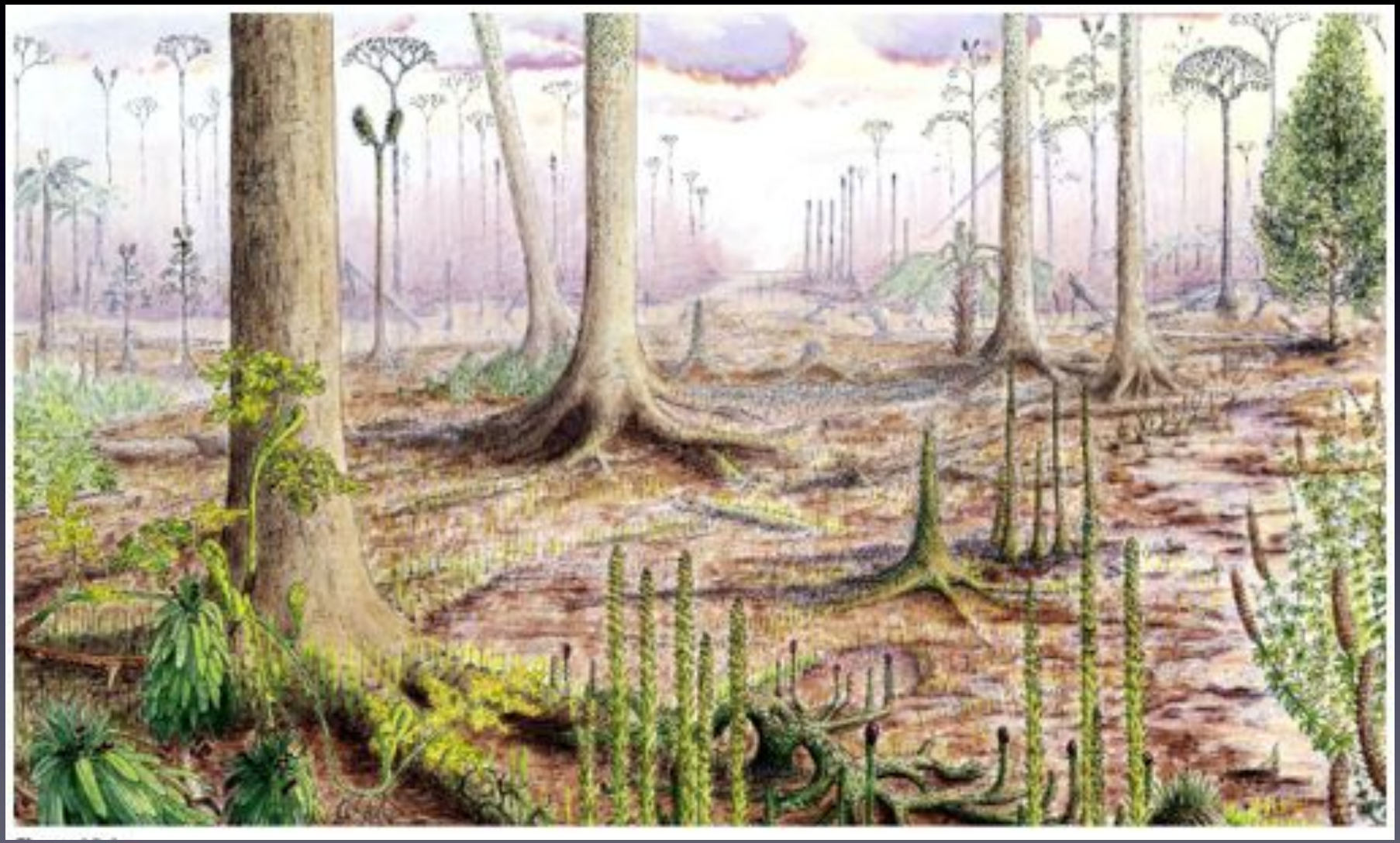
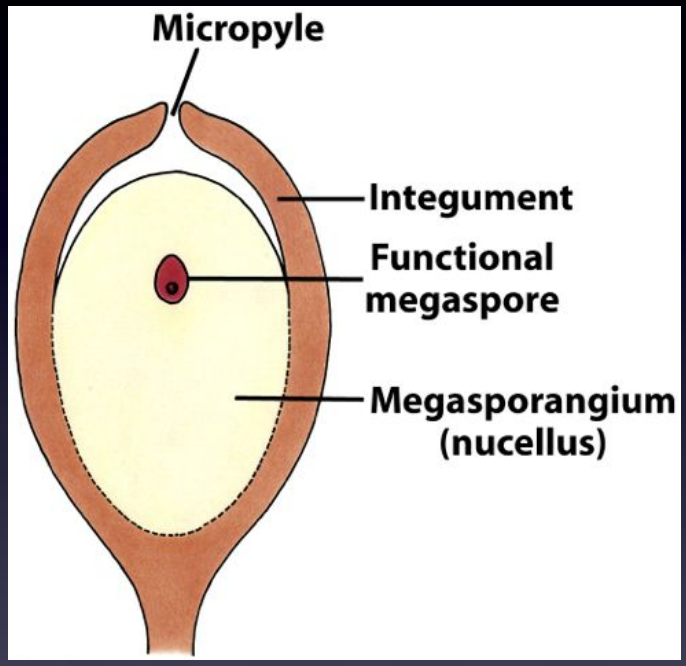
GYMNOSPERMS

With a great survival value, the seed plants became dominant
The seed coat protects the embryo and the food storage, critical for germination and establishment of the new plant on an inhospitable land



