

Introduction to Botany. Lecture 33

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Outline

1 Questions and answers

2 Spermatophyta

- Classes of seed plants
- Conifers
- Gnetophytes



1 Questions and answers

2 Spermatophyta

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- Gnetophytes



Previous final question: the answer

What is seed?



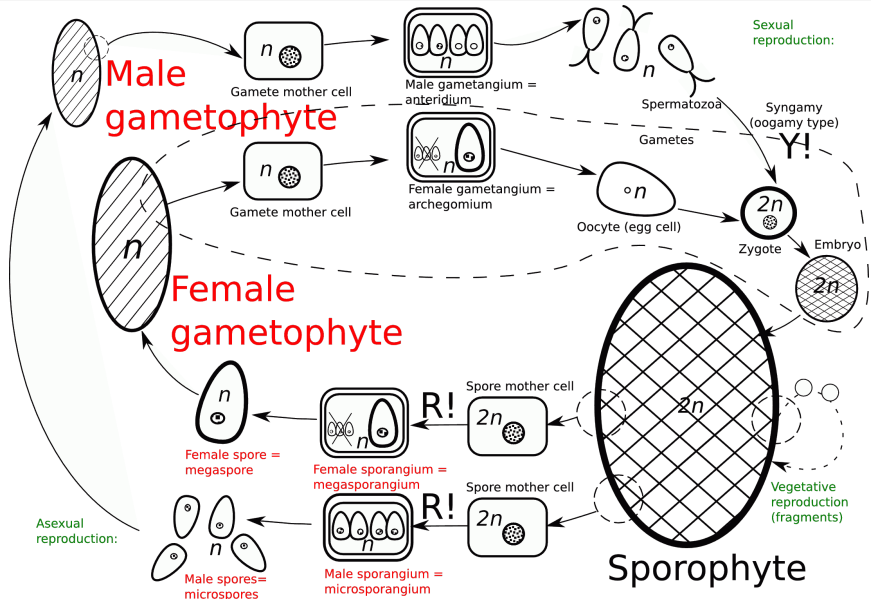
Previous final question: the answer

What is seed?

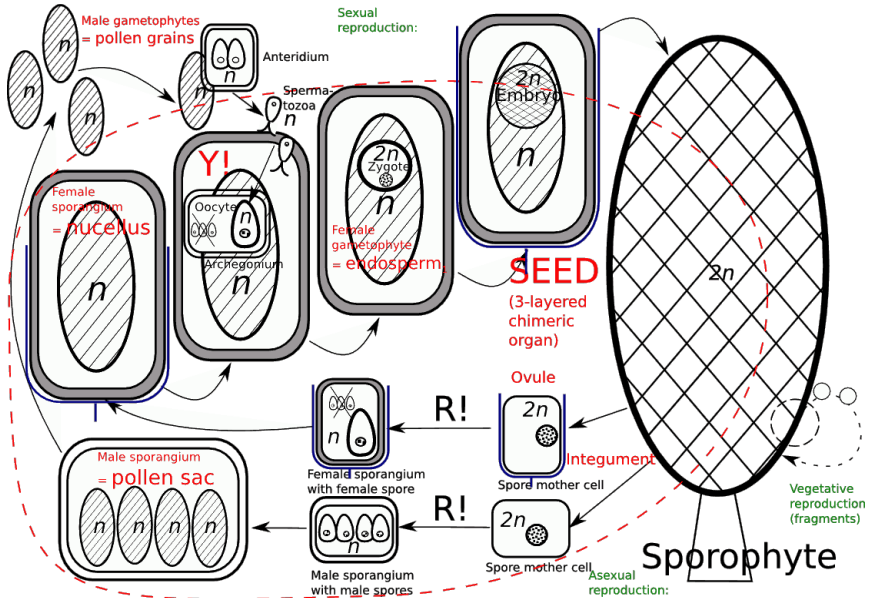
- Seed is a **chimeric organ** with three layers: (1) mother sporophyte tissue (integument + nucellus), (2) female gametophyte tissue (endosperm) and (3) daughter sporophyte (embryo).



Heterosporic cycle: differences



Life cycle of seed plants: differences



Spermatophyta

Classes of seed plants



Spermatophyta: seed plants

- \approx 600 species of non-angiosperms and \approx 250,000 species of angiosperms
- Sporic life cycle with sporophyte predominance and **seed**
- Gametophyte is reduced to cells inside ovule or inside pollen grain. Minimum number of cells is 3 for male gametophyte (pollen grain) and 4 for female gametophyte (embryo sac of angiosperms). Anteridia are reduced. In angiosperms and Gnepopsida, archegonia are also reduced.
- Sporophyte always starts development from embryo located inside nutrition tissue, endosperm₁ (female gametophyte) or endosperm₂ (second embryo)
- Have axillary buds
- Homoiohydric plants (same as ferns)
- Have secondary thickening



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 *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 ≈ 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)



Spermatophyta

Conifers



Pinopsida

- Three orders, several families and ≈ 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



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



Spermatophyta

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 (endosperm₂). Also have endosperm₁ (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

- \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 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



Spermatophyta classes (and genera)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Ginkgoopsida	0	0	1	0	0	0	1	1	0	1	0	0	0
Cycadopsida	1	0	0	0	1	0	1	1	0	1	0	1	0
Pinopsida	0	1	1	0	1	0	0	1	0	1	0	0	1
<i>Gnetum</i>	1	0	1	1	0	0	0	0	0	1	1	0	0
<i>Welwitschia</i>	1	0	0	1	1	1	0	0	0	1	1	1	1
<i>Ephedra</i>	0	1	1	0	0	1	0	1	1	1	1	0	0
Angiospermae	1	0	0	1	0	1	0	0	1	0	1	1	1

1 Tropical; 2 Leaves needle- or scale-like; 3 Coniferous wood; 4 Vessels; 5 Cones; 6 Bisexual fructifications; 7 Flagellate sperm (and micropylar chamber, and no pollen tube); 8 Archegonia; 9 Double fertilization; 10 Endosperm₁; 11 Endosperm₂; 12 Insect pollination; 13 Wind seed dispersion.

Characters are not necessary relevant to all members of class. Angiosperms characters taken from most primitive members (Magnoliidae subclass).



Final question (3 points)



Final question (3 points)

If reproduction via seeds is better than reproduction via spores, why there are 10,000 species of ferns and only 600 species of gymnosperms?



Summary

- Heterosporic plants have two kinds of spores: female (megaspores) and male (microspores)
- Seed plants have compact life cycle where almost all stages happen on mother sporophyte
- 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



For Further Reading



J. E. Bidlack, Sh. H. Jansky.

Stern's introductory plant biology. 12th edition.

McGraw-Hill, 2011.

Chapters 22.



Th. L. Rost, M. G. Barbour, C. R. Stocking, T. M. Murphy.

Plant Biology. 2nd edition.

Thomson Brooks/Cole, 2006.

Chapters 24.

