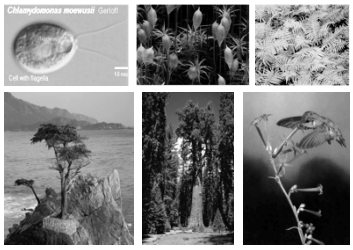
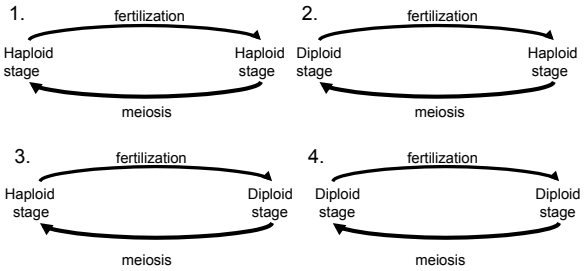
The Evolution of Plants - They Made the Land Green, Part 2

1. We'll use clickers today.
2. Diffusion HW due on Friday 3/4
3. Bring 2 calculators for each group on Friday, if possible
4. Exam regrade request due on Friday 3/4



Clicker question: Which plant life cycle is correct?



Which stage is the gametophyte, and which stage is the sporophyte?

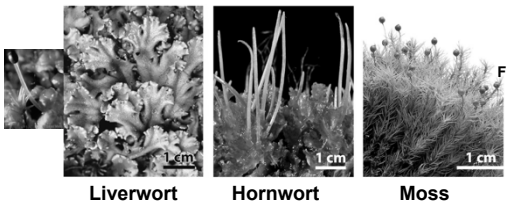
Clicker question:

A. ___ retained many features of aquatic ancestors, and
B. ___ evolved most of the terrestrial adaptations

1. A. Sporophytes; B. Sporophytes.
2. A. Sporophytes; B. Gametophytes.
3. A. Gametophytes; B. Sporophytes.
4. A. Gametophytes; B. Gametophytes.

Bryophytes - non-vascular plants

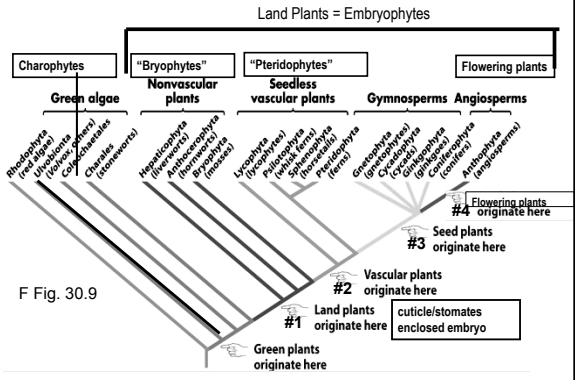
- Three phyla: liverworts, hornworts, mosses
- Abundant in moist habitats
- Persistent gametophytes, ephemeral dependent sporophytes
- Zygotes divide to form diploid embryos (young sporophytes)
- Mature sporophyte often develops three parts - capsule (sporangium producing haploid spores via meiosis), seta (stalk), and foot embedded in gametophyte for nutrition.



F Fig. 30.7

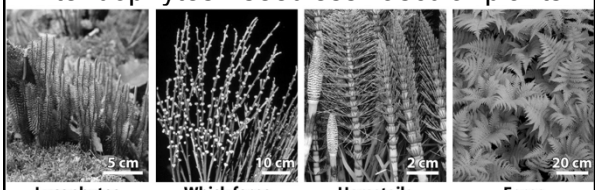
Liverwort **Hornwort** **Moss**

1. First radiation of land plants - protection!



F Fig. 30.9

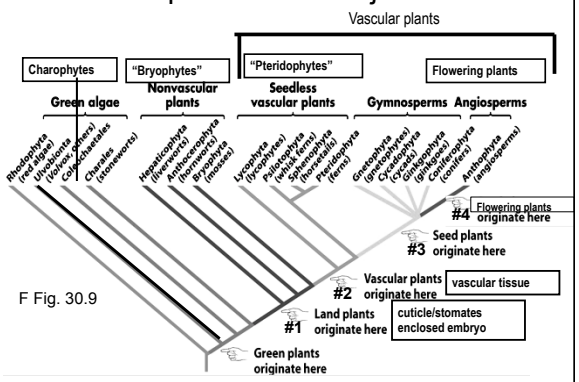
Pteridophytes - seedless vascular plants