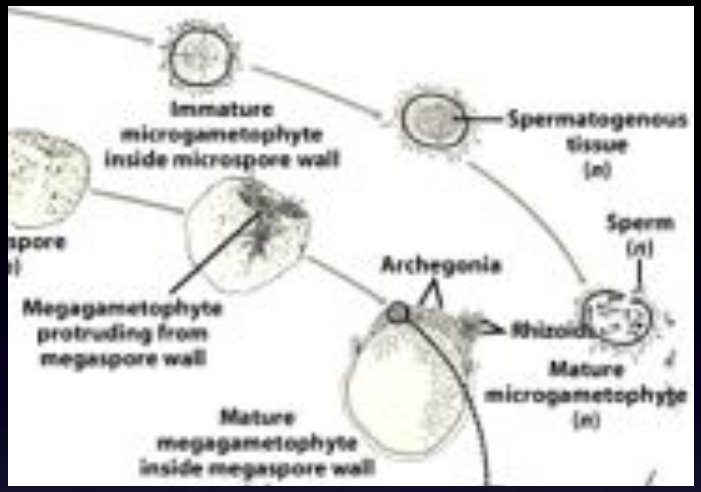
EVOLUTION OF THE SEED

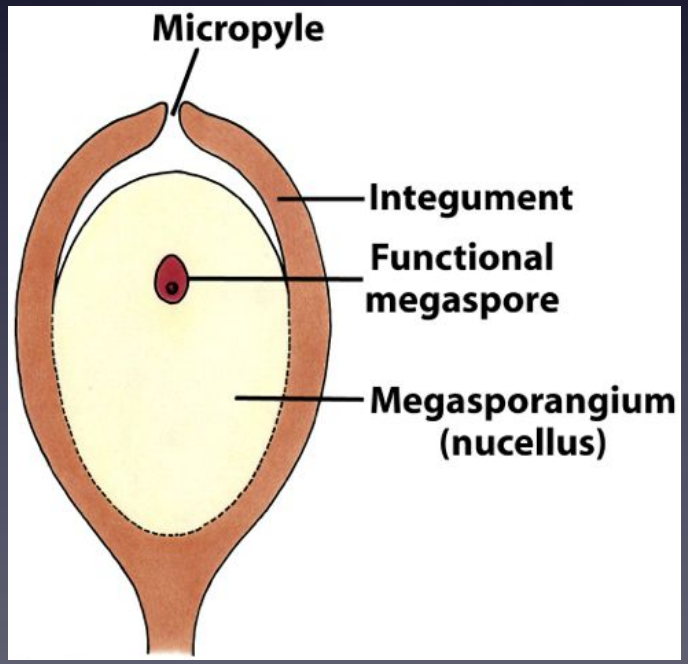
- All seed plants are heterosporous
- Microspores with microgametophytes
- Megaspores with megagametophytes
- A seed is an extreme case of heterospory that has been modified to form an ovule (the structure that develops into a seed)
- A seed is a mature ovule containing an embryo
- The immature ovule consists of a megasporangium surrounded by one or two additional layers of tissue, the integuments



Events leading to the evolution of an ovule:

1. Retention of the megaspores within the megasporangium which is fleshy and called the nucellus
2. Reduction of the number of megaspores mother cells in each megasporangium to one
3. Survival of only one of the four megaspores
4. Formation of a megagametophyte inside the single functional megaspore (endosporic)
5. Development of the embryo within the gametophyte
6. Formation of an integument that completely envelops the megaspornagium, except for an opening or micropyle
7. Modification of the apex of the megasporangium to receive microspores or pollen grains





A seed consists of an embryo, stored food, and a seed coat

- In modern seed plants the ovule consists of a nucellus enveloped by one or two integuments with a micropyle
- In gymnosperms, the nucellus contains a megagametophyte composed of nutritive tissue and archegonia
- After fertilization, the integuments become the seed coat, and the seed is formed

There are five phyla of seed plants with living representatives

Seed plants appeared 365 mya in the Devonian

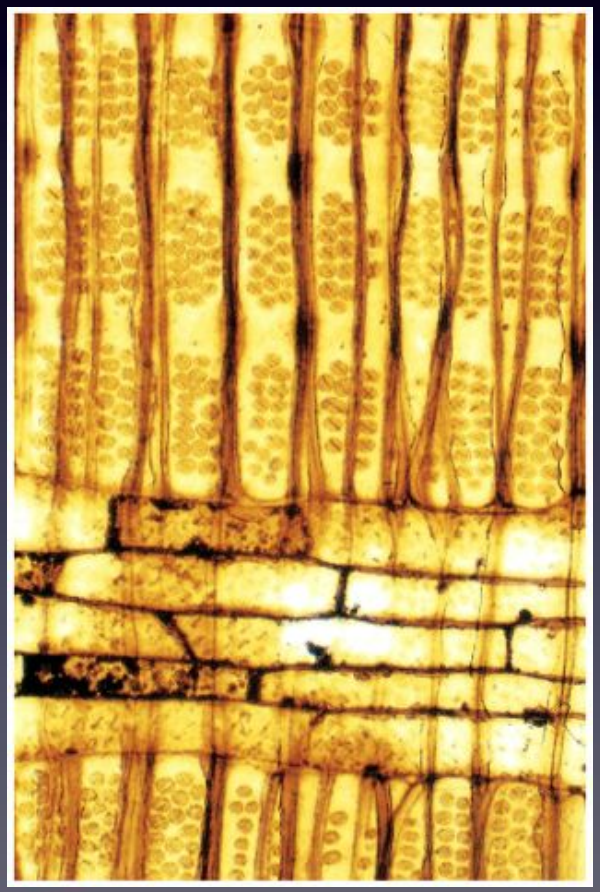
1. Cycadophyta
2. Ginkgophyta
3. Coniferophyta
4. Gnetophyta

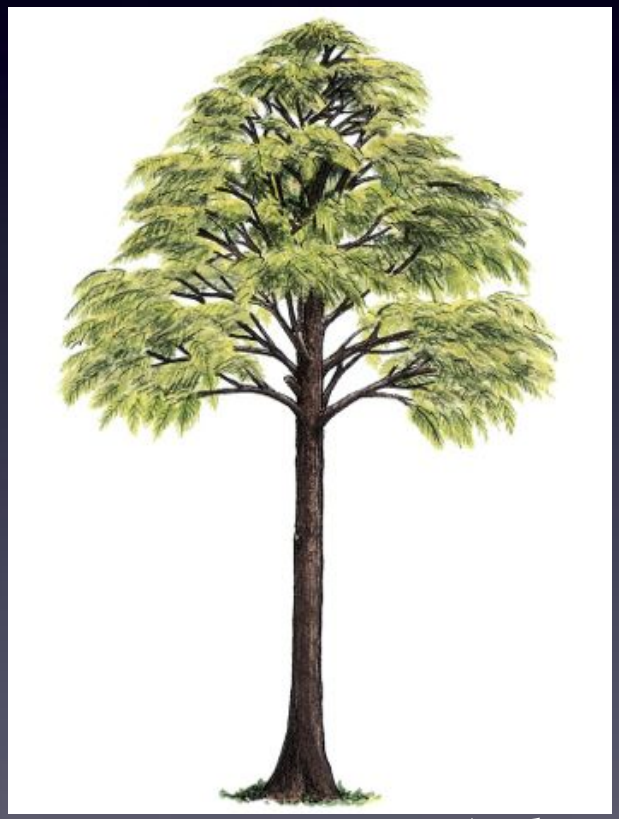
} Gymnosperms, 840 spp

5. Anthophyta, angiosperms or flowering plants, 300,000 spp

Progymnosperms

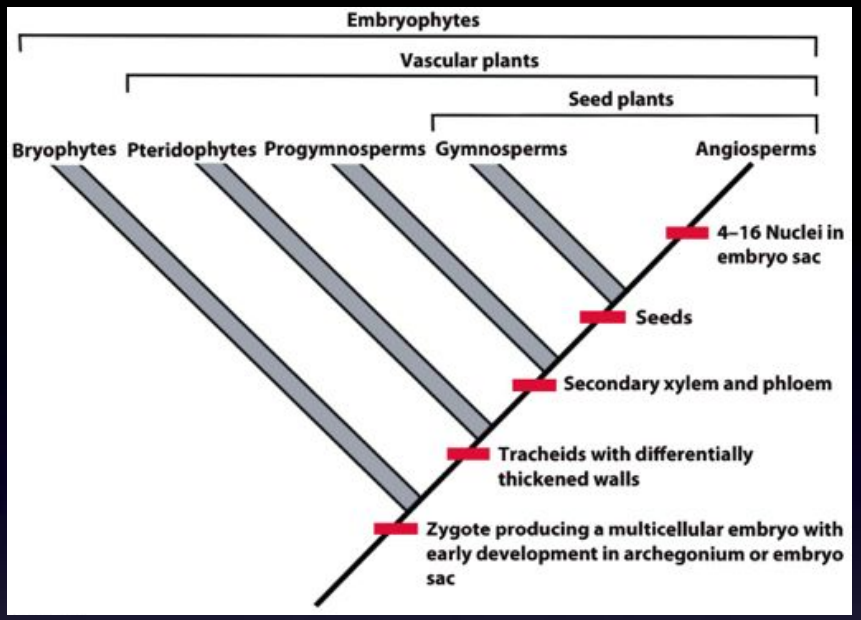
- Appeared during the late Paleozoic
- Intermediate between Trimerophytes and seed plants
- Dispersed spores and secondary xylem
- Bifacial vascular cambium: producing 2ary xylem (internally) and 2ary phloem (externally)





