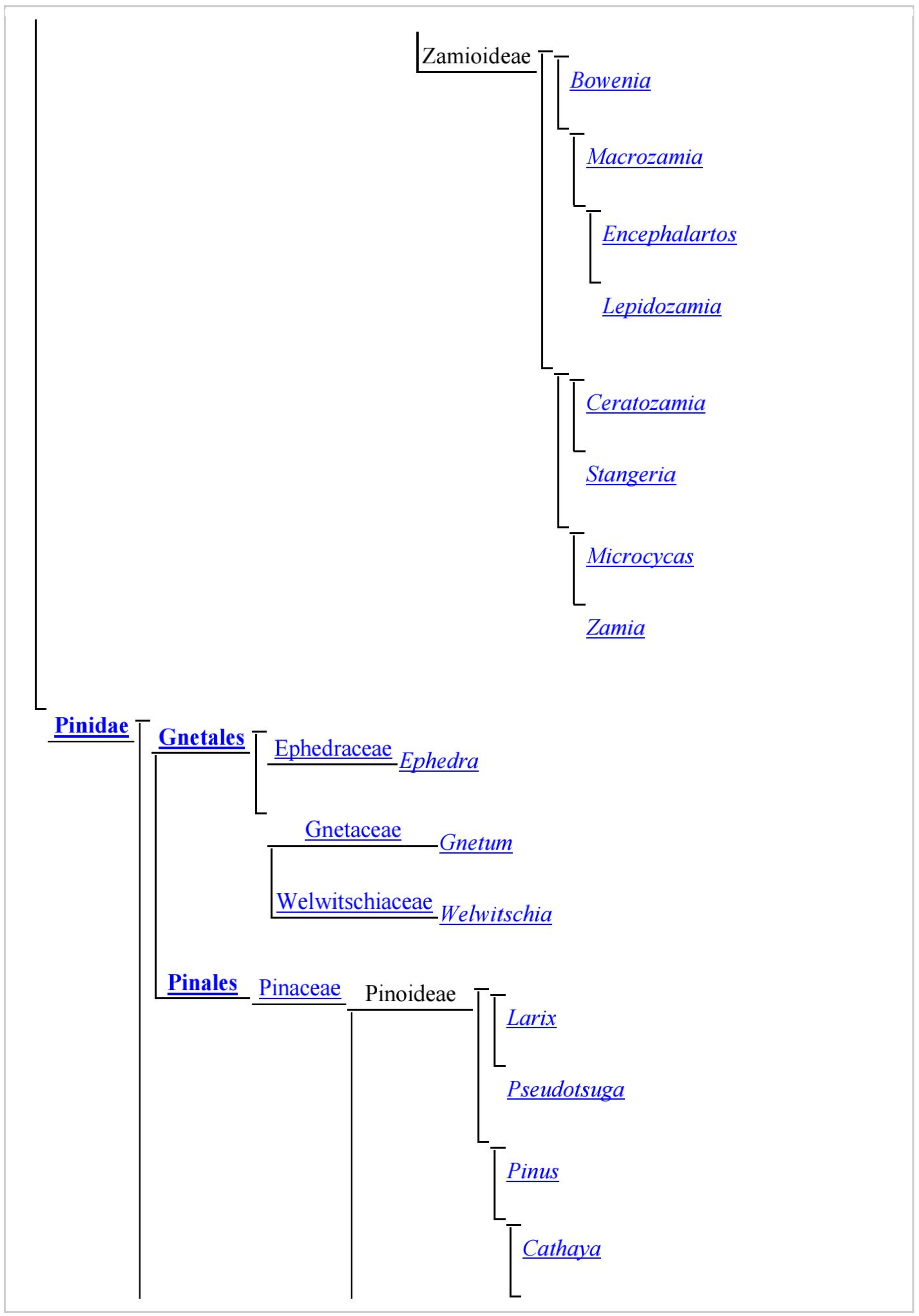
