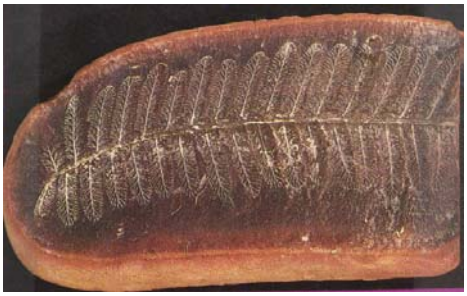
The Gymnosperms

The Gymnosperms include four Phyla of seed-dispersing vascular plants. The name, Gymnosperm means “naked seed” because Gymnosperms do not produce a tissue around the seed for protection and dispersal as Angiosperms do. In addition to the four extant phyla, there is one phylum comprised of three orders of extinct seed plants, including the Pteridospermales, the seed ferns.

Progymnospermophyta (Fossils Phylum)
Pteridospermales (The seed ferns)
Fossil imprints of seed fern leaves are abundant. Observe the demonstration fossil.



Cycadophyta (The Cycads)
There are 9 genera and about 100 species of Cycads, including *Zamia*, which is native to Florida, and a rather common house plant, *Cycas revoluta*, the sago palm. All Cycads are shrubs. Most are less than 2 meters tall and the largest is only 15 meters in height.

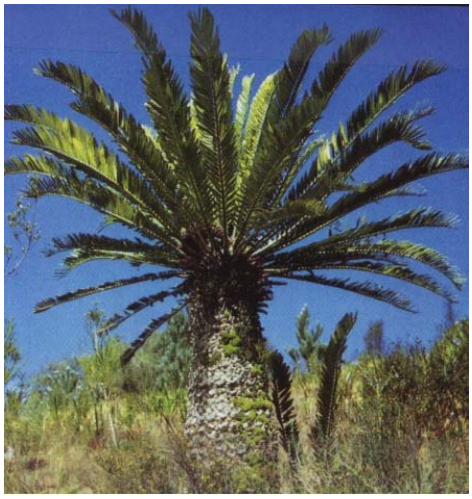
Cycads are found in tropical and subtropical regions. They were much more abundant in past eras than today. There is some evidence that seeds require animal dispersal, and the animals that fed on Cycads are no longer around to eat and then disperse seeds. Cycad seeds are difficult to germinate.

Vegetative characteristics of the Cycad sporophytes
Observe the Cycad in the greenhouse and the preserved Cycad strobili available.

Note the crown of long, leathery, pinnately compound leaves (Palm-like). The leaves form a spiral pattern around the short columnar unbranched stem. Most Cycads produce only a few leaves each year.

Check to see if any new leaves are opening. The Cycads have leaves with circinnate vernation as do the ferns.

Zamia



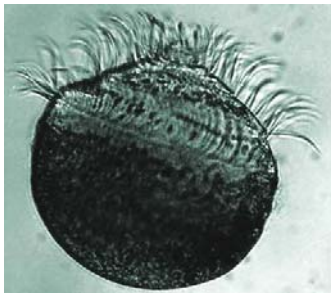
South African cycad

Reproduction in Cycads

All Cycads are dioecious. The very large male and female strobili are found on separate plants. The female strobilus may be a meter in length. Sporangia (called pollen sacs in the male) are produced on sporophylls in both female and male. Observe the strobili demonstration materials available. Both male and female sporangia retain the spores after meiosis and male and female gametophytes develop within the diploid sporangia on the sporophyte plants. The male gametophyte consists of a pollen grain that contains multiflagellated sperm. Mature pollen is released from the diploid strobilus and once pollen reaches a female gametophyte, retained in the megasporangium of its diploid plant, sperm must swim to the egg. The zygote develops into the seed, still protected by the previous generation diploid sporangial tissue as well as the surrounding female gametophyte tissues.

Male strobilus

Female strobilus



Cycad sperm

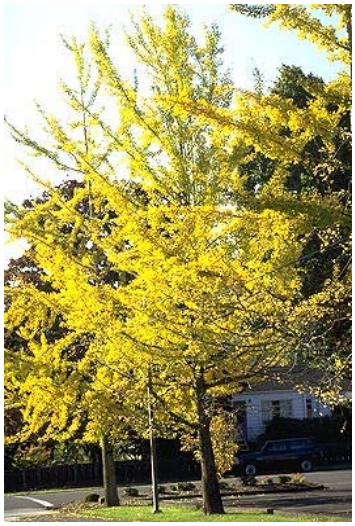
Ginkgophyta (Ginkgo or Maidenhair tree)
While fossil Ginkgoes are quite common, including in Washington state (we have a State Park named after Ginkgo) only *Ginkgo biloba.* survives today because it was preserved in Asian royal gardens for centuries.