Archaeopteris

LIVING GYMNOSPERMS



Four phyla

1. Cycadophyta or cycads
2. Ginkgophyta or maidenhair tree or ginkgo
3. Gnetophyta or gnetophytes
4. Coniferophyta or conifers

•Gymnosperms means naked seed, the ovules and seeds are exposed on the surface of sporophylls and analogous structures

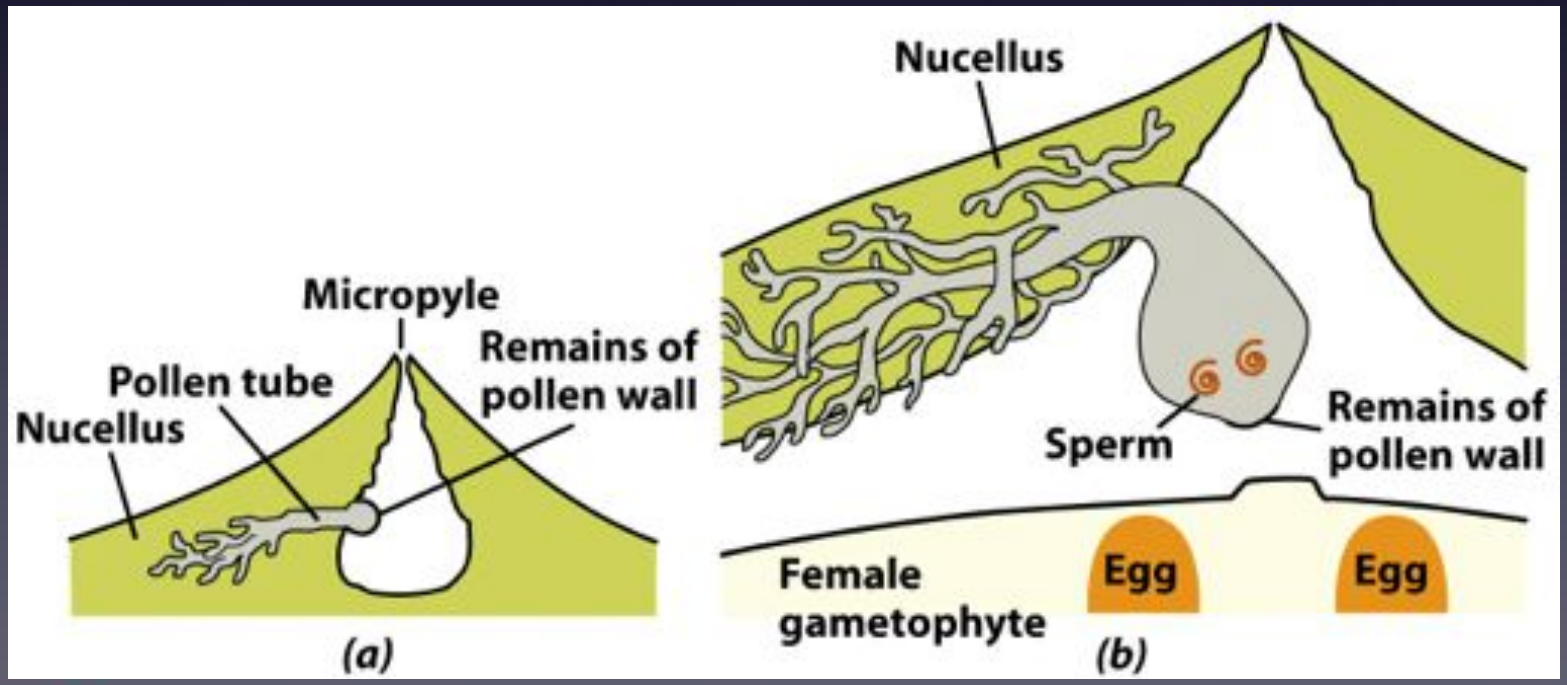
•Their phylogenetic relationships are unclear, but they seem to form a monophyletic group with a closer relationship between gnetophytes and conifers

In the gymnosperms, the microgametophytes (male gametophytes) develop as pollen grains

- Megagametophytes produce several archegonia thus several embryos may develop within a single ovule (polyembryony)
- In gymnosperms water is not required for fertilization
- The male gametophyte or microgametophyte (pollen grain) is transferred by the wind (pollination)
- After pollination the endosporic microgametophyte produces a tubular outgrowth, the pollen tube
- Microgametophytes do not form antheridia

•In conifers and gnetophytes the sperm are nonmotile and the pollen tubes convey the sperm directly to the archegonia

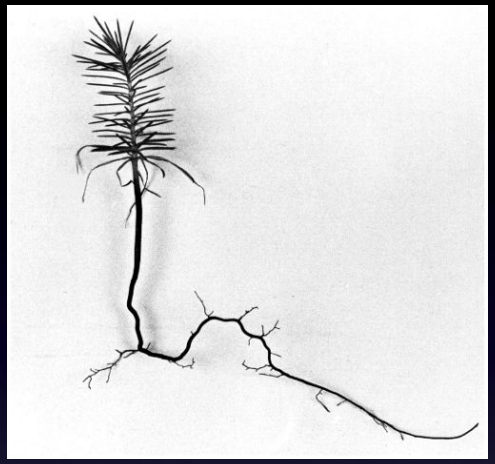
•In cycads and ginkgo the microgametophytes produce pollen tubes that grow in the tissue of the nucellus absorbing nutrients
•Eventually the pollen tube bursts over the archegonium releasing the multiflagellated swimming sperm cells



PHYLUM CONIFEROPHYTA

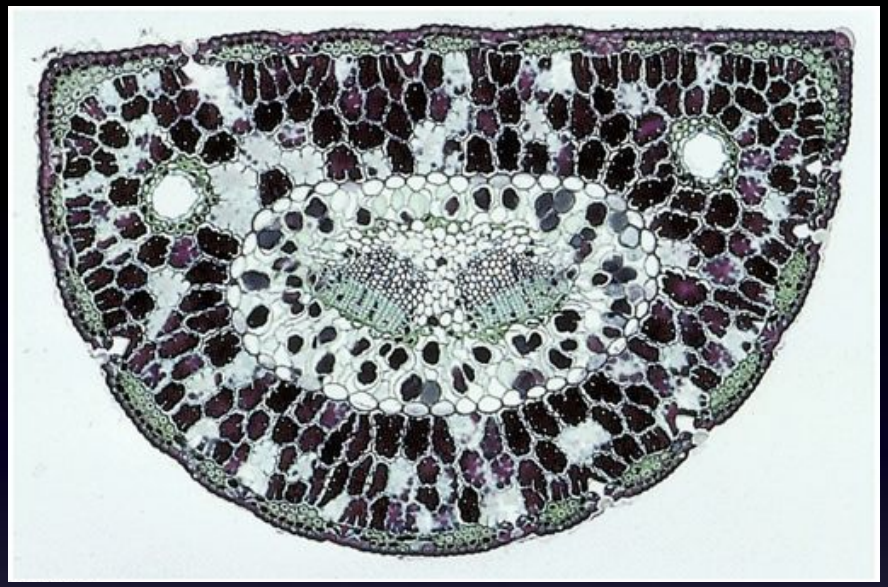
- The most numerous, most widespread, and more ecologically important gymnosperms
- 70 genera and 630 spp
- Tallest vascular plant redwood *Sequoia sempervirens* from California is a conifer
- Conifers include pines, firs, and spruces, are of great commercial value
- Many of their present features may represents adaptations to past dry and cold periods