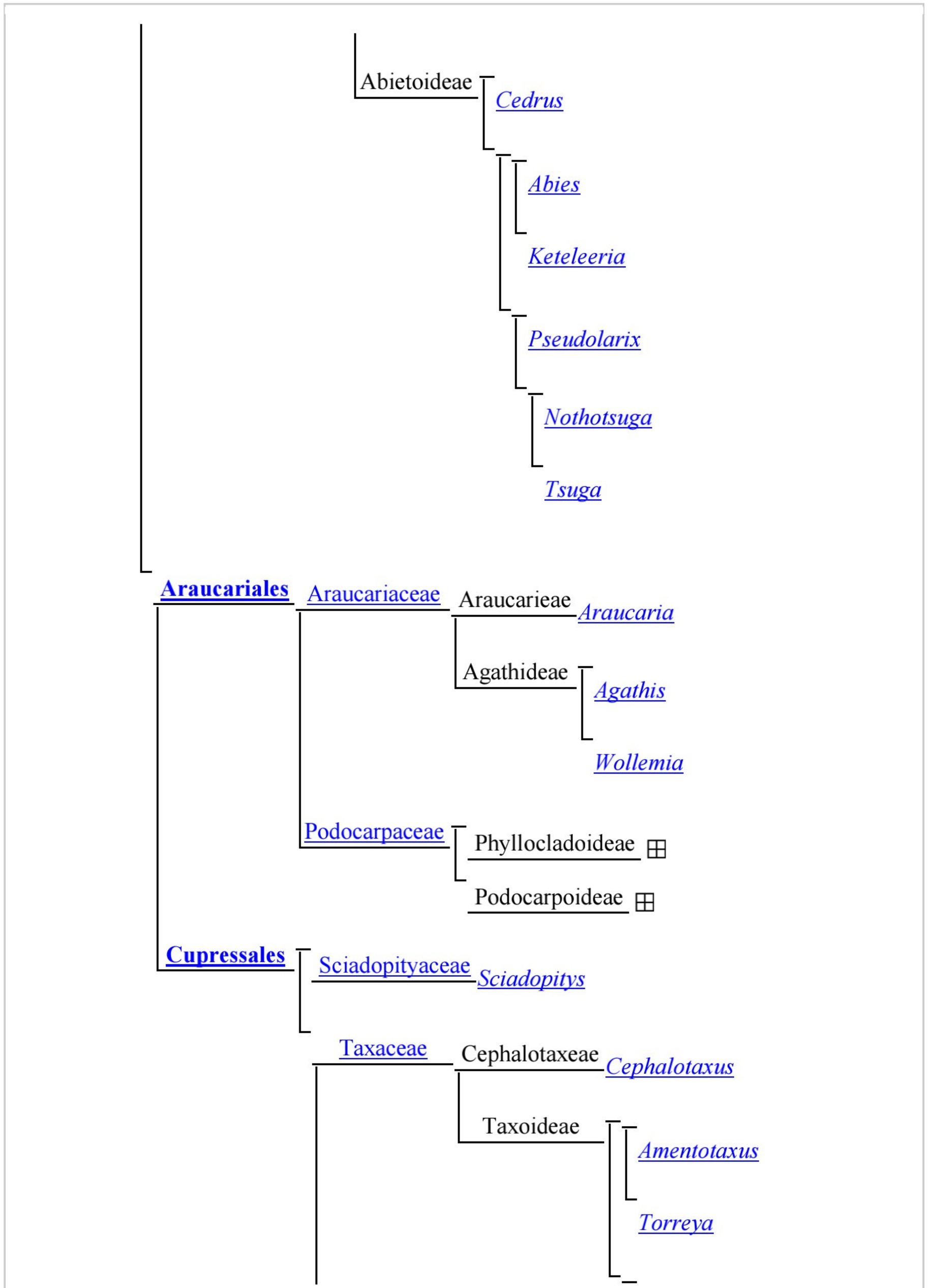
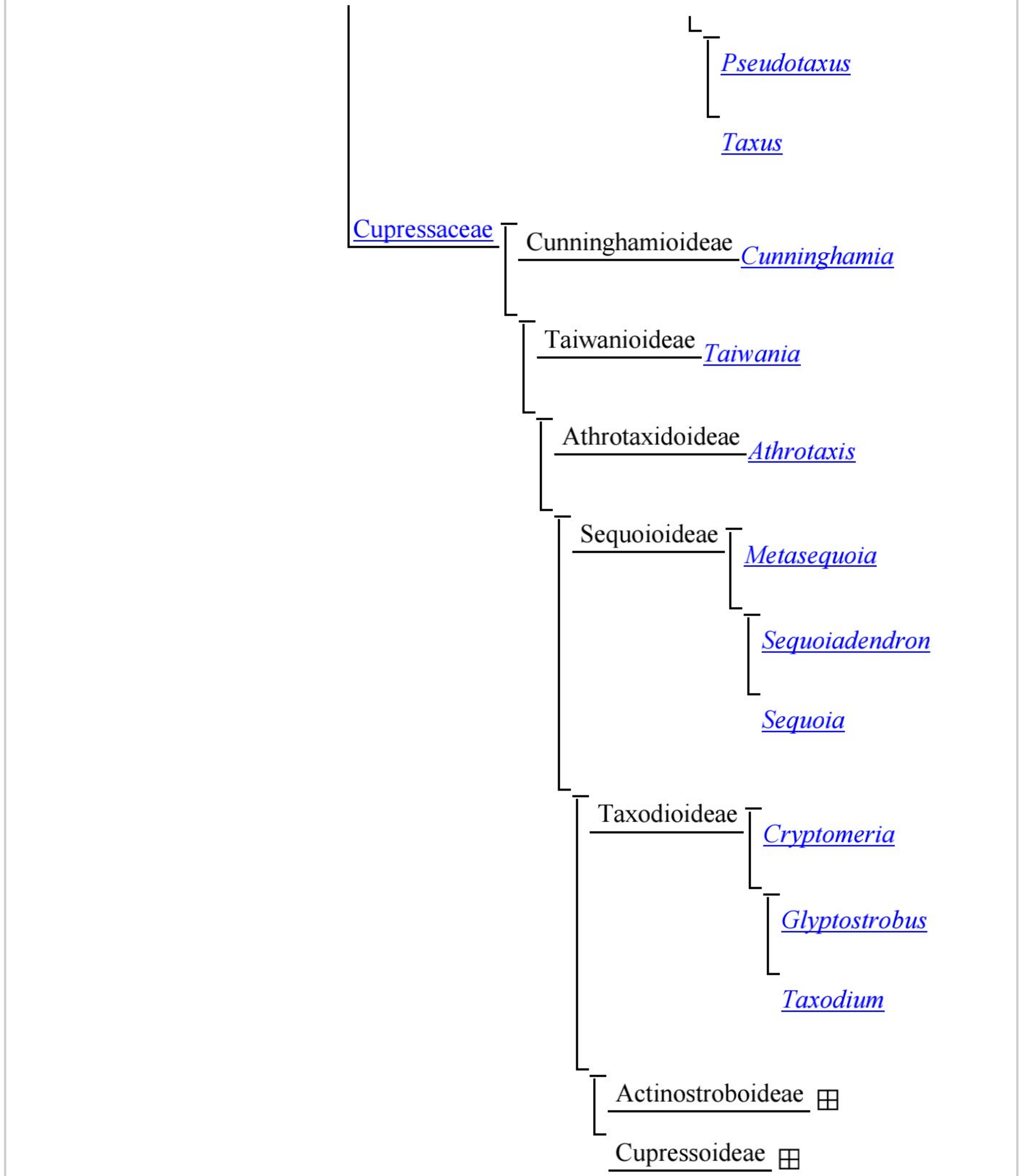
Phylogeny of Gymnosperms[21][22][23][24]









