

# Introduction to Botany. Lecture 36

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December 6, 2013



## 1 Questions and answers

## 2 Seed plants

- Diversity of seed plants
- Conifers
- Gnetophytes
- Flowering plants



## 1 Questions and answers

## 2 Seed plants

- Diversity of seed plants
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# Previous final question: the answer

What is a seed?



# Previous final question: the answer

What is a seed?

- Chimeric organ: 3 genotypes
- Mother sporophyte ( $2n$ ) + female gametophyte ( $n$ ) + embryo ( $2n$ )
- Seed coat + endosperm<sub>1,2</sub> + embryo



# Seed plants

## Diversity of seed plants



# Spermatophyta classes

- **Ginkgoopsida**, ginkgo class
- **Cycadopsida**, cycads
- **Pinopsida**, conifers
- **Gnetopsida**, gnetophytes or chlamydosperms
- **Angiospermae**, or Magnoliopsida, flowering plants

*Italicized text below is not necessary to remember*



# Ginkgoopsida

- *Smallest class, only one species (!), Chinese tree Ginkgo biloba which became extinct several thousand years ago but saved as a "church tree".*
- *Distinctive triangle-shaped leaves with dichotomous venation*
- *Ovules are solitary or paired; microsporangia are in catkin-like structures; has sexual chromosomes (!)*
- *Pollen grains produce two multi-flagellate spermatozoa which swim to large oocyte*
- *Seeds are fruit-like (generally edible), become ripe laying on a ground for a long time*
- *Almost no phytophagous insects damage Ginkgo leaves; the fungal symbiont of Ginkgo also belongs to separate class inside basidiomycetes, Bartheletiomycetes.*





# *Ginkgo biloba* ovules



# *Ginkgo biloba* male organs



# *Ginkgo biloba* seeds



# Cycadopsida

- *Two families, dozen genera and  $\approx$  300 species distributed mostly in tropics*
- *Palm-like plants, with large (and usually very rigid) pinnate leaves*
- *Stem structure is not similar to conifers and Ginkgo; cycads have large pith and anomalous secondary thickening via multiple cambium rings*
- *Ovules are attached to modified leaves (sporophylls) and usually gathered in large upright cones; microsporangia are always in cones*
- *Also have multi-flagellate spermatozoa, archegonia and large oocyte*
- *Large seeds are animal-distributed; life cycle is extremely slow (several years from initiation of cone to germination of seed).*



# Cycadopsida families

- *Two families, sometimes even placed in different orders:*
  - *Cycadaceae, with only genus Cycas. They do not have female cones, ovules are attached to leaves which are not radically modified. Leaves have fiddleheads (same in ferns!).*
  - *Zamiaceae, with all other genera (Zamia integrifolia is native to USA). Have female cones.*