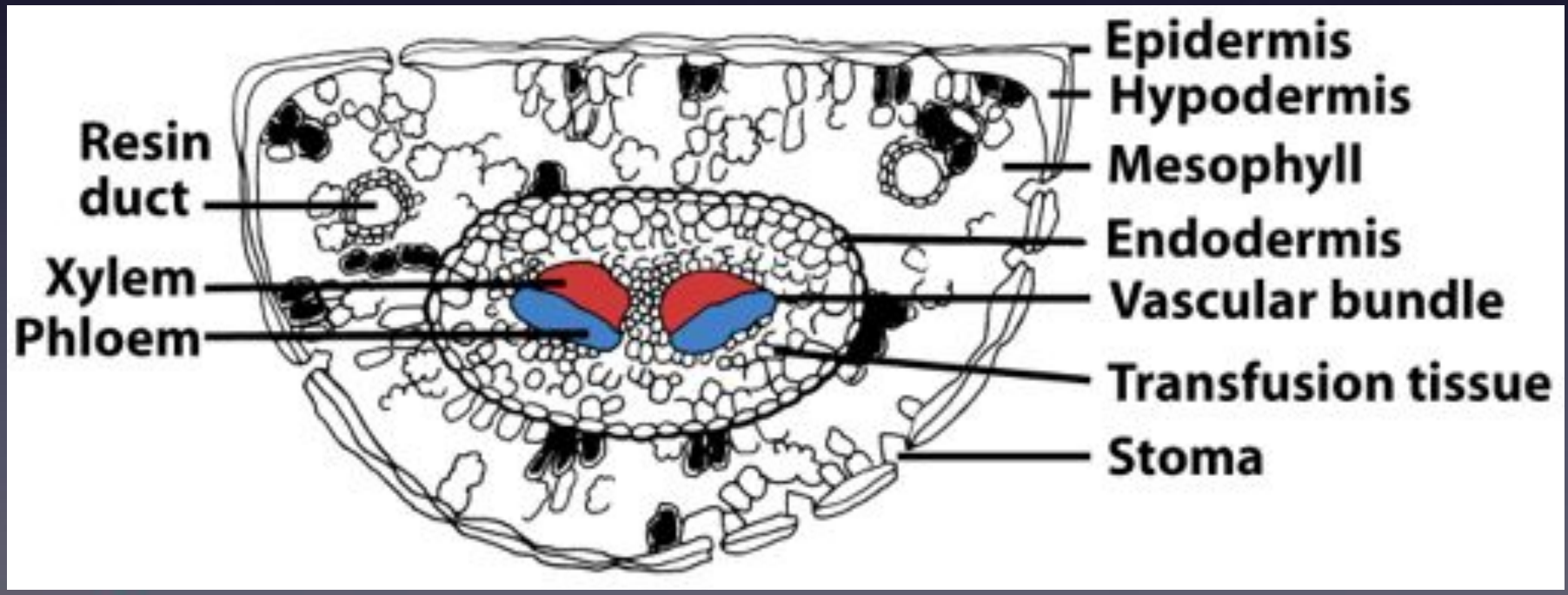
Pines are conifers with a unique leaf arrangements



- The pines (*Pinus*) consists of 90 spp
- First leaves are needlelike and arranged spirally
- After a year or two the leaves are produced in bundles or fascicles (1-8)
- Fascicles are short shoots wrapped by small scalelike leaves
- A short shoot is a determinate (limited in growth) branch, sometimes may produce indeterminate growth

•Leaves are adapted to grow in xeric conditions: thick cuticle, thick hypodermis, stomata sunk, mesophyll with wall ridges projected into the cells, resin ducts, 1-2 vascular bundles surrounded with transfusion tissue, and endodermis



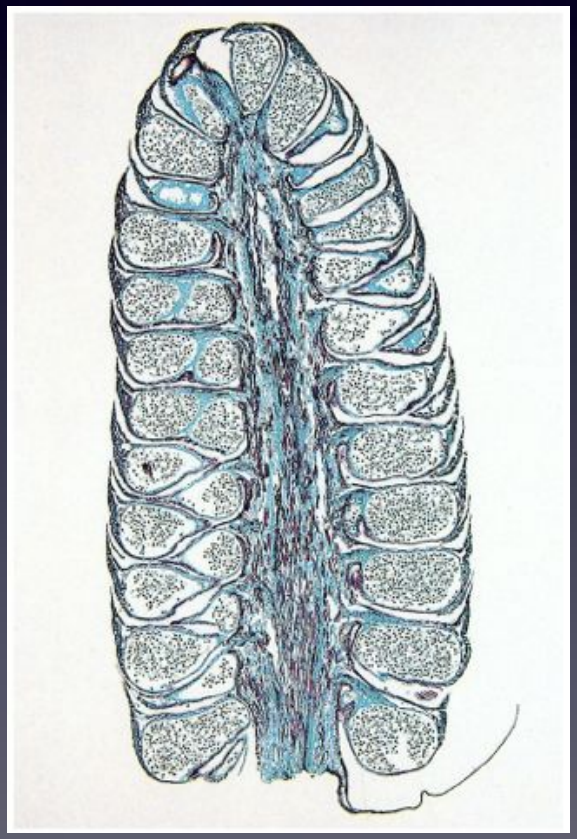


The pine life cycle extends over a period of two years

•Microsporangia and megasporangia in pines are borne in separate cones or strobili on the same tree

•Microsporangiate (pollen-producing) cones are found on the lower branches and are small

•Microsporophylls are spirally arranged, each with two microsporangia



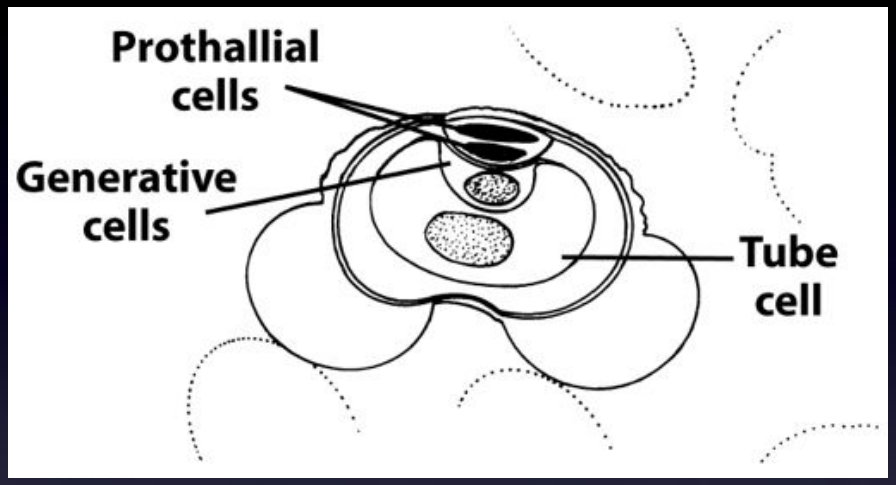
•A microsporangium contains many microsporocytes or microspore mother cells