F Fig. 30.7

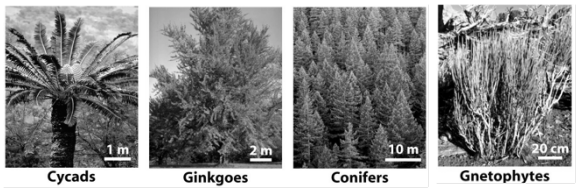
- major pteridophyte innovation was vascular tissue
- xylem (water and ion transport) and phloem (sugar transport)
- more efficient intercellular transport
- greater size due to the hardening agent lignin in xylem
- large sporophytes with vascular tissue
- small free-living gametophytes without vascular tissue

2. Vascular plants - one major innovation



F Fig. 30.9

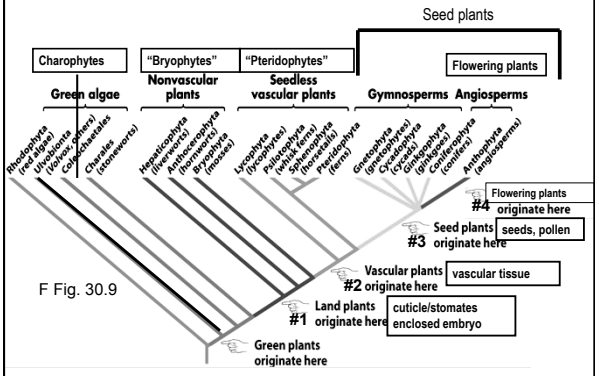
Gymnosperms - vascular plants with naked seeds



- Major innovations - seeds and pollen (with very reduced, microscopic gametophytes)
- 4 major groups with a total of 800 tree and shrub species
- Dominant tree species at high elevations and high latitudes, plus certain arid environments

F Fig. 30.7

3. Seed plants - two major innovations

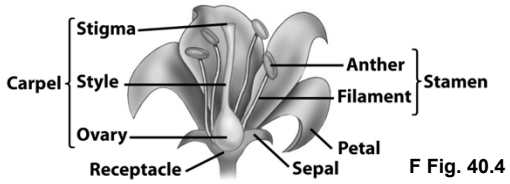


F Fig. 30.9

Angiosperms - vascular seed plants with flowers and fruits as reproductive structures

- 4th radiation of land plants - the origin of flowers
- >250,000 species (~ 90% of land plants)
- Rapid diversification around 130 mya
- Darwin's "abominable mystery"
- All major domesticated crop plants
- Routine manipulation of animals to carry out sexual reproduction and seed dispersal

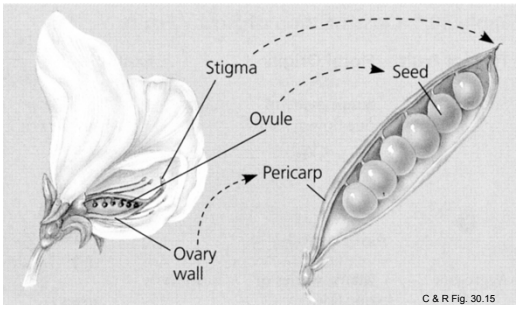
Basic Parts of a Flower



F Fig. 40.4

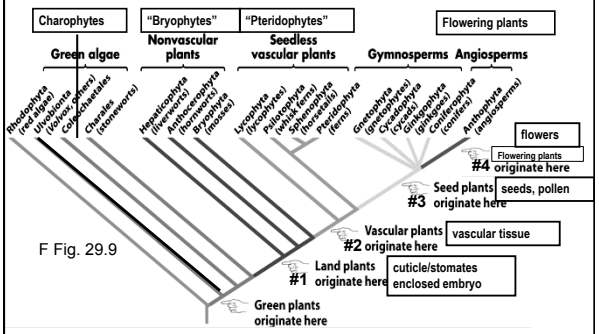
- sepal - leaf-like organ for protecting floral bud
- petal - often colored organ for attracting pollinators
- stamen - male organ for producing pollen
- carpel (stigma/style/ovary)- female organ for producing eggs ovules develop inside of ovary

Fruits develop from modified floral organs



Fertilized ovule -> seed Enlarged ovary -> fruit wall

Summary - 4 successive radiations of land plants following evolutionary innovations



F Fig. 29.9

Study Questions = Learning objectives

1. Describe the general life cycle of the land plants, being certain to specify the names and ploidy levels of the major processes, unicellular stages, and multicellular structures.
2. Draw the phylogenetic tree of land plants, and place the names of the major lineages and the origins of the diagnostic traits in the correct positions on it.
3. What evolutionary constraints are acting on the gametophyte generations of land plants?
4. What evolutionary innovations appear in their sporophyte generations?
5. Be able to describe the major terrestrial adaptations of land plants and their significance.
6. Provide sufficient evidence to support the concepts listed in the slide entitled: "Summary - land plant life cycle" in the middle of this lecture.