Further information: Spermatophyte

A formal classification of the living gymnosperms is the "Acrogymnospermae", which form a monophyletic group within the spermatophytes.[25][26] The wider "Gymnospermae" group includes extinct gymnosperms and is thought to be paraphyletic. The fossil record of gymnosperms includes many distinctive taxa that do not belong to the four modern groups, including seed-bearing trees that have a somewhat fern-like vegetative

morphology (the so-called "seed ferns" or pteridosperms).[27] When fossil gymnosperms such as these and the Bennettitales, glossopterids, and *Caytonia* are considered, it is clear that angiosperms are nested within a larger gymnospermae clade, although which group of gymnosperms is their closest relative remains unclear.

The extant gymnosperms include 12 main families and 83 genera which contain more than 1000 known species.[2][26][28]

Subclass Cycadidae

- Order **Cycadales**
  - Family **Cycadaceae**: *Cycas*
  - Family **Zamiaceae**: *Dioon*, *Bowenia*, *Macrozamia*, *Lepidozamia*, *Encephalartos*, *Stangeria*, *Ceratozamia*, *Microcycas*, *Zamia*

Subclass Ginkgoidae

- Order **Ginkgoales**
  - Family **Ginkgoaceae**: *Ginkgo*

Subclass Gnetidae

- Order **Welwitschiales**
  - Family **Welwitschiaceae**: *Welwitschia*
- Order **Gnetales**
  - Family **Gnetaceae**: *Gnetum*
- Order **Ephedrales**
  - Family **Ephedraceae**: *Ephedra*

Subclass Pinidae

- Order **Pinales**
  - Family **Pinaceae**: *Cedrus*, *Pinus*, *Cathaya*, *Picea*, *Pseudotsuga*, *Larix*, *Pseudolarix*, *Tsuga*, *Nothotsuga*, *Keteleeria*, *Abies*
- Order **Araucariales**
  - Family **Araucariaceae**: *Araucaria*, *Wollemia*, *Agathis*
  - Family **Podocarpaceae**: *Phyllocladus*, *Lepidothamnus*, *Prumnopitys*, *Sundacarpus*, *Halocarpus*, *Parasitaxus*, *Lagarostrobos*, *Manoao*, *Saxegothaea*, *Microcachrys*, *Pherosphaera*, *Acmopyle*, *Dacrycarpus*, *Dacrydium*, *Falcatifolium*, *Retrophyllum*, *Nageia*, *Afrocarpus*, *Podocarpus*
- Order **Cupressales**
  - Family **Sciadopityaceae**: *Sciadopitys*
  - Family **Cupressaceae**: *Cunninghamia*, *Taiwania*, *Athrotaxis*, *Metasequoia*, *Sequoia*, *Sequoiadendron*, *Cryptomeria*, *Glyptostrobus*, *Taxodium*, *Papuacedrus*, *Austrocedrus*, *Libocedrus*, *Pilgerodendron*, *Widdringtonia*, *Diselma*, *Fitzroya*, *Callitris*, *Actinostrobus*, *Neocallitropsis*, *Thujopsis*, *Thuja*, *Fokienia*, *Chamaecyparis*, *Cupressus*, *Juniperus*, *Calocedrus*, *Tetraclinis*, *Platycladus*, *Microbiota*

- Family **Taxaceae**: *Austrotaxus*, *Pseudotaxus*, *Taxus*, *Cephalotaxus*, *Amentotaxus*, *Torreya*

Extinct groupings

[edit]

- Order Cordaitales
- Order Calamopityales
- Order Callistophytales
- Order Caytoniales
- Order Gigantopteridales
- Order Glossopteridales
- Order Lyginopteridales
- Order Medullosales
- Order Peltaspermales
- Order Corystospermales (also known as Umkomasiales)
- Order Czekanowskiales
- Order Bennettitales (cycadeoids)
- Order Erdtmanithecales
- Order Pentoxylales
- Order Czekanowskiales
- Order Petriellales

