



Gymnosperms

Gymnosperms are a group of seed plants united and distinguished from the angiosperms by their seeds being borne naked on cones, strobili or simply unaggregated sporophylls (e.g., Figure 1). Indeed, *gymnos* and *sperma* are Greek for 'naked seed'. In class we will study three groups: cycads, ginkgo, and conifers. Although small by species numbers (ca. 1000 spp globally), they are of great interest and economic importance (Table 1).



Figure 1. Female Queen Sago cycad at the Millersville University greenhouse. **A**, whole plant; **B**, close-up of ovule-bearing megasporophylls loosely clustered among the terminal rosette of leaves.

Table 1. Some Gymnosperm Economic Botany

1. Cycads are important ornamentals and, due to poaching, most are protected under CITES.
 2. Ginkgo is an important ornamental tree, particularly in urban areas where it can tolerate the harsh conditions of compacted soil and sidewalk planting. Ginkgo leaf extract or ground up leaves comprise a popular herbal supplement thought to increase blood flow to the brain and therefore clarity of thought.
 3. *Taxus* (yews) is important as ornamentals and as a source of Taxol, a brand name for an effective chemotherapy drug.
 4. The cypress family, Cupressaceae, includes many ornamental trees and shrubs, ranging from junipers and red-cedars (*Juniperus* spp.) to many others such as arborvitae (*Thuja occidentalis*). Some are important in the lumber or timber industry (e.g., cedar boards and shingles from species of *Juniperus* and *Thuja*). The fleshy cones of *Juniperus communis* is used to flavor gin. *Sequoia* (coastal redwood) and *Sequoiadendron* (giant redwood) include the tallest and largest tree species, respectively, and draw big money in California for tourism.
 5. The pine family, Pinaceae, includes many ornamental trees and shrubs, as well as species important in the timber and Christmas tree industries. Edible seeds (“pine nuts”) come from certain species, and turpentine is distilled from the resin of *Pinus* spp. Rosin is the waxy component of conifer (mostly Pinaceae) resin, and this is used for musical and athletic applications requiring friction.
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I. Introductory Exercise

Determine the identity of three major groups below as Conifers, Cycads, or Ginkgos based upon the descriptions. Fill in the blanks with the correct lineage name.

A. _____ (Conifers, Cycads, or Ginkgos?) comprise an ancient lineage of tropical trees and shrubs: they existed before and outlasted the non-avian dinosaurs, and there are even fossils of these tropical plants on Antarctica. In many ways, they resemble ferns, but with thicker leaves, woody stems, and seeds. Table 1 lists the characteristics of this group of plants.

Table 1. Characteristics of Group A.

- 1) Shrubs or trees with a single, typically unbranched stem.
 - 2) Leaves typically evergreen; in a terminal rosette; pinnate and leathery; leaflets typically with dichotomous leaf venation; circinate vernation common.
 - 3) Sexual system dioecious.
 - 4) Pollen from microsporangia (male) borne on sporophylls and grouped into a strobilus.
 - 5) Seeds and megasporangia (female) borne in ovules which are borne on loosely clustered megasporophylls (*Cycas*) or into a strobilus (*Zamia*).
 - 6) Seed coat may become fleshy and colored to attract animal dispersers.
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B. _____ (Conifers, Cycads, or Ginkgos?) once consisted of dozens of species living millions of years ago throughout North America and Northern Asia. Today, however, there is just one extant Chinese species, _____ (Table 2).

Table 2. Characteristics of Group B.

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- 1) Trees with a branched stem.
 - 2) Leaves deciduous; borne singly but on first year stems but clustered on lateral short shoots from older stems; simple, fan-shaped, with dichotomous venation.
 - 3) Sexual system dioecious.
 - 4) Pollen from microsporangia (male) borne in pendulous strobili clustered on short shoots.
 - 5) Ovules and megasporangia in clusters of 2 or 3 on pendulous peduncle from short shoots; mature seeds 1-2 per peduncle.
 - 6) Seeds coat becomes fleshy at maturity and stinks.
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C. _____ (Conifers, Cycads, or Ginkgos?) are the largest and most economically important group of gymnosperms. The group is defined by their ovulate cones (conifer means “cone-bearing”) and resin ducts (aka resin canals) that run through all parts. A more comprehensive list of characteristics is as follows in Table 3.

Table 3. Characteristics of Group C.

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- 1) Trees or shrubs with a branched stem.
 - 2) Resin ducts (resin canals) throughout.
 - 3) Leaves typically evergreen (some deciduous) and needle-shaped.
 - 4) Sexual system monoecious or dioecious.
 - 5) Pollen from microsporangia (male) borne in pendulous or erect strobili; strobili often in clusters.
 - 6) Seeds and megasporangia (female) borne in ovules borne on scales in cones (each scale subtended by a bract).
 - 7) Seed coat dry, papery, often winged for wind dispersal.
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II. Families to Know on Sight (no keying allowed for lab quizzes or final)

A. Cycads

1. Cycadaceae

Diagnostic Summary: Dioecious, evergreen trees (shrub-like when young) with unbranched stems and a terminal rosette of large, leathery, pinnate leaves. Leaflets with a midrib and no visible secondary veins. Pollen borne in stiff strobili from distal nodes. Seeds borne on loosely aggregated, elongate sporophylls from distal nodes.

2. Zamiaceae

Diagnostic Summary: Dioecious evergreen shrub-like plants with rosettes of large, leathery, pinnate leaves. Leaflets lacking a midrib and leaf venation dichotomous, Pollen born in stiff strobili from distal nodes. Seeds borne in strobili on short, peltate sporophylls.

B. Ginkgo

1. Ginkgoaceae

Diagnostic Summary: Dioecious, deciduous trees with fan-shaped leaves and dichotomous leaf venation, born singly on first-year stems, laterally in tufts on short shoots on older stems. Pollen borne in small, pendulous strobili tufted on short lateral shoots. Seeds born in pairs (or singly when one not fertilized) on pendulous, leafless peduncles tufted on short lateral shoots.

C. Conifers

1. Cupressaceae

Diagnostic Summary: Resinous, monoecious or dioecious trees or shrubs with needle-like or scale-like leaves (scale-like leaves opposite or whorled); bark often peely-fibrous; cones often round with peltate seed-scales with fused subtending bract, and >2 small, isolaterally winged, wind-dispersed seeds; seeds and cones smaller than in Pinaceae. *Juniperus* represents a particularly stark exception to cone morphology for this family since it resembles a berry at maturity.

2. Pinaceae

Diagnostic Summary: Resinous, monoecious trees or shrubs with needle-like leaves; cones elongate and larger than in Cupressaceae, with many spirally arranged, laminar scales, each scale bearing free of subtending bract and with just 2 medium to large, unilaterally winged seeds.

III. Genera to Know (you can write your own key to genera and use on lab final)

A. Cycadaceae – not in book

1. *Cycas* (trees & shrubs)

B. Zamiaceae – not in book

2. *Zamia* (trees & shrubs)

C. Ginkgoaceae – p. 106

3. *Ginkgo* (trees)

D. Taxaceae – p. 114

4. *Taxus* (shrubs & small trees)

E. Cupressaceae – p. 112

5. *Chamaecyparis* (included by some in *Cupressus sensu lato*) (shrubs & trees)

6. *Juniperus* (shrubs & trees)

7. *Thuja* (trees)

F. Pinaceae – p. 106

8. *Abies* (trees)

9. *Cedrus* (trees)

10. *Larix* (trees)

11. *Picea* (trees)

12. *Pinus* (shrubs & trees)

13. *Pseudotsuga* (trees)

14. *Tsuga* (tree)