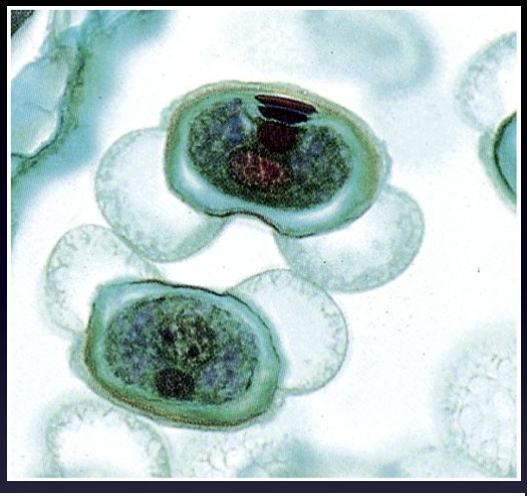
•In early spring the microsporocyte will produce by meiosis four haploid microspores

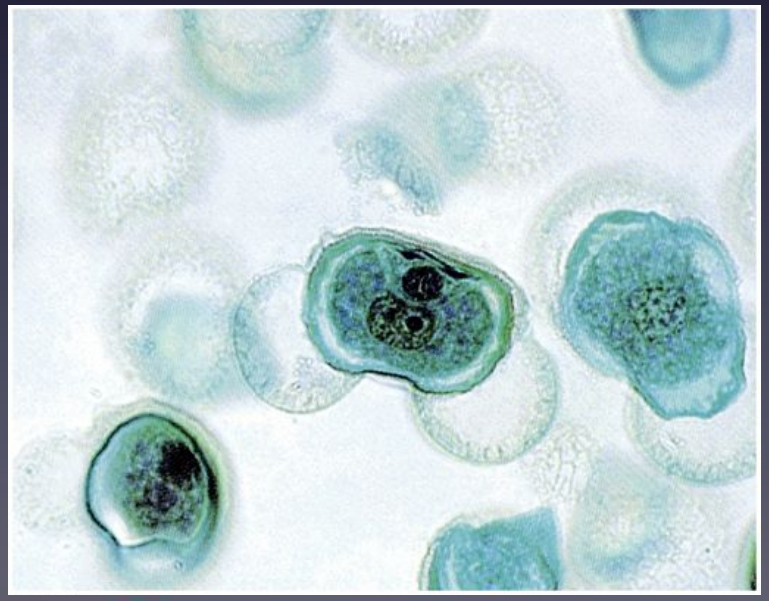
•Each microspore develops into a winged pollen grain

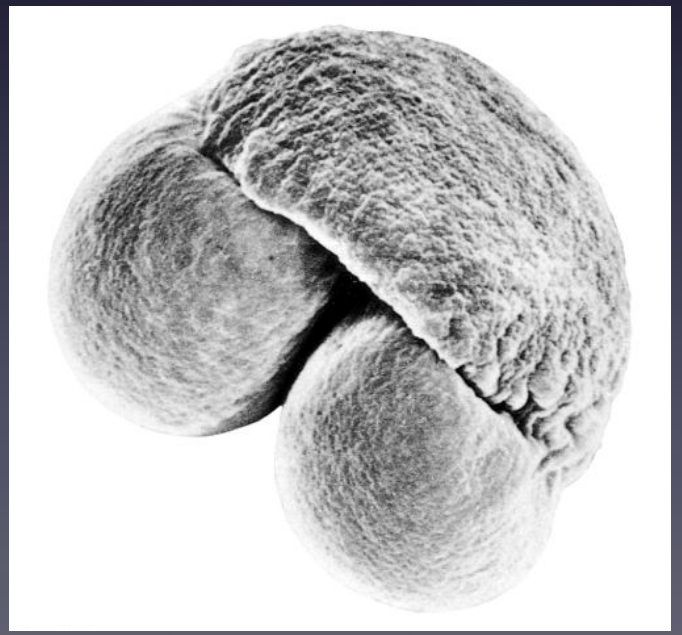
•Each pollen grain consists of four cells: two prothallial cells, a generative cell, and a tube cell

•This is the immature four-celled microgametophyte released as pollen in huge amounts and carried away by wind