Fungi - To be or not to be (motile)

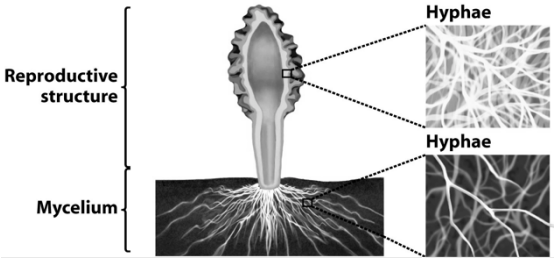
- a fascinating kingdom of large multicellular eukaryotes
- 100,000 known species (estimates of 1.5 million)
- nutritional strategy - absorption of dissolved organic compounds
- decomposers (saprobes), symbionts, parasites (pathogens)


Dave Straney (CMBG)


Don Nuss (UMBI)


Ray St. Leger (ENTM)

Basic structure

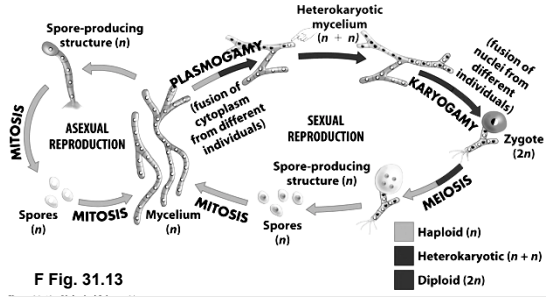


F Fig. 31.6

Hypha - an individual fungal filament
Mycelium - a vegetative mat composed of numerous fungal hyphae
Mushroom - a reproductive structure composed of numerous fungal hyphae

Basic nutritional strategy - Absorption

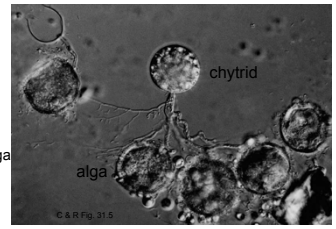
Basic life cycle



F Fig. 31.13

Plasmogamy - the fusion of two hyphae from different mycelia
Heterokaryotic stage (=heterokaryon) - separate haploid nuclei ($n_1 + n_2$) in hybrid mycelium
Karyogamy - the fusion of $n_1 + n_2$ nuclei to form diploid nuclei

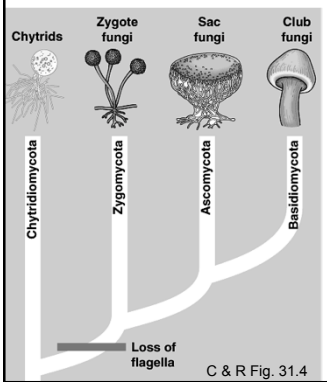
Chytrids - uncertain affinity until rRNA analysis



Zoospore (TEM)

- An obscure group of unicellular or small coenocytic (= multinucleate) aquatic eukaryotes
- Absorptive nutritional strategy as saprobes of organic matter or parasites of other eukaryotes
- Cell walls made of chitin - an amino-sugar polymer
- Flagellated zoospores

Fungal phylogeny



C & R Fig. 31.4

To be or not to be motile,
now that was the question
facing the ancestors of fungi;

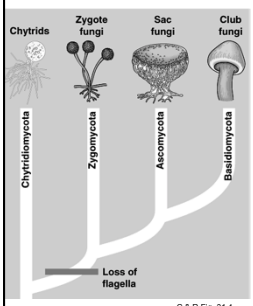
Whither 'tis advantageous to
suffer your fame and fortune
with aquatic life, or

To take arms against the
fresh land full of green plants,
and thereby find a new life.

Ah now, there's the respect that
avoids the calamity of
everlasting extinction!