Vegetative Features of the Gingko
The Ginkgo is a deciduous tree that grows to about 100' in height. There are two types of branches on Ginkgoes:

- Indeterminate branches →Long shoots
- Determinant branches→Spur shoots

The spur shoots contain clusters of leaves each year. The short shoots, or spur shoots are more common than the long shoots, so growth is slow and limited. The leaves of Ginkgo are fan-shaped, often with notch in center and pale green in color. Most are about 2" wide. They turn a vibrant gold in the autumn, and abscise around Halloween. The veins branch dichotomously, which is a unique leaf venation pattern. A Ginkgo can always be identified from its leaves.

Observe the Gingko tree available. Identify both long shoots and spur shoots. Observe the unique shape and venation pattern of the leaves.

Ginkgo biloba habit and fall color

Ginkgo biloba leaves

Ginkgo mature seeds
Note the spur shoot at the bottom

Reproduction in Ginkgo
The Ginkgo is a dioecious tree. Both male and female "strobili" are reduced in number of sporangia and in size and in the number of sporangia produced.

Observe the demonstration materials available showing the male strobili, female paired ovules and seeds. The male "strobili" are formed from short pendant microsporophylls, each of which has microsporangia. The haploid microspores are retained within the sporangia and the male gametophyte consists of a pollen grain containing multiflagellated sperm. Mature pollen is ultimately released from the diploid sporangia. The female reproductive structure consists of 2 ovules (which is what the megasporangia are called in the seed plants) each of which contain archegonia. Pollen delivers the sperm to the female ovules, but sperm, once released from the pollen grain (the male or microgametophyte) must swim to the egg contained within the archegonium of the ovule.

After fertilization, Gingko seeds grow to about cherry-sized, and have a fleshy seed coat that is easily confused with a fruit of a flowering plant. The fleshy outer seed coat decomposes at maturity.

The seeds are edible and are sold as "white nuts" in many Asian markets.


Gingko ovules


Ginkgo male strobili

Gingko leaf extract is marketed as an herbal "pick-me-up". It may help minimize migraine symptoms, and a recent rigorous study indicated that Ginkgo may provide some help for memory retention in the elderly. Ginkgo extract acts in a manner similar to aspirin or other blood thinning medications, and should not be used by those who take such medications.

The Gnetophyta

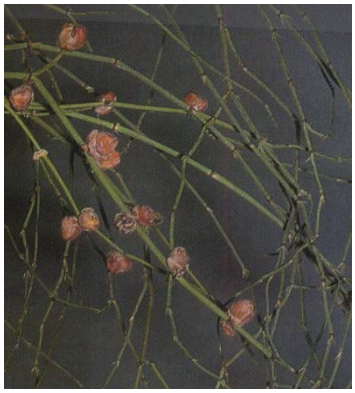
The members of the Gnetophyta are a "weird" group of plants. They are perhaps the youngest of the vascular plants; the first fossils postdate flowering plants, being only about 50 million years old. They have some characteristics in common with the other gymnosperms, and some with the angiosperms, notably the presence of vessels in their xylem.

There are three representatives in the Gnetophyta

Ephedra

Ephedra is a shrub of American SW Desert that sort of resembles a dry Scot's broom with no leaves. It is commonly called Mormon Tea. It is a natural source of ephedrine, a mimic of epinephrine and is widely marketed for a number of uses. One should use extreme caution when using herbal *Ephedra* products. Deaths have been attributed to its use.

