



## A new classification and linear sequence of extant gymnosperms

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### Abstract

A new classification and linear sequence of the gymnosperms based on previous molecular and morphological phylogenetic and other studies is presented. Currently accepted genera are listed for each family and arranged according to their (probable) phylogenetic position. A full synonymy is provided, and types are listed for accepted genera. An index to genera assists in easy access to synonymy and family placement of genera.

### Introduction

Gymnosperms are seed plants with an ovule that is not enclosed in a carpel, as is the case in angiosperms. The ovule instead forms on a leaf-like structure (perhaps homologous to a leaf), or on a scale or megasporophyll (homologous to a shoot) or on the apex of a (dwarf) shoot. Megasporophylls are frequently aggregated into compound structures that are often cone-shaped, hence the colloquial name for some of the group: conifers. Homologies of the ovuliferous structures as yet are not entirely resolved. Seeds of gymnosperms may be enclosed at maturity by fused cone scales or bracts, which are sometimes fleshy causing the fruiting structures (cones) to be confused with berries (e.g. juniper “berries”). In spite of their often slow rates of growth and long periods between pollination and seed maturity, gymnosperms can be dominant in some areas. Some extant cycads and gnetophytes are entirely or primarily insect pollinated, whereas *Ginkgo* and all conifers are wind pollinated. Only a few species are known to be polyploid, and no species are reported to be allopolyploid. Extant gymnosperms are not numerous. There are about 1026 species in all: the three ‘non-conifer’ groups comprise ca 310 species of cycads in 10 genera, one extant ginkgophyte and 80–100 gnetophytes in three genera; according to Farjon (2010) there are a total of ca 615 species of conifers in 70 accepted genera.

Hori *et al.* (1985) were the first to find that extant gymnosperms were sister to the angiosperms, but they included only three genera, *Cycas*, *Ginkgo* and *Metasequoia*, so this was not considered a particularly good evaluation of the topic. Troitsky *et al.* (1991) used ribosomal RNA and also found extant gymnosperms to be monophyletic, but they too sampled taxa thinly; although a total of 11 genera were used (three cycads, two gnetophytes, *Ginkgo* and five conifers), and only up to six genera from the whole set were included in each analysis. Likewise, Hasebe *et al.* (1992) used plastid *rbcL* sequences on a small set of taxa and similarly found extant gymnosperms to be monophyletic. The first broadly sampled molecular phylogenetic study to examine gymnosperm relationships was that of Chaw *et al.* (1997), and like the other studies they found extant gymnosperms to be sister to the angiosperms. Chase *et al.* (1993) assumed that the sister group relationship of