BIOL 1010 Introduction to Biology: The Evolution and Diversity of Life. Spring 2011 Sections A & B

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Monday, March 7, 2011
The plant world, life needs 'em

Why are plants so important?
Where'd they come from?
Let's start with the 'primitive' ones after trying to answer those questions.
It’s hard to imagine the world without plants!
Once they colonized the land, a cascade of events began . . .

- That profoundly changed the course of evolutionary history on the earth.
- They changed the atmosphere over what phytoplankton had already done by absorbing even more CO$_2$ and exhaling even more O$_2$.
- They began to form the base of all sorts of terrestrial food chains.
- Their dead parts (leaf and twig litter especially) contributed to an explosion of biodiversity both on land and in the waters of the world.
All ‘true’ plants are . . .

* Multicellular organisms with eukaryotic cells;
* Photosynthetic autotrophs (with the notable exceptions of a few parasitic species).
* Nearly all live on land. They all have the . . .
* Same photosynthetic pigments (esp. chlorophyll a), cellulose-rich cell walls, and use starch to store sugar. They also all experience an . . .
* Alternation of generations — with a diploid sporophyte, and a haploid gametophyte. However, there is a . . .
* Notable evolutionary trend for land plants to change the relative size of the gametophyte smaller and of the sporophyte larger.
As plants become more ‘advanced’ the gametophyte stage gets tinier and tinier.
It's so dry out of the pool!

Terrestrial habitats have selected for many adaptations: to hold the body erect, to retain moisture, and to survive and reproduce without being immersed in water. Amazing.

These include:

- Leaves to capture solar energy;
- Roots to anchor and absorb water and nutrients;
- Cuticle to minimize water loss;
- Stomata to enable efficient gas exchange and reduce water loss;
- Lignin + cellulose to strengthen and support cell walls; and . . .
- Vascular tissue to transport water and nutrients (in many plants).

Not all plants have all these adaptations, but many have other additional ones. Plants have been the quiet, powerful type . . . .
Those major innovations:

1) Stomata,
2) Leaves,
3) Cuticle,
4) Xylem and phloem,
5) Lignin, and
6) Roots!
But where'd they all, and all of their innovations, come from?

* Remember the primary, basal clades in the Eukaryotic tree of life.
* Here's another version from a 2004 paper by Palmer, Soltis, and Chase:
* [http://www.amjbot.org/cgi/content/full/91/10/1437](http://www.amjbot.org/cgi/content/full/91/10/1437)
And here’s where they fit in with the rest of the Eukaryotes according to the Tol.

The Archaeplastids are one of the basal clades of Eukaryotes. They all seem to have the same cyanobacterial-like chloroplast from a single primary endosymbiotic event that happened about 1.6 BYA.

The green plants split from a common ancestor of the red algae around 1.5 BYA (http://www.amjbot.org/cgi/reprint/91/10/1656).

http://tolweb.org/Eukaryotes/3

http://ucjeps.berkeley.edu/TreeofLife/poster.php
Just under a billion years ago the true plants diverged from a common ancestor with most of the green algae. And then less than half a million years ago the land plants diverged off that lineage.
An ancestral charophyte (a type of green algae with the extant ToL name Charales) likely gave rise to land plants. The land plants are technically the Embryophytes, their embryos are enclosed and have sterile tissue within them.

- http://tolweb.org/Green_plants/2382
- http://mbe.oxfordjournals.org/cgi/content/abstract/23/6/1324
- The land plants are technically the Embryophytes, their embryos are enclosed and have sterile tissue within them.
Which can roughly be put into four groups...

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*Table 20.1 Four Groups of Plants*  
*Land plants, i.e. the Embryophytes*

Sorted by these innovations.
And we'll concentrate on the 'primitive' ones first.

- Marchantiomorpha (liverworts)
- Anthocerotophyta (hornworts)
- Bryophyta (mosses)
- Horneophytopsida ♦
- Aglaophyton major ♦
- Rhyniopsida ♦
- Lycopodiopsida (lycophytes)
- Eophyllophyton bellum ♦
- Psilophyton dawsonii ♦
- Cladoxylopsida ♦
- Polypodiopsida (ferns, including horsetails and whiskferns)
- Pertica varia ♦
- Aneurophytales ♦
- Archaeopteridales ♦
- Protopityales ♦
- Spermatopsida (seed plants: flowering plants, conifers, etc.)

That's these guys.

http://tolweb.org/Embryophytes/20582
One, a polyphyletic group called the Bryophytes.

- They are all seedless, nonvascular plants.
- But are not a clade (they're actually paraphyletic).
- Water and nutrients move through the plant by diffusion and osmosis alone.
- They lack true leaves and roots. But have . . .
- Flattened photosynthetic leaflike areas, and . . .
- Hair-like rhizoids for anchoring the organism to the soil and absorbing nutrients.

http://en.wikipedia.org/wiki/Bryophyte
Here’s how your text places them among the other land plants.
And the Palmer, Soltis, and Chase article uses a similar scheme, with divergence dates included.
Both phylogenies agree with the ToL.