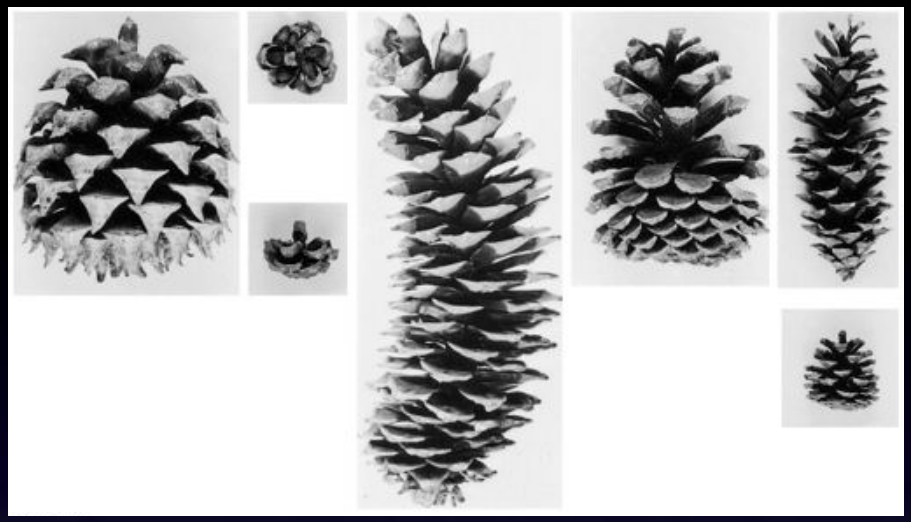


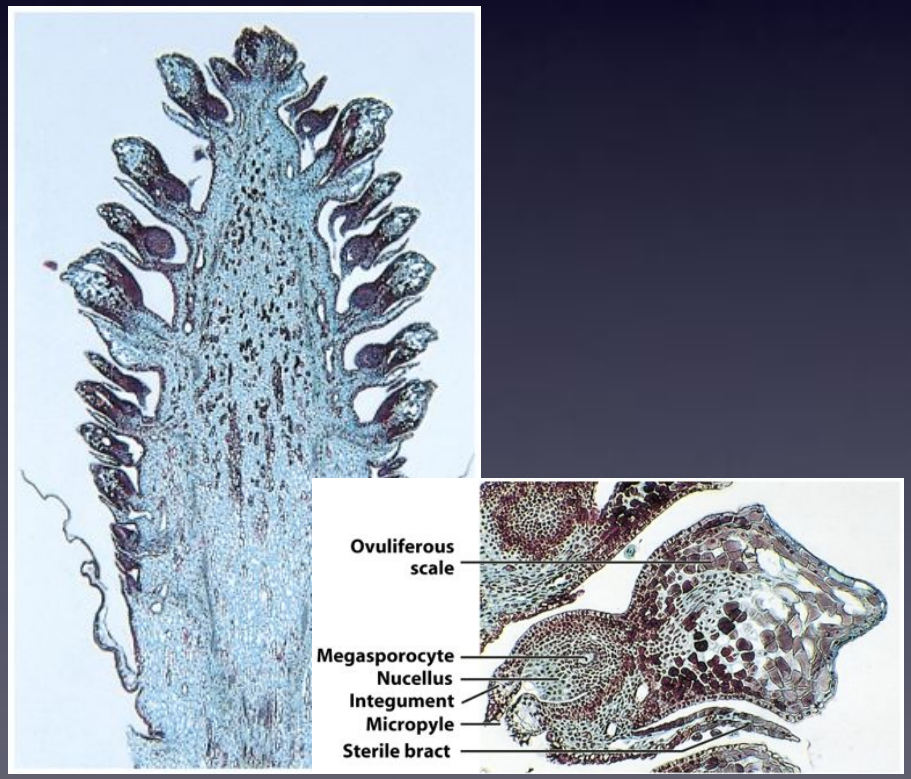




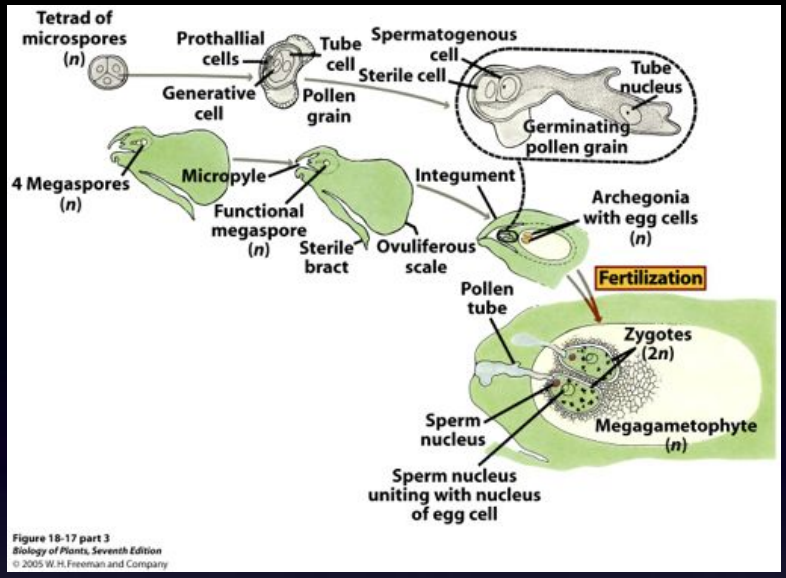


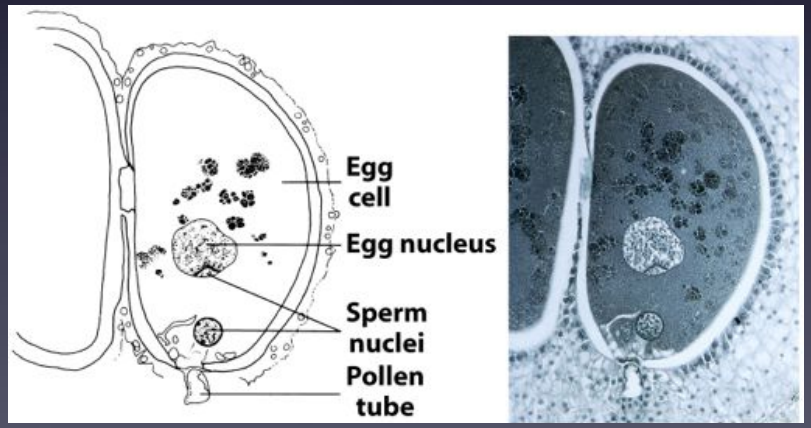
- Megasporangiate cones or ovulate cones, are found on the upper branches
- Ovulate cones are larger and complex
- The ovuliferous scales (cone scales) are entire modified determinate branch systems known as seed-scale complexes
- Each complex consists of the ovuliferous scales (two ovules) and a subtending sterile bract
- Each ovule consists of a multicellular nucellus (the megasporangium) surrounded by a massive integument with the micropyle
- Each megasporangium contains a single megasporocyte or megaspore mother cell
- By meiosis this gives rise to four megaspores (only one is functional)



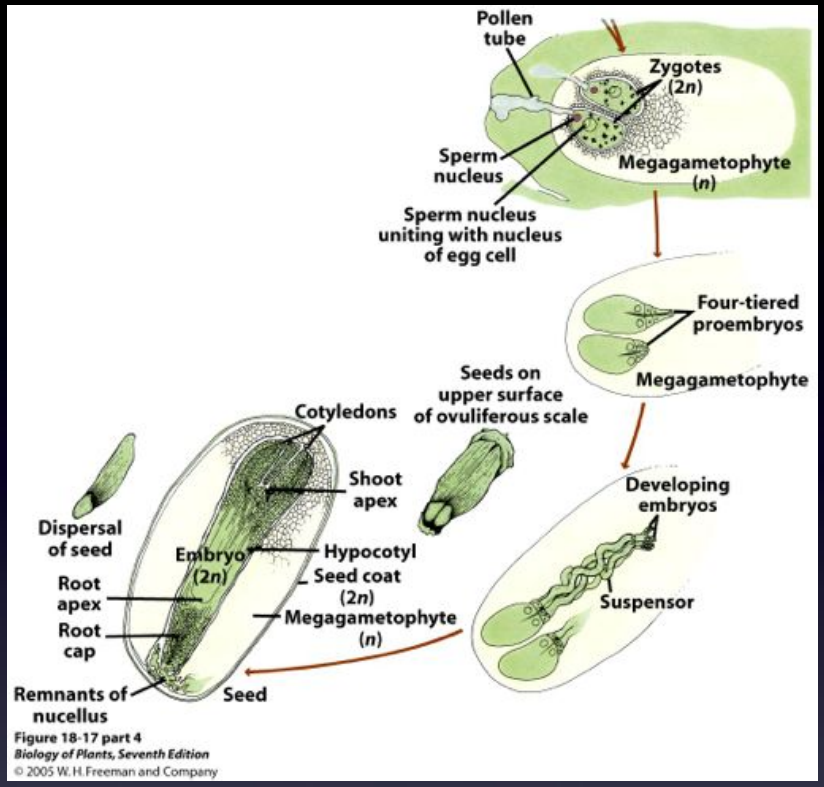


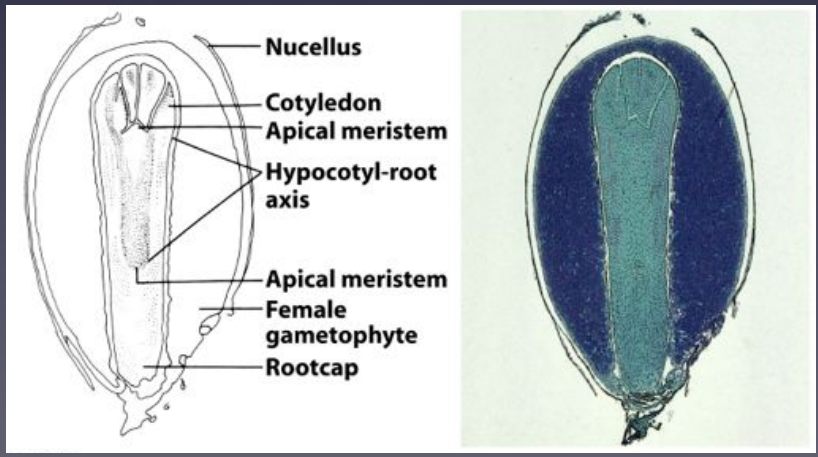
•Pollination occurs in spring
•Pollination drops exuded form the micropyle trap pollen grains
•When pollination drops contract they carry the pollen grains through the micropylar canal and into contact with the nucellus
•After pollination the scales grow together and protect the ovules
•Pollen grain germinates and form a pollen tube
•Six months after pollination the megaspore starts forming the megagametophyte
•Fifteen months after pollination the archegonia are formed
•At this point the pollen grain has germinated into the pollen tube that has reached the megagametophyte through the nucellus
•The generative cell forms two cells, a sterile cell and a spermatogenous cell
•The spermatogenous cell will divide producing two sperm (no antheridia are formed)