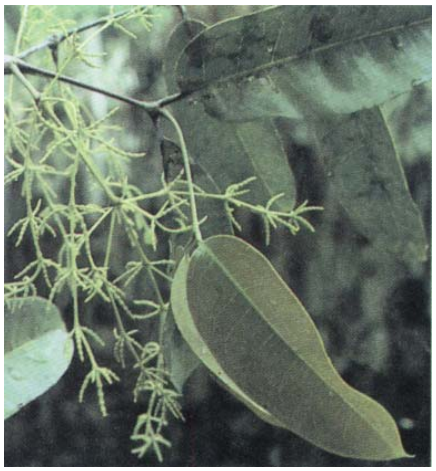
Ephedra male strobili



Female

Gnetum

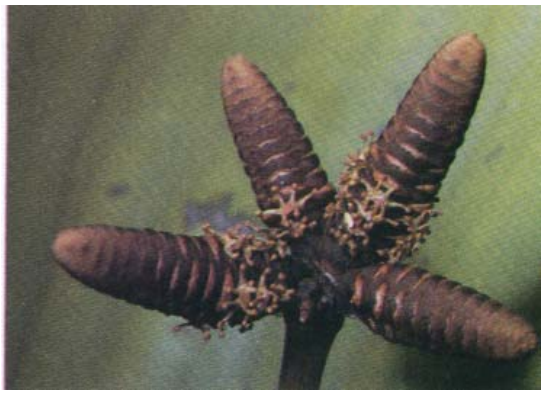
Members of the genus, *Gnetum*, are vines or shrubby trees of the wet tropics of Indonesia, South America and Africa.



Welwitschia

Welwitschia is restricted to the Namib desert of Namibia and adjacent regions of southwestern Africa between 14° – 35° S Latitude from the western coast to 100 miles inland in areas of about 2" of annual precipitation. *Welwitschia* has two large, basal strap-shaped leaves that grow from a basal stem and produces a deep taproot that grows down toward the water table. The leaves become shredded at the tips with time and the plant appears to be a rosette of many leaves.

Welwitschia mirabilis



Male Strobilus

Female

Coniferophyta
The conifers are the most diverse and abundant gymnosperms. Conifers comprise the predominant vegetation of the Taiga biome, a northern hemisphere biome that covers more land mass than any other biome except deserts. Taiga is characterized by cold, long winters, and short, dry summers. The conifer shape and leaf structure are ideally suited to these conditions. The world's tallest and oldest plants are conifers. The largest single volume stem is also a conifer. Conifers include pine, fir, spruce, hemlock, yew, juniper, cypress, cedar, larch, redwood and many others. We have about 18-20 native conifer species in Washington and numerous ornamental conifers are used in landscaping. The conifers are economically very important for the wood products and paper industries.

All conifers have secondary growth and are either trees, or in a few cases, shrubs. Conifers are heterosporous and monoecious; male and female sporangia are borne on the same plant but in separate strobili called cones.

Look at the various demonstration conifer materials available. The genera of native conifers can be readily distinguished from each other by their mature female cones and by their branches and needles. Some conifers, such as cedars and junipers, produce scale-like needles. Most conifers have one needle per node. Pines, larches and some cedars have from two to several needles in a fascicle (cluster or bunch). Some conifer species needles attach to the stem with a little "peg". Others do not have the peg and leave distinctive leaf scars on the stem when they dehisce. All these features are used in identification


Juniper


Pine


Giant Sequoia


Fraser Fir

Cones
The female megastrobilus or cone contains ovules (archegonia-containing structures) typically borne on and protected by hardened cone scales. A bract subtends each cone scale. The female cone scales are not always hardened. In juniper, the cone is often called a juniper berry. Yews do not produce a hardened cone, either. The seed is surrounded by a bright fleshy aril. The cone scales are spirally arranged along the megastrobilus to form the familiar female cone.

Each female cone scale has two ovules, or megasporangia. The ovule is a complex structure and is involved not just in meiosis to form the megaspores, but also in female gametophyte development and in seed development of the next generation. As in the other seed plants, the female gametophyte stage is totally dependent upon, and retained by, the sporophyte. Moreover, the next generation embryo sporophyte develops within the female gametophyte located in the previous generation's sporophyte.

The male strobili, or cones, are formed by spirally arranged microsporophylls along the strobilus axis; each microsporophyll of the male strobilus has two microsporangia.

Locate the male strobili (male cones) and the female pollination cones, fertilization cones and mature cones on the demonstration materials.