# *Cycas* sp.: young leaflets form fiddleheads



# Male *Cycas* sp. in dry season



# *Cycas* sp. seeds





# *Encephalartos gratus* (Zamiaceae)



# *Zamia integrifolia* (Zamiaceae)



# Seed plants

## Conifers

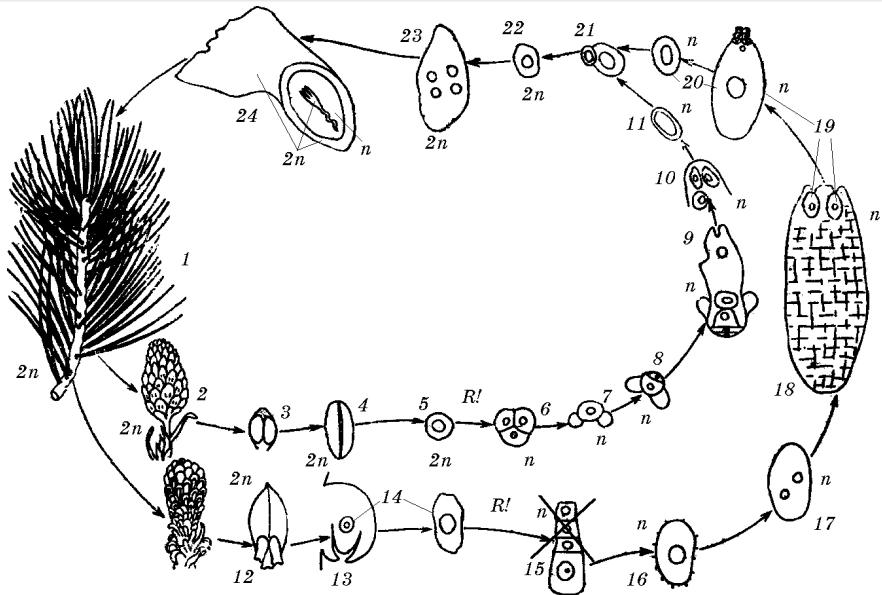


# Pinopsida

- *Three orders, several families and  $\approx$  300 species*
- *Mostly temperate evergreen trees, but some are deciduous (like *Larix*, *Pseudolarix*, and part of *Cupressaceae*)*
- *Stem with large amount of xylem, relatively small cork and minute pith*
- *Ovules are always attached to specialized leaves (seed scales) and together with bract scales they are compacted in cones; microsporangia are attached to microsporophylls and also occur in cones of simpler structure*
- *Male gametes without flagella (spermata), consequently, pollen grains grow into **pollen tubes***
- *Female gametophyte is more reduced than in cycads and Ginkgo*
- *Seeds are wind- and animal-distributed, life cycle shorter but still up to two years*



# Life cycle of conifers: another view



# Pinopsida orders and families

- *Pinales*
  - **Pinaceae.**
- *Araucariales*—*grow mostly in tropics or in South Hemisphere.*
  - *Araucariaceae*
  - *Podocarpaceae*
- *Cupressales*
  - *Sciadopityaceae*
  - *Cupressaceae (incl. Taxodiaceae)*
  - *Cephalotaxaceae*
  - *Taxaceae*



# Pinaceae

- Have resin and needle-like leaves, often in shortened shoots, **brachyblasts**. Large cones with paired (seed and bract) scales.
- Biggest conifer family, include large genus *Pinus* (pine) and other genera like *Larix* (larch), *Cedrus* (cedar), *Picea* (spruce), *Abies* (fir) etc.



# Cupressaceae and Taxaceae

- **Cupressaceae**—cypress family. No resin. Cones are small, with fused bract and seed scales. Leaves are dimorphic, needle-like and scale-like. Part of genera (formerly belong to Taxaceae family) are deciduous but with branches instead of leaves. Genera: *Cupressus* (cypress), *Juniperus* (juniper), *Taxodium* (bald cypress), *Sequoia* (coastal red cedar), *Sequoiadendron* (mountain red cedar), *Metasequoia* etc.
- **Taxaceae**—yew family. Female cones are modified in berry-like structures with one enlarged red scale. Leaves are needle-like. No resin. *Taxus* (yew) provides famous reddish-brown, springy wood.