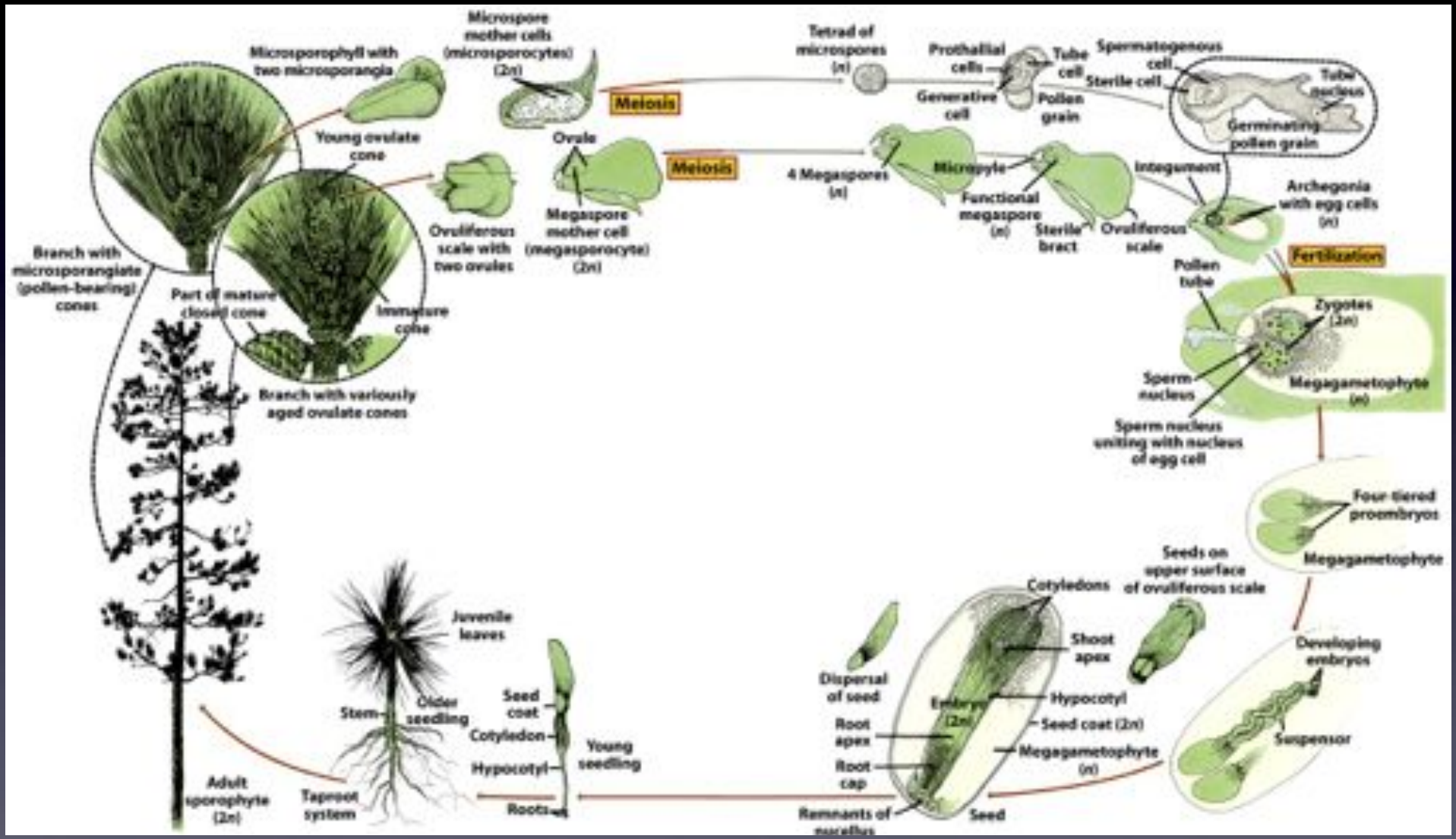


- Some 15 months after pollination the pollen tube reaches the egg cell (fertilization)
- Only one embryo develops
- Four tiers of cells are produced
- The tier farthest from the micropylar end begins to form an embryo
- The other cells become the suspensor cells
- The integument develops into a seed coat
- The seed is a combination of two different diploid sporophytic generations (the seed coat and the embryo) and one haploid gametophytic generation (food reserve)
- The embryo consists of a hypocotyl-root axis, with a rootcap on the apical meristem at one end, and the apical meristem with several cotyledons or seed leaves at the other





Life cycle of a pine



Other important conifers occur throughout the world

Firs, *Abies*

Larches, *Larix*
Spruces, *Picea*

Hemlocks, *Tsuga*

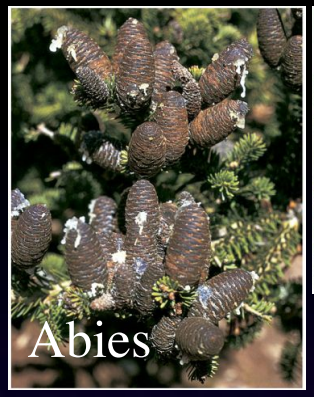
Douglas firs, *Pseudotsuga*

Cypresses, *Cupressus*

Junipers, *Junipers*

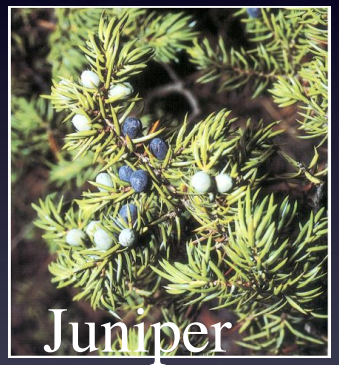
In the yews family (Taxaceae) a solitary ovule is borne in a reduced cone and surrounded by a fleshy cuplike structure called the aril

