Plant Diversity

(Freeman Ch 30 & 40)

Videos
28-3, 28-5, 39-3

25 February 2010
ECOL 182R UofA
K. E. Bonne

Plant Diversity

• From Sea to Land
• Origins, Relationships, Diversity
• Shared Derived Traits (Synapomorphies)
• Nonvascular to Vascular Plants
• Seedless to Seeds

The Evolution of Land Plants
(from the edge of the swamp...)

Eukaryotic Green stuff

Original Land Plants Related to Algae
Land plants retain derived features they share with a green algae (Charales):
• Chlorophyll \(a \) and \(b\)
• as a storage product
• in cell walls.

Lecture Schedule (middle third)

18 Feb KB - Fungi, Ch31
23 Feb KB - Prokaryotes & Protists, Ch28&29
25 Feb KB - Plant Diversity, Form, Function, Ch30&31
2 Mar KB - Plant Form and Function, Ch36&37
4 Mar KB - Plant Function, Ch38&39
9 Mar KB - Plant Ecology, Ch50,52,53
11 Mar KB - Ecology, Ch50,52,53
13-21 Mar Spring Break
23 Mar KB - Biology of the Galapagos
Wikelski 2000 and http://livinggalapagos.org/
25 Mar KB - Part 2: Discussion and Review.
30 Mar KB - EXAM 2

Figure 29-8

<table>
<thead>
<tr>
<th>Eukarya</th>
<th>Archaea</th>
<th>Bacteria</th>
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<td>Discicristata</td>
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<td>Cellular slime molds</td>
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<td>Plasmodial slime molds</td>
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</tbody>
</table>

Green plants

Eight major lineages
of eukaryotes (protist branches are in color)
Land Plants are Monophyletic

Land plants are monophyletic, all descendants from a single common ancestor.

Synapomorphy: development from an embryo protected by tissues of the parent plant. Therefore, also called embryophytes.

(phyton = plant)

Land Plants Comprise ~Ten Clades

Nonvascular (3 clades)
- paraphyletic group
- liverworts,
- hornworts
- mosses

Vascular plants, or tracheophytes (7 clades)—all have conducting cells called -tracheids,
- monophyletic group

Moving to Land
Plants first appeared on land between 400–500 million years ago.

Environmental Challenges:
1. transport to all parts
2. support (fight gravity)
3. disperse

Adaptations for Land
1. Cuticle
   - waxy covering that retards water
2. Gametangia enclosing gametes
3. Embryos in a protective structure
4. Pigments that protect against UV radiation
5. Spore walls containing sporopollenin
   - resists desiccation and
6. Mutualistic relationships with fungus
   - to promote \_\_\_\_\_\_\_\_\_\_\_\_\_ from soil
Plants Help Create Soil

Ancient plants contributed to soil formation.
Acids secreted by plants help break down rock.
Organic material from dead plants contributes to soil structure.
Create habitat and pave way for succession of other species.

Nonvascular Plants Are Similar to Ancestral Land Plants

Today's nonvascular plants are thought to be similar to the first land plants.
They grow in moist environments in dense mats.
They are small, there is no system to conduct water or minerals from soil to plant body parts.

Extant Plants

Three Nonvascular Clades (paraphyletic group)
- Liverworts
- Hornworts
- Mosses

Alternation of Generations

All plants have alternation of generations (= multicellular haploid & multicellular diploid)
- gametophyte, 1n
- sporophyte, 2n

Moss Lifecycle (Nonvascular Plant)

Sporophyte (2n) required for egg and sperm to meet, and attached to gametophyte (1n)
Nonvascular: Gametophyte Dominates

In nonvascular plants:
- gametophyte is larger, longer-lived, and more self-sufficient than the sporophyte.
- gametophyte generation is
- sporophyte may or may not be photosynthetic, but is always nutritionally dependent on the gametophyte, and is permanently attached.
- reduction of the gametophyte generation is a major theme in plant evolution.