Male strobili

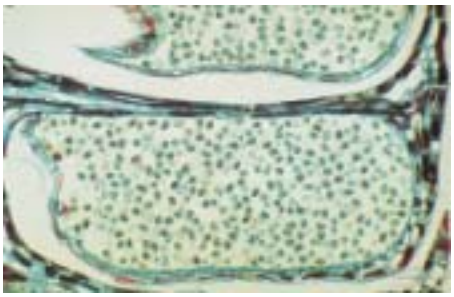

Pollination cones

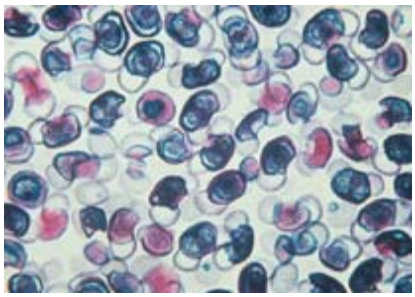

Fertilization cones


Mature cone

Gametophyte Stage
The gametophyte stage is greatly reduced and retained within the male and female sporangia (often called pollen sac and ovule for some reason). Male gametophytes form pollen grains. The mature pollen grain consists of four cells: two prothallial cells, a generative cell and a tube cell, which grows the pollen tube through which the sperm migrates to the egg once pollen is successfully delivered to the female gametophyte. Sperm is formed from the generative cell. Many conifers produce distinctive winged pollen.

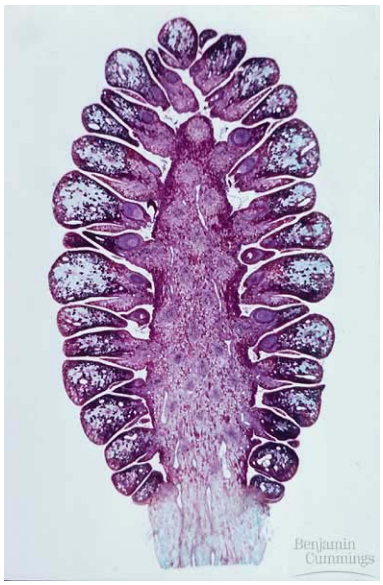
Observe the prepared slide of pine pollen. You may want to make a wet mount of fresh pollen, too.


Microsporangium

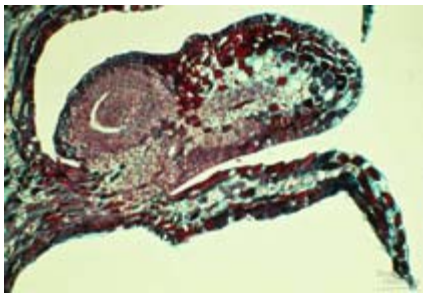


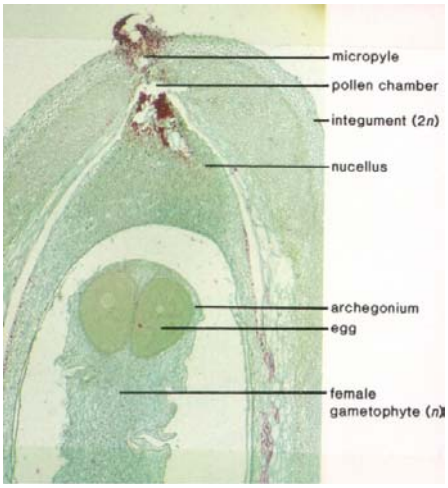
Pine pollen

The female gametophyte, which develops from the megaspore, contains two or more archegonia. The surrounding megasporangial tissue is modified into the integument layers, which protect the gametophyte and eventually form the seed coat, and the nucellus layers from which the gametophyte obtains nutrients. In pines, the female gametophyte takes one year to develop after pollination. The pollen grain germinates at pollination and grows the pollen tube, but the generative cell does not form sperm until the female gametophyte is mature. The immature female cone (which contains the megasporangia on its cone scales) is called the pollination cone. When the female gametophyte is mature, the cone is referred to as the fertilization cone. Cones with mature seeds are called mature cones. Seeds obtain nutrients from nutrient tissue within the female gametophyte (which got its nutrients from the sporophyte.



Ovulate cone





Megasporangium

It may take up to two years after pollination for a seed to mature. Most seeds are dispersed by wind; however, squirrels and other small animals disperse many seeds when they collect cones and seeds and stash them away for winter food supplies. Conifer seeds have many cotyledons. This is visible when they germinate.

Pine embryo

Pine seed

Pine seedling

If you wish, prepared slides of microsporangia and pollen development are available, as are prepared slides of female sporangia, ovules and archegonia. Familiarize yourself with the pine life history. Recall that anatomical features of conifer wood and needles were studied earlier in the term.

Pine Life History