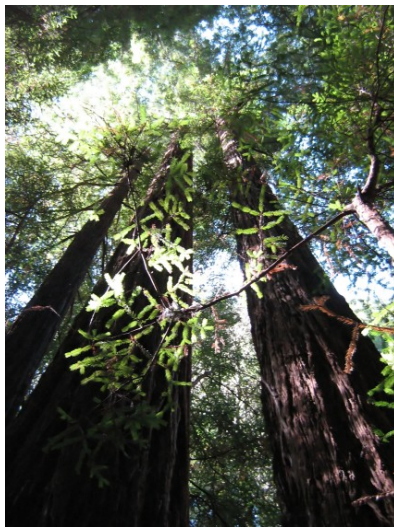




# *Pseudolarix amabilis* (Pinaceae), spring



# *Sequoia sempervirens* (Cupressaceae)



# *Taxus baccata*, Taxaceae



# Seed plants

## Gnetophytes



# Gnetopsida

- Small class of only three genera (*Ephedra*, *Welwitschia*, *Gnetum*), which are so different that botanists place them in different orders (and sometimes even subclasses).
- Tropical trees (*Gnetum*) or desert shrubs (*Ephedra*) or nobody-knows-what (*Welwitschia*)
- Stem structure is similar to conifers but *Gnetum* and *Welwitschia* have vessels (like angiosperms)
- Ovules are solitary, **covered with additional outer integument** (however, **this is not a pistil** because micropyle come out of this cover)
- Male gametes are spermatia, have pollen tube and **no archegonia** in *Gnetum* and *Welwitschia* (like in angiosperms). Multiple fertilization and polyembryony is widespread, *Ephedra* even has a double fertilization (like angiosperms). Only one embryo survives, other are eaten (endosperm<sub>2</sub>). Also have endosperm<sub>1</sub> (female gametophyte).
- *Welwitschia* is insect-pollinated, other are wind-pollinated like most non-angiosperms.
- Seeds are animal-dispersed (except *Welwitschia*).
- Amazingly, molecular data show relations with conifers, not with angiosperms!



# Gnetum

- *Tropical shrubs, vines or small trees (30–35 species) with opposite leaves with pterodromous venation (like angiosperms again!). However, investigation of leaf development showed that initially leaf had dichotomous venation (like Ginkgo and some conifers).*
- *Dioecious plants, male and female structures (fructifications) are catkin-like*
- *Seeds big, colored*



# *Gnetum* seeds



# *Gnetum* female fructifications





# *Gnetum* male fructifications



# Welwitschia

- *One species occurring in Namibian desert (South Africa)*
- *Life form is completely unusual, the best description is “overgrown seedling”: small trunk with only two (constantly growing on the basement and degrading on top) wide leaves with parallelodromous venation. Secondary thickening anomalous (like in cycads). Wood with vessels.*
- *Insect-pollinated (!) dioecious plants*
- *Fructifications are cone-like; male one is similar to flower and contain sterile ovule (!)*
- *Seeds are wind-dispersed*



# *Welwitschia*



# *Welwitschia*



# *Welwitschia* female cones



# *Welwitschia* male cones



# *Welwitschia* pollinators: *Odontopus sexpunctulatus* bug



# Ephedra

- *≈ 35 species growing in dry places across all North Hemisphere and also in South America*
- *Shrubs or small trees, leaves are usually reduced to scales, stems are articulate (like horsetails). Wood is similar to conifers.*
- *Plants are monoecious or dioecious, male and female (bisexual also occur) fructifications are short, covered with thick scales*
- *Wind-pollinated, animal dispersed*
- *Ephedra sinensis is a source of pharmaceutically important **ephedrine***
- *In all, Ephedra is more primitive than two other genera of Gnetopsida: wood does not contain vessels, ovule has large archegonia*





# *Ephedra*



# *Ephedra nevadensis*, female fructification



# *Ephedra nevadensis*, male fructification



# *Ephedra* seeds



# Seed plants

# Flowering plants



# Flowering plants are “Spermatophyta 2.0”

- Reduction of gametophyte: 3-celled pollen and 7-celled embryo sac
- No archegonia and anteridia
- Spermatia, pollen tube
- Double fertilization
- New endosperm (second embryo)
- Cupule (pistil) and fruit
- In general, **angiosperms have accelerated life cycle** needed for fast-growing herbs

**Note: angiosperms = flowering plants = class Magnoliopsida**



# Final question (2 points)



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How to optimize the life cycle of seed plants? Name at least two possible optimizations.





# Summary

- Starting from **Pinopsida**, seed plants lost flagellate spermatozoa and micropylar chamber, and develop pollen tube
- Three genera of **Gnetopsida** are very divergent and morphologically close to angiosperms whereas molecular data place them close to conifers
- **Angiosperms** optimized their life cycle using (a) reduction, (b) signaling second embryo and (c) sophisticated pollination



# For Further Reading



A. Shipunov.

*Introduction to Botany* [Electronic resource].

2010—onwards.

Mode of access:

[http://ashipunov.info/shipunov/school/biol\\_154](http://ashipunov.info/shipunov/school/biol_154)



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