Nonvascular Plant Reproduction

Male: antheridium
Female: archegonium

Base of archegonium grows to protect embryo during early development.

(land plants aka embryophytes)

Life cycle of a moss

Mosses are sister group to plants

Moss... *Sphagnum* grows in swampy places.
The upper layers of moss compress lower layers that are beginning to decompose, forming peat.
Long ago, continued compression led to the formation of...
Vascular Plants Arose from Nonvascular

Recently, fossilized fragments of ancient liverworts have been discovered.

Vascular Plants Comprise Seven Clades

10 clades of land plants:
- Nonvascular (3 clades)
  - liverworts, hornworts, and mosses
  - paraphyletic group
- Vascular plants, or tracheophytes (7 clades)
  - conducting cells called tracheids
  - monophyletic group

Evolution of Vascular Plants

Vascular plants have a branching,

Mature sporophyte is nutritionally independent from the gametophyte.

Still must have water for part of the life cycle—for the flagellated, swimming sperm.

Paleozoic: Carboniferous

- Large glaciers and swamp forests of treeferns and horsetails.
- Fossilized forests formed the coal we now mine for.
Evolution of Leaves

Megaphylls:

Figure 28.17 Horsetails

The Life Cycle of a Homosporous Fern

Sporophyte and Gametophyte are each

Bristlecone Pine

If you could imagine a living tree as old as the pyramids of Egypt, what do you think it would look like? It would look like a bristlecone pine, Pinus longaeva, the known tree species in the world.

The bristlecone pine only lives in scattered, arid mountain regions of six western states of America, but the oldest are found in the Ancient Bristlecone Pine Forest in the White Mountains of California. There the pines exist in an exposed, windswept, harsh environment, free of competition from other plants and the ravages of insects and disease. The oldest bristlecones usually grow at elevations of 10,000 to 11,000 feet.

Evolution of Leaves

Megaphylls:

The Life Cycle of a Homosporous Fern

Video 28-5

Early Vascular Plants

During the Permian, the continents came together to form Pangaea. Extensive glaciation occurred late in the Permian.

Lycophyte-fern forests were replaced by gymnosperms.

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The oldest known tree is "Methuselah", which is 4,789 years old. To keep Methuselah from harm, this tree isn't labeled, as the other trees are. An older tree called Prometheus was killed shortly after it was discovered in 1964. This happened when a geologist searching for evidence of Ice Age glaciers was taking some core samples from several bristlecones. Just as he realized he had found a tree over 4,000 years old, his coring tool broke. Amazingly the U.S. Forest Service gave him permission to cut down the tree. Prometheus turned out to be 4,950 years old. It was a 300 year old tree when the pyramids were being built in Egypt.

Bristlecone Pine

Laboratory of Tree-Ring Research
http://www.ltrr.arizona.edu/

Which of the following are vascular plants?

a Juniper
b Sunflower
c Fern
d Moss
e Horsetail
f Liverwort
g Lily

(Gymnosperms & Angiosperms)
Seed Plants

Seed Plants Took Over
Surviving seed plants fall into two groups:

• Gymnosperms: pines and cycads
• Angiosperms: flowering plants

The Evolution of Seed Plants

Late in the Devonian, some plants developed
secondary growth: thickened woody stems of xylem.

First species with secondary growth were the progymnosperms: seedless vascular plants, now extinct.

Wood: proliferated xylem, gives support and allows plants to grow above their competitors for sunlight.
Evolution of Plants
Horsetails and ferns (Pteridophytes) replaced by plants

Gymnosperms
Extant gymnosperms are probably a clade.
Gymnosperm: the ovules and seeds are not protected by ovary or fruit tissue.

