Key Concepts -- Lecture 9 (cycads, ginkgos, and gnetophytes) IB168: Spr 2009

Reading: Today – pp. 108—118; next Wednesday --

I. Cycads -- Monophyletic group, variously recognized as division (Cycadophyta), subdivision (Cycadicae), or order (Cycadales). Another example of arbitrary ranks in taxonomy. **Most species extinct**: Only about 200--300 spp. in 10--11 genera and 2(--3) families, found in tropical/subtropical environments. Only one species in U.S. (Florida and Georgia): Zamia integrifolia. Known from fossils since early Permian (late Paleozoic), ca. 230 million years ago. Especially rich in diversity during Jurassic, the "Age of Dinosaurs."

A. **Palm-like or fern-like in appearance**:
1. **Woody stem** (subterranean or aerial), with **leaves at apex** of **unbranched** trunk (unless damaged, then may branch). Loss of branching a likely a cycad synapomorphy.
2. Leaves **pinnately-compound** (**once**-compound in most, except Bowenia, which has twice-compound leaves); **persistent leaf bases** (similarity to palms ends here), **partial circinate vernation in Cycadaceae (Cycas; only leaflets inrolled, not midrib).** Herbage poisonous (glycosides) called **cyasins** (paralytic to livestock)

B. **Roots**
1. **Coralloid and upwardly growing**, in part - Symbiotic association with blue-green bacteria (Nostoc &/or Anabaena) in special upwardly growing, coralloid roots. Bacteria constitute a green band in cortex of coralloid roots - **FIX N_2**. Only gymnosperm known to have association with nitrogen fixing organism. Shared derived feature for cycads.
2. Contractile roots -- Can pull plant toward soil; a protective response to stress.

C. **Reproductive morphology**
1. **Dioecious** (unusual condition in conifers, although prevalent in Podocarpaceae, Taxaceae, and Araucaria); that is, with different plants bearing pollen vs seeds; **sex change** reported under stress.
2. **Seeds borne on megasporophylls** (that is, on leaf homologues; unlike conifers, wherein seeds are borne on scales that each equate to a branch, rather than a leaf).
- Generally, the megasporophylls are borne in seed cones at apex of upright stem (up to several cones produced during a reproductive period), although not in Cycas (see below).
3. **Seed (or megasporangiate) cones** of cycads are thought to be the **largest ever** for a plant (some up to 90 pounds and 2 feet in length). Largest conifer cone is small by comparison. Cycas with leaf-like megasporophylls, not in cones (stem grows up through center after seed production), megasporophylls of Dioon somewhat intermediate between those of Cycas and other cycads.
4. **Seeds** are **large** (**not flattened and not wind dispersed**, unlike conifers) and **generally brightly colored** with **"edible (for some animals)" (starch rich) outer layer** (sarcotesta) and **hard inner layer** (sclerotesta). Seeds are attached to megasporophyll, generally two per megasporophyll (more in Cycas). **Animal dispersed** seeds **or** cones (cones **sometimes brightly colored or conspicuous**, as well). Elephants eat whole cone of some African cycads, disperse seeds in dung. Monkeys may run off with entire cone. Mammal and bird dispersal.

5. **Pollen-bearing cones** can be **numerous (up to 100)** and are generally **morphologically dissimilar from seed cones** (usually less bulky), with more microsporophylls than megasporophylls. **Male and female plants otherwise morphologically identical**.
6. Lots **(up to 100s) of microsporangia on undersurface of microsporophyll**, like sori under a fern leaf (unlike conifers - gen. two, up to 15 in Araucariaceae).
7. **Pollination mediated by insects** (ancient beetle lineages such as weevils, one ancient bee lineage), possibly wind in some species. Where studied**, beetles eat microsporophylls or pollen**, possibly attracted to odor and/or heat of **pollen and ovuliferous cones**. Scales of seed cone tightly sealed or barely separated, wind pollination ineffective despite massive amount of pollen produced by male cones. **Insect pollination of cycads may have preceded origin of flowering plants by 100 million years**.
8. Fertilization like that of conifers, but **sperm are motile** with up to 40,000 flagellae in a spiral arrangement at end of cell (top shaped sperm), **like Ginkgo**. Motile sperm may be ancestral feature of early seed plants in general.
- Most cycads can reach **reproductive maturity within 15 years (in cultivation)**.
D. **Conservation status**: Disappearing, overcollecting, habitat destruction.

II. GINKGO - One extant species, Ginkgo biloba, may be extinct in wild
A. Date back to the **Jurassic** at least, prehistorically a worldwide group with considerable diversity.
B. Conifer-like in overall growth form (**excurrent branching**), and once placed in Taxaceae.
C. **Leaves** highly unusual: **fan-shaped, with forked venation**, **deciduous** (unlike most conifers, except e.g., larches and Metasequoia)
D. **Short-shoot** morphology, with all reproductive structures borne from these rather than terminal shoots.
E. **Closer to cycads or conifers?**
1. Like cycads:
- **dioecious** (somewhat unusual in conifers),
- **motile huge sperm** that swim into archegonia (after penetration of megasporangium by pollen tube),
- **unflattened "fleshy" seeds** (outer layer foul when ripe, but actual embryo and associated megagametophyte nutritious and of medicinal value).

III. GNETOPHYTES
A. **Diversity**
- Another gymnosperm group of low diversity.
- Three families, with exceedingly different growth forms and vegetative features:
1. Ephedraceae (Ephedra) - ~65 species; semi-arid habitats, with scale-like leaves, photosynthetic ridged stems (reminiscent of Equisetum)
2. Gnetaceae (mostly in Gnetum) - ~30 spp. of vines (one tree); tropical rain forests.
3. Welwitschiaceae (Welwitschia) - Darwin's "platypus of the plant world", one species, Namib Desert of sw Africa and surroundings, one pair of foliage leaves grow throughout life; branched strobiliferous shoots.

B. Morphological characteristics of Gnetophytes

1. United as group in part by:

a. **opposite** decussate, or whorled leaves,

b. protruding **tubular inner integument** of ovules (**two integuments**)

c. unique xylary elements (**vessels** in 2ndary xylem; of independent origin from those in angiosperms)

d. **both pollen and seed cones are compound** (that is, the structures bearing ovules or pollen sacs are branches, not leaves)

e. **football-shaped, striated pollen** (except in Gnetum).