- my apologies to Shakespeare's Hamlet

Three phyla of terrestrial fungi

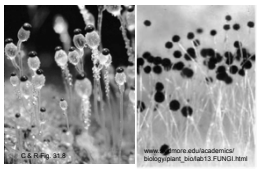


C & R Fig. 31.4

- No flagellated cells
- Different reproductive structures
- Fossil evidence suggests that these phyla may initially have evolved as the symbionts of first land plants.
- Convergent life styles - all 3 phyla act as decomposers, parasites, and symbionts most often associated with plants.
- Decomposers - critical role in the recycling of organic and inorganic nutrients.
- Revised phylogeny - chytrids and zygote fungi are paraphyletic - see Freeman Fig. 31.9

Zygote fungi - zygomycetes

Sac fungi - ascomycetes



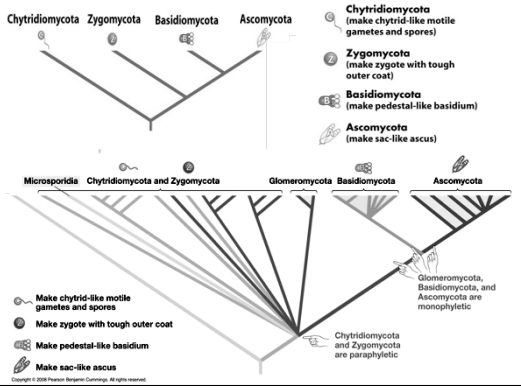
Pilobolus **(dung fungus)** ***Rhizopus*** **(bread mold)**

A) ***Hygrophorus*** **(scarlet cup)** **B)** ***Tuber*** **(truffles)** **C)** ***Morchella*** **(morel)**

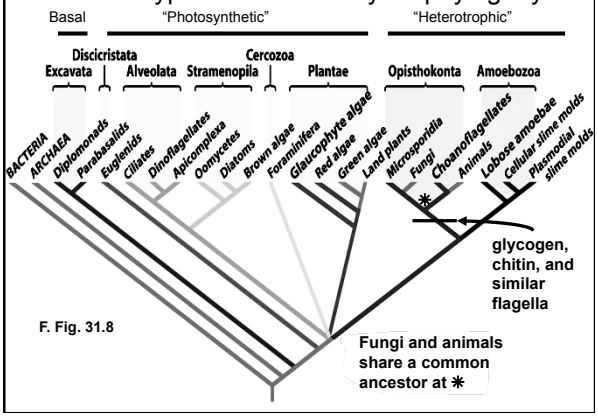
Club fungi - basidomycetes

waxy cap **puffball** **shelf fungus** **stinkhorn fungus**

Fungal molecular phylogeny – Work in progress (F. Fig. 31.9)



Current hypothesis of eukaryote phylogeny

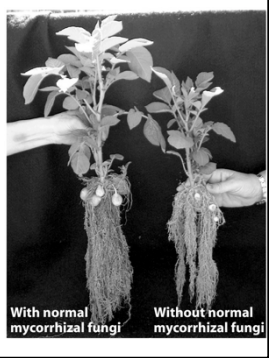


F. Fig. 31.8

Fungal life styles - convergent morphological, physiological, and ecological adaptations

Mycorrhizae ("fungus roots") - mutualistic associations of fungi and the roots of almost all plants

Great agricultural and evolutionary significance



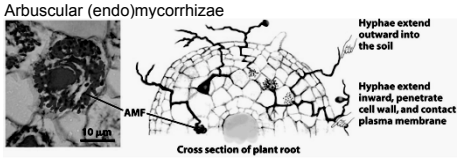
F Fig. 31.1

Mycorrhizae

Ectomycorrhizae

F Fig. 31.11

Arbuscular (endo)mycorrhizae

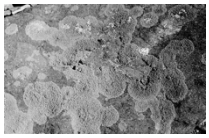


- Fungal mycelium extends from root surface into the surrounding soil, greatly increasing the surface area for ion uptake, especially PO_4^{3-}.
- Plant supplies organic nutrients to the fungus

Lichens - unusual plant-like "organisms" often found growing on barren soil, rocks, trees, and concrete often in harsh environments

botit.botany.wisc.edu/images/332/Lichens/Foliose_lichen_130_d.html

Foliose (leaf-like) lichen



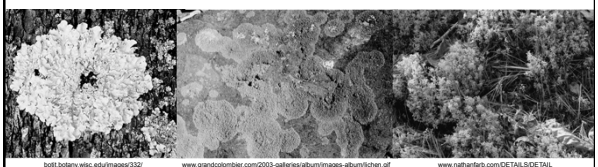
www.grandcolombier.com/2003-galleries/album/images-album/lichen.gif

