Introduction to Botany. Lecture 35

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December 1, 2014

Outline

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Previous final question: the answer

What are integument and nucellus?

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What are integument and nucellus?

- Nucellus: female sporangium, megasporangium, second layer of seed
- Integument: ovule cover, first layer of seed

Seed plants

Diversity of seed plants

Spermatophyta classes

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

Ginkgoopsida

- Smallest class, only one species (!), Chinese tree *Gigkgo 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 mutli-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, whith 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)

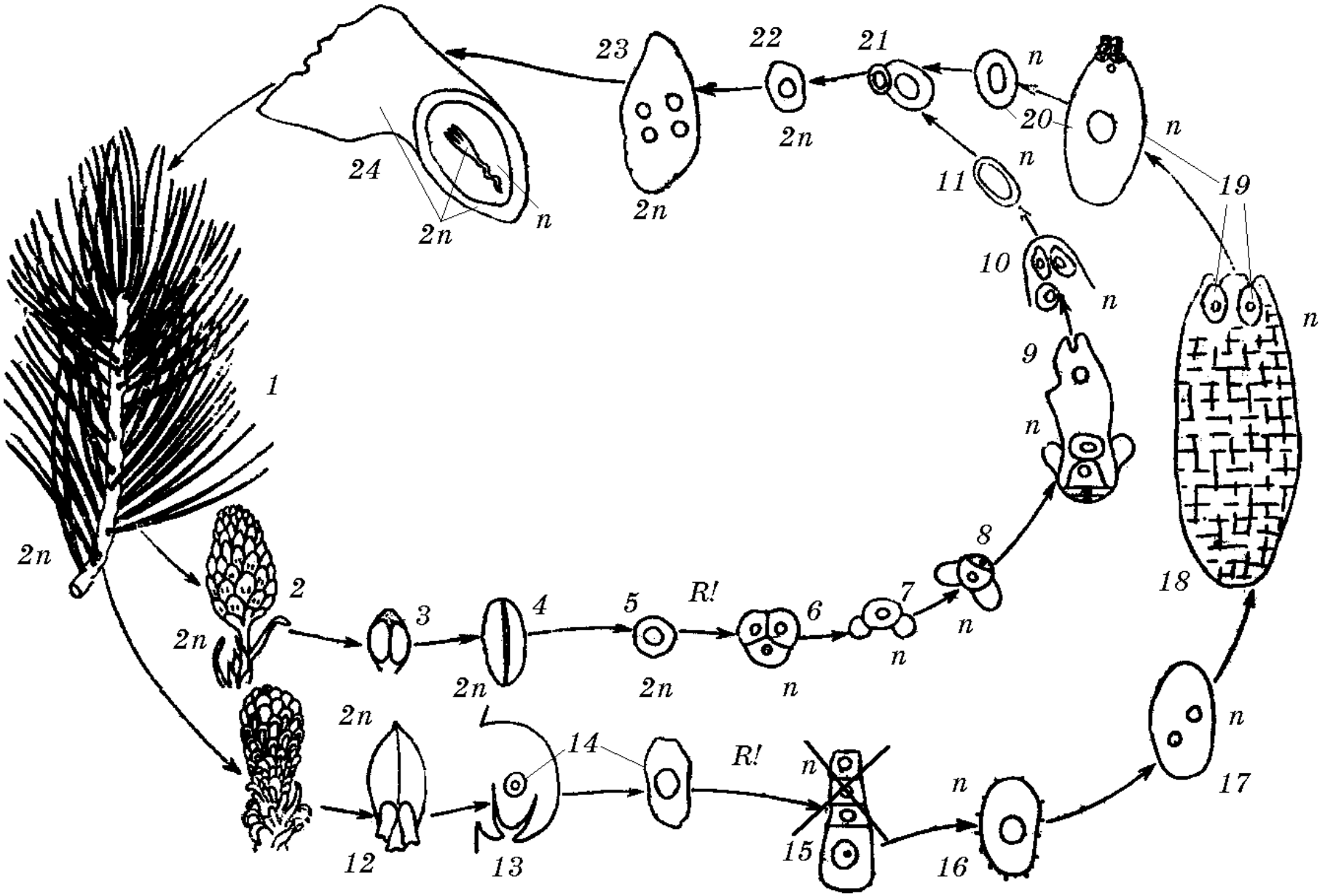
Seed plants

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 (spermatia), 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 an polyembryony is widespread, *Ephedra* and *Gnetum* even has a double fertilizarion (like angiosperms). Only one embryo survives, other are eaten (endosperm_2). Also have endosperm_1 (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 (!) dioecius plants
- Fructifications are cone-like; male one is similar to flower and contain sterile ovule (!)
- Seeds are wind-dispersed

Welwitschia

Welwitschia

Welwitschia female cones

Welwitchia male cones

Welwitchia pollinators: *Odontopus sexpunctulatus* bug

Ephedra

- $\approx$ 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 monoecoius 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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Please explain why the pollen tube is an advanced way of fertilization.

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

Summary

- Seed plants have compact life cycle where almost all stages happen on mother sporophyte

For Further Reading

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