Four major groups of living gymnosperms:
- Cycads: Cycadophyta—140 species
- Ginkgos: Ginkgophyta—one living species, Ginkgo biloba
- Gnetophytes: Gnetophyta—90 species in 3 genera
- Conifers: Coniferophyta—600 species, the cone bearers
- Cycads and Ginkgos still have

Living fossils: Gingko

Triassic (200mya)

Gingko biloba

Cycas revoluta

UA Campus

http://arboretum.arizona.edu/plantwalks.html
Gymnosperm Evolution

Most living gymnosperms have only tracheids for water conduction and support. Angiosperms have vessel elements and fibers alongside of tracheids.

Evolution of Seed Plants

Gametophyte generation is reduced even further than it is in ferns. Haploid gametophyte develops partly or entirely while attached to the sporophyte.
Megasporangium is surrounded by integument made of sporophytic structures.

Megasporangium and the integument together form the ovule (which develops into a).
After fertilization, diploid zygote divides to produce an embryonic sporophyte. Growth is then suspended, the embryo enters a dormant stage, with the end product being a multicellular seed. How might suspension of growth be a fitness advantage?

Evolution of Seed Plants

Seeds and Secondary Growth are the main reasons for the success of seed plants—currently the dominant life forms in terrestrial environments.

Then came the FLOWERS!

Seeds have tissues from three generations:
1. Seed coat develops from the sporophyte parent (integument).
2. Female gametophytic tissue from the next generation contains a nutrient supply for developing embryo.
3. Embryo is the new sporophyte generation.

Seeds are well-protected resting stages. May remain viable for many years, germinating when conditions are favorable. Seed coat protects from drying out as well as predators. Many seeds have adaptations for dispersal.

<table>
<thead>
<tr>
<th>Classification of Land Plants</th>
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<tbody>
<tr>
<td>GROUP</td>
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</table>
| NON-SEED PLANTS | Leafy Liverworts | No thallus stage; gametophyte flat Embryos encased in sporophyte grows basally (from the ground) }
| Bryophyta | Hornworts | Ramets | |
| VASCULAR PLANTS | Club mosses and allies | Club mosses and allies | Monocotyledonous sporeangia in leaf axil | Differences between root, stem and leaf (dicotyledonous growth) |
| Angiosperms | Conifers | Conifers | Conifers | Conifers |
| Gnetophyta | Gnetophytes | Gnetophytes | Seed in cone; needle-like or scale-like leaves | Endosperm: protoplast; gymnosperms: much reduced; seeds with fruit |
| Gymnosperms |Conifers | Conifers | Conifers | Conifers |

Note: No endlich groups are included in this classification.
Angiosperms

Oldest angiosperm fossils are Cretaceous, 140 million years old.
Radiation was explosive: angiosperms became dominant in only 60 million years.
Over 250,000 species exist today.

Female gametophyte even more reduced—usually only seven cells.

Angiosperm Synapomorphies

- Xylem with vessel elements and fibers
- Phloem with companion cells

- Triploid endosperm
- Ovules and seeds

Carpels

Angiosperm: "enclosed seed"—the ovules and seeds are enclosed in a modified leaf called a carpel.
Carpels provide protection, and may interact with pollen to prevent self-pollination.
**Flowers**

**Stamens** bear **microsporangia**: consist of **filament** and **anther**.

**Carpels** bear **megasporangia**. One or more carpels form the **pistil**— **stigma**, **style**, and **ovary**.

**Flowers**

**Petals (corolla)** and **sepalas (calyx)** are modified leaves. Often play a role in attracting pollinators. The calyx often protects the flower bud before it opens.

**Flowers**

**Perfect flowers**: have both **mega-** and **microsporangia**.

**Imperfect flowers**: either **mega** or **microsporangia**.

**Monoecious**: "one-housed"; male and female flowers occur on the same plant. **Dioecious**: "two-housed"; male and female flowers on different plants.

**Inflorescence**: grouping of flowers. Different families have characteristic types.
Double Fertilization (in Angiosperms)

- One sperm nucleus unites with the egg nucleus to form the zygote.
- Second sperm nucleus moves through the female gametophyte and fuses with the polar nuclei in the central cell to form a single triploid (3n) cell.
- This triploid cell undergoes a series of mitotic divisions that form a triploid tissue called __________.
- Endosperm stores nutrients that will be needed by the __________.