Redwood family, Taxodiaceae, with the bald cypress, *Taxodium*

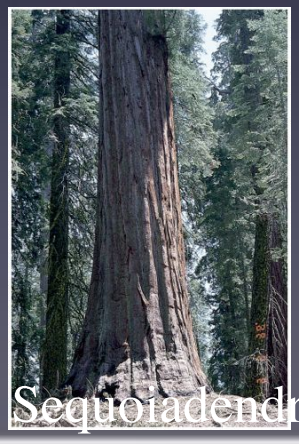

Abies

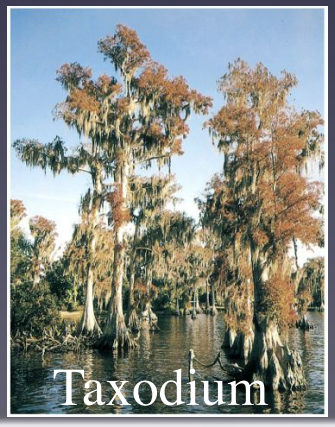

Larix


Cupressus


Juniper


Taxus


Sequoiadendron

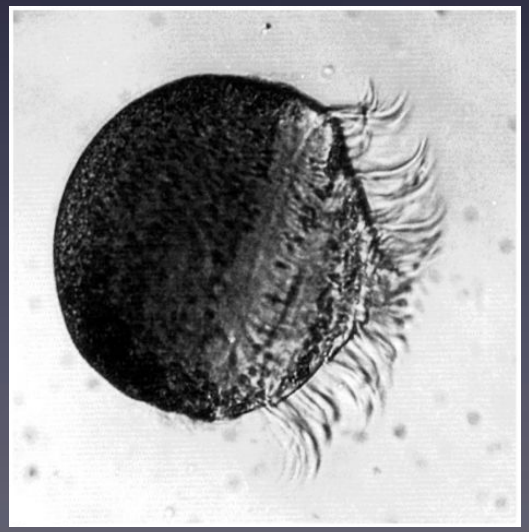

Taxodium

OTHER LIVING GYMNOSPERMS PHYLA: CYCADOPHYTA, GINKGOPHYTA, AND GNETOPHYTA

Cycads belong to the Phylum Cycadophyta

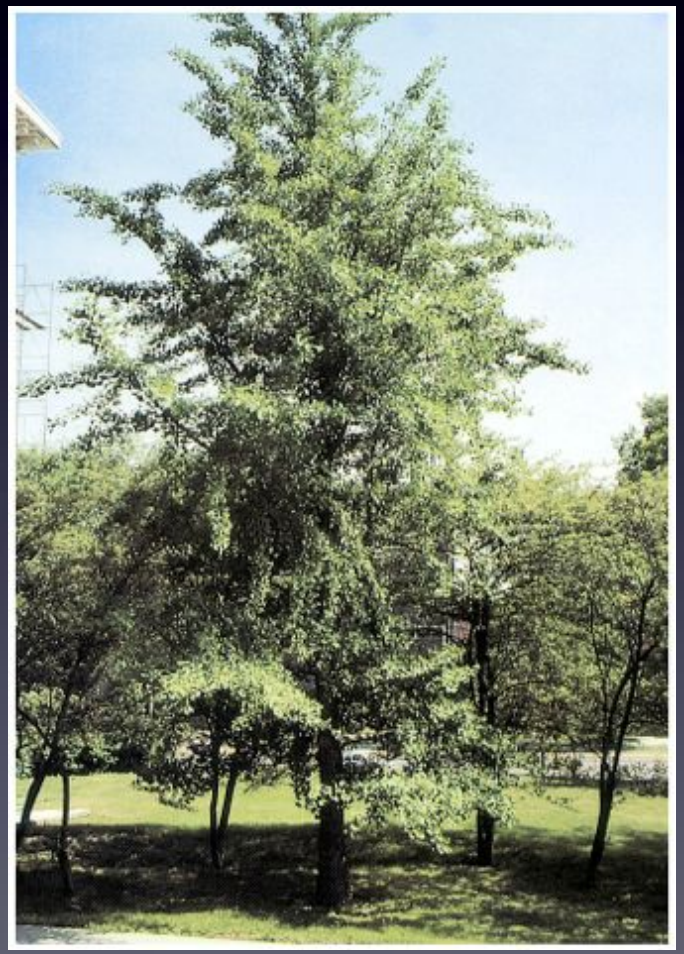
- Cycads are palm-like plants found in tropical and subtropical regions
- Age of Cycads and dinosaurs: 250 mya during the Permian period
- Living cycads: 11 genera and 140 spp
- *Zamia pumila* from FL is the only US native

- Cycads are large plants
- Distinct trunk with leaves at the top (sago palms)
- With vascular cambium
- Often highly toxic with neurotoxins and cacinogenic compounds
- Associated with cyanobacteria
- Pollen and ovulate cones on different plants
- Free multiflagellated sperm
- Pollination by insects (beetles)



Ginkgo biloba is the only living member of the Phylum Ginkgophyta

- The maidenhair tree has fan-shaped leaves with dichotomous venation
- Tree with 30 m or more
- *Ginkgo* is deciduous
- Resistant to air pollution
- Ovules and microsporangia on different individuals
- Ovules are borne in pairs
- Seeds are covered by fleshy seed coats (rancid odor)
- Like cycads, ginkgos form multiflagellated sperm



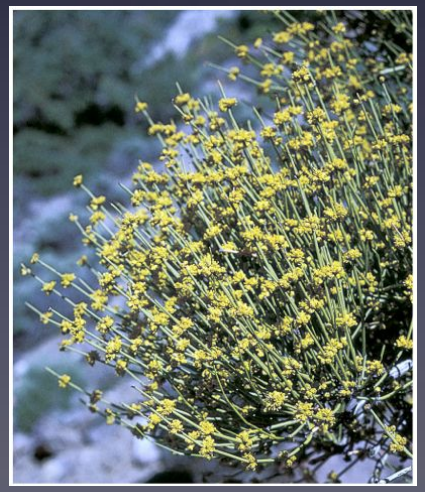
The Phylum Gnetophyta contains members with angiosperm-like features

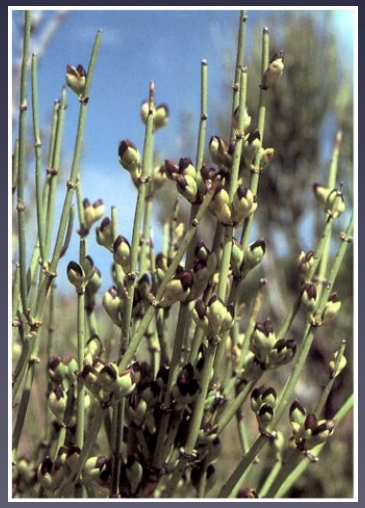
•Three living genera and 70 spp: *Gnetum, Ephedra* and *Welwitschia*

•*Gnetum* form trees and climbing vines in moist tropics

•*Ephedra* are shrubs with jointed stems in arid regions

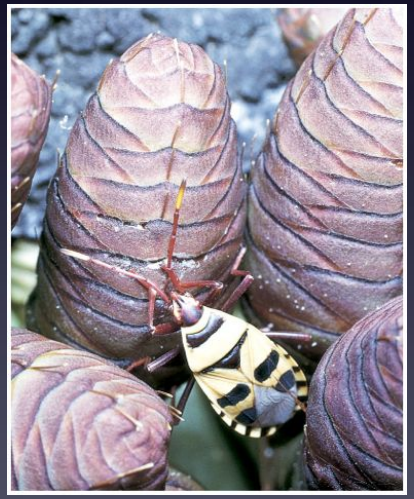
•*Welwitschia* is found buried in sandy soil with a woody concave disk and two strap-shaped leaves on coastal deserts of SW Africa





Gnetophytes are closely related to angiosperms (flowering plants) in many features:

- Similarity of strobili to inflorescences
- Similar vessels in their xylem
- Lack of archegonia



Pollination occurs by wind and insects, they also produce nectar!

SUMMARY

- A seed develops from an ovule
- Seed plants most likely evolved from the progymnosperms
- All gymnosperms have the same basic life cycle
- Pollination and pollen tube formation eliminate the need for water for the sperm to reach the egg
- There are four phyla of gymnosperms with living representatives