- However, the word “bryophyte” is used differently between the sources. The ToL reserves it just for the mosses, whereas your text and Palmer, et al. uses it for all the ‘primitive plants’ except the ferns and fern-like (seedless, vascular) plants.

- No biggy. We’ll be covering all of them today, but first the ‘bryophytes.’

- In the text’s usage there’s about 24,000 species of bryophytes; these include . . .
The three major phyla:

- **Mosses:**
  - Most closely related to vascular plants.
  - Have a conspicuous 'leaf-like' gametophyte, and a conspicuous 'stalk-like' sporophyte.

- **Liverworts:**
  - Have flattened, lobed "leaves." May be . . .
  - Most closely related to ancestral land plants.

- **Hornworts:**
  - Smallest group (only around 100 species).
  - Named for the shape of their sporophyte.
Bryophytes (according to your author)

a. The moss *Splachnum luteum*;
b. A liverwort;
c. The hornwort *Anthocerus*.

In all cases the sporophyte generation is the stalk-like appendage.
Another moss, sphagnum, accumulates in huge bogs and partially decomposes creating “peat moss,” which is used for horticulture and fuel.
Most bryophytes use asexual reproduction. Liverworts and mosses make gemmae, which are small pieces of tissue, that detach when raindrops hit them, and then they grow into new plants.
But they also do it sexually, albeit kind weirdly.

- Weird thing is the most conspicuous generation is the haploid gametophyte.
- Gametes form by mitosis on separate male and female leaf-like gametophyte structures.
- The sperms swim to the egg – this requires a moist habitat with surface condensation.
- The sporophyte generation begins at fertilization, producing a diploid zygote . . .
- That remains attached to the gametophyte and divides mitotically forming a stalked sporangium where . . .
- Specialized cells divide meiotically to produce haploid spores. These are released and germinate, dividing mitotically to produce the new haploid gametophyte.
Here’s a picture of this “alternation of generations” in bryophytes.
Leaving the bryophytes, let’s explore the ferns and fern-like plants.

* These ‘primitive’ plants are . . .
* All seedless, but vascular. Which means they . . .
* Have xylem and phloem vascular tissue that allows for true roots, stems, and leaves.
* This permits life in drier habitats.
* Plus the xylem’s thick cell walls can support much larger plants than in the bryophytes.
* They also have a well-developed cuticle and stomata to minimize water loss.
In your text they are placed in one clade.

The 12,000 plus species are split into four main lineages.
With roughly four groups:

1. The Club mosses are most basal (i.e. most ‘primitive’):
   - These are known as Lycopods. And include . . .
   - Club mosses and spike mosses. They are . . .
   - Not bryophytes, but not really that fern-like either.
   - [Link](http://tolweb.org/Lycopodiopsida/20607)

2. Horsetails:
   - One living genus, *Equisetum*. Many have silica crystals in their cell walls.
   - [Link](http://en.wikipedia.org/wiki/Equisetum) and [Link](http://tolweb.org/Equisetidae/33130)

3. Whisk ferns:
   - Are very simple plants. Most have no obvious leaves.
   - [Link](http://en.wikipedia.org/wiki/Psilotum) and [Link](http://tolweb.org/Psilotales/21662)

4. The true ferns, the Polypodiidae, a.k.a. the leptosporangiate ferns:
   - This is the largest group of the four. Next to the flowering plants, the leptosporangiate ferns are the most diverse group of living land plants.
   - They have fronds – analogous to leaves, which grow from . . .
   - Rhizomes – underground stems.
   - Their remains from the Carboniferous period form present day coal deposits.
   - [Link](http://tolweb.org/Polypodiidae/21666)
However, the club mosses are separated from the other ferns and fern-like plants by several extinct taxon.

http://tolweb.org/Polypodiidae/21666
The rest are truly ferns and ‘fern-likes’

* These are the Polypodiopsida. They are . . .
* Grouped into a common clade by many criteria.
* However, the branching order within them is contentious.
* Did horsetails or whisk ferns diverge first? Your text says horsetails; ToL and Palmer et al. say whisk ferns. It doesn’t really matter.
The ferns and other related fern-like plants

http://tolweb.org/Polypodiopsida/20615
Some representatives:

a. A true fern, *Phegopteris*;
b. True ferns have ‘fiddlehead’ developing fronds;
c. The club moss *Lycopodium*; and . . .
d. The horsetail *Equisetum*.
And a whisk fern, Psilotum.
Most of these plants also use an alternation of generations type of sexual reproduction.

* The sporophyte produces haploid spores by meiosis on the underside of fronds. But . . .
* The spores germinate into tiny, inconspicuous, heart-shaped gametophytes.
* Swimming sperms require a film of free water.
* Gametes fuse to form zygote.
* Diploid cell grows into large, conspicuous sporophyte.
Here's an illustration of this form of lifestyle.
That’s it for ‘primitive’ plants,
But we’ll move right on to the ‘advanced’ plants now.