Inside the ovary, the ovule develops into a seed consisting of:

- The developing embryo (2n)
- The endosperm (3n), which provides nutrition to the growing embryo
- Additional food storage tissue formed from the megagametophyte, called perisperm
- Outermost layer of tissue, the integument, develops into the seed coat

The ovary itself develops into a fruit.

- The ovary wall, aka pericarp, often thickens & separates into distinct layers.

The Angiosperms: Flowering Plants

- Specialized leaves (petals and sepals) are important for attracting pollinators
  - Many angiosperms are animal-pollinated increasing the likelihood of outcrossing (in exchange for nectar or pollen)
  - Coevolution has resulted in some highly specific interactions, but most plant-pollinator systems are not highly specific

- Evolutionarily ancient angiosperms have a large and variable number of floral structures (petals, sepals, carpels, and stamens)
  - Evolutionary trend within the group:
    - reduction in number of floral organs
    - differentiation of petals and sepals,
    - changes in symmetry, and
    - fusion of parts.
Pollination Syndromes

- **Beetle flowers**: dull color, strong odor
- **Bee flowers**: blue or yellow with nectar guides
- **Moth and butterfly flowers**: long corolla tube
- **Bird flowers**: lots of nectar, red, odorless
- **Bat flowers**: lots of nectar, dull colors, strong odors
- **Wind**: no nectar, dull colors, odorless

Flowers pollinated by moths tend to bloom at night, are white, and are long and tubular.
Wind pollinated angiosperms

*Angraecum sesquipedale*

*Xanthopan morgani predicta*
Pollination by mammals!

Video 39.3 Pollination of a night-blooming cactus by a bat

Fruit & seed dispersal

- **Wind**: fruits & seeds have "wings"
- **Water**: fruits & seeds float
- **Animal (endozoochory)**: fleshy, edible fruits
- **Animal (exozoochory)**: bristles, hooks, or sticky substances
### The Angiosperms: Flowering Plants

- **Specialized leaves (petals and sepals)** are important for attracting pollinators:
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- **Evolutionarily ancient angiosperms** have a large and variable number of floral structures (petals, sepals, carpels, and stamens):
  - Evolutionary trend within the group:
    - reduction in number of floral organs,
    - differentiation of petals and sepals,
    - changes in symmetry, and
    - fusion of parts.
Asteraceae

2 types of flowers

Angiosperm Diversification

More than 250,000 species

Plants Support Our World

Plants contribute to ecosystem services: processes by which the environment maintains resources that benefit humans.

Plants are primary producers: photosynthesis traps energy and carbon, making them available to consumers.

Plants Support Us

Seed plants are our primary food source.

Twelve are most important: rice, coconut, wheat, corn, potato, sweet potato, cassava, sugarcane, sugar beet, soybean, common bean, banana.

Half of the world’s population gets most of its food energy from ___
Plants Support Us

Many medicines come from seed plants. Medicines are found by screening large numbers of plants, or screening large numbers of chemical compounds. Ethnobotanists also discover medicinal plants by studying people and their uses of plants all over the world.

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>PLANT SOURCE</th>
<th>MEDICAL APPLICATION</th>
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<tbody>
<tr>
<td>Atropine</td>
<td>Belladonna</td>
<td>Dilating pupils for eye examination</td>
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<tr>
<td>Bromelain</td>
<td>Pineapple stem</td>
<td>Controlling tissue inflammation</td>
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<td>Digitalin</td>
<td>Foxglove</td>
<td>Strengthening heart muscle contraction</td>
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<td>Morphine</td>
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<tr>
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<td>Treatment of ovarian and breast cancers</td>
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<td>As muscle relaxant in surgery</td>
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<tr>
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<td>Periwinkle</td>
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