Life cycle

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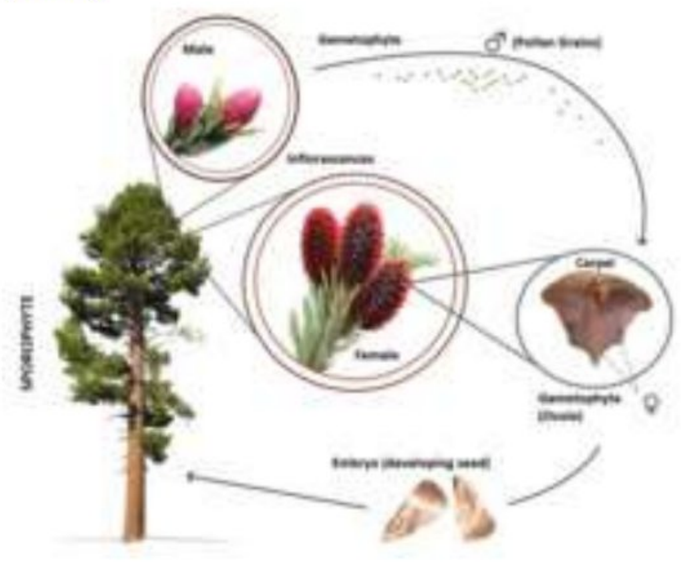

Example of gymnosperm lifecycle

Gymnosperms, like all vascular plants, have a sporophyte-dominant life cycle, which means they spend most of their life cycle with diploid cells, while the gametophyte (gamete-bearing phase) is relatively short-lived. Like all seed plants, they are heterosporous, having two spore types, microspores (male) and megaspores (female) that are typically produced in pollen cones or ovulate cones, respectively.[29] The exception is the females in the cycad genus *Cycas*, which form a loose structure called megasporophylls instead of cones.[30] As with all heterosporous plants, the gametophytes develop within the spore wall. Pollen grains (microgametophytes) mature from microspores, and ultimately produce sperm cells.[29] Megagametophytes develop from megaspores and are retained within the

ovule. Gymnosperms produce multiple archegonia, which produce the female gamete.[citation needed]

During pollination, pollen grains are physically transferred between plants from the pollen cone to the ovule. Pollen is usually moved by wind or insects. Whole grains enter each ovule through a microscopic gap in the ovule coat (integument) called the micropyle. The pollen grains mature further inside the ovule and produce sperm cells. Two main modes of fertilization are found in gymnosperms. Cycads and *Ginkgo* have flagellated motile sperm[31] that swim directly to the egg inside the ovule, whereas conifers and gnetophytes have sperm with no flagella that are moved along a pollen tube to the egg. After syngamy (joining of the sperm and egg cell), the zygote develops into an embryo (young sporophyte). More than one embryo is usually initiated in each gymnosperm seed. The mature seed comprises the embryo and the remains of the female gametophyte, which serves as a food supply, and the seed coat.[32]

Gymnosperms ordinarily reproduce by sexual reproduction, and only rarely express parthenogenesis.[33] Sexual reproduction in gymnosperms appears to be required for maintaining long-term genomic integrity.[33] Meiosis in sexual land plants provides a direct mechanism for repairing DNA in reproductive tissues.[33] The likely primary benefit of cross-pollination in gymnosperms, as in other eukaryotes, is that it allows the avoidance of inbreeding depression caused by the presence of recessive deleterious mutations.[34]

Genetics

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The first published sequenced genome for any gymnosperm was the genome of *Picea abies* in 2013.[35]

Uses

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Gymnosperms have major economic uses. Pine, fir, spruce, and cedar are all examples of conifers that are used for lumber, paper production, and resin. Some other common uses for gymnosperms are soap, varnish, nail polish, food, gum, and perfumes.[36]