Crustose lichen

www.nathanfarb.com/DETAILS/DETAIL_Reindeer%20Moss%20on%20Ledge.jpg

Fructose (shrub-like) lichen ("reindeer moss")

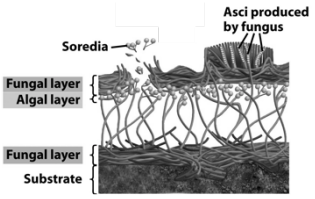
Lichens



botit.botany.wisc.edu/images/332/Lichens/Foliose_lichen_130_d.html www.grandcolombier.com/2003-galleries/album/images-album/lichen.gif www.nathanfarb.com/DETAILS/DETAIL_Reindeer%20Moss%20on%20Ledge.jpg

- Tight symbiosis - 25,000 named species as if they were single organisms.
- Separated symbionts can grow in the lab, but the fungi do not survive well, if at all, in the wild.
- Lichens can tolerate extreme cold and arid conditions, in which the separated symbionts can not live by themselves.
- Lichens are important pioneers on barren rock and soil surfaces, such as burned forests and volcanic flows.

Lichen - tight symbiotic association of a fungus with a green alga or a cyanobacterium



F Fig. 31.20

Alga provides fungus with food by "leaking" carbohydrates.

Fungus provides overall structure, secretes acids to release ions from the substrate, and produces toxins to deter herbivores.

Asexual reproduction involves the formation of **soredia**, which are small clusters of hyphae with embedded algae.

Plant pathogens

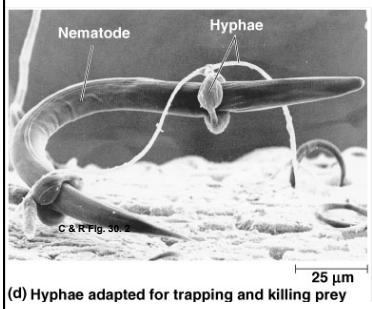
Of the 100,000 known fungal species, c. 30% (!) act as parasites/ pathogens of other eukaryotes, almost exclusively plants.

Puccinia graminis
wheat rust

Claviceps purpurea
rye ergot

Ophiostoma ulmi
Dutch elm disease

Animal pathogens - c. 50 species

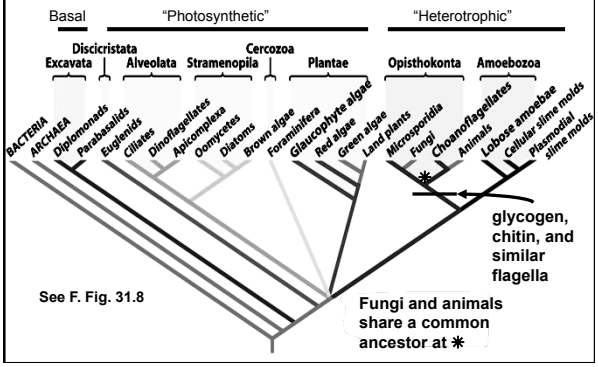


(d) Hyphae adapted for trapping and killing prey

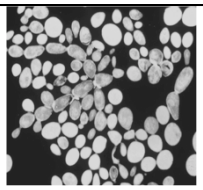
Arthobotys

Entomopathogenic fungus

"It's easy to eat your old companions, but it's more difficult to eat your relatives."



Human significance



Food sources - unicellular fungi (yeasts) involved in winemaking, brewing, and baking.

Saccharomycetes cerevisiae - high metabolic rates

Aerobic baker's yeast - produces CO_2 for raising bread
Anaerobic brewer's yeast - ferments sugar into alcohol

Molecular genetics - the genome of *Saccharomyces* is the best characterized genome of all eukaryotes

Diseases - dermal infections - athlete's foot and ringworm
opportunistic infections - immunocompromised patients

Summary Questions = Learning Objectives

- Filamentous growth form specialized for the absorption of dissolved nutrients
- How have the fungi modified the typical eukaryotic life cycle?
- Major ecological role as decomposers
- Most basal phylum is the aquatic chytrids
- Early evolution of terrestrial phyla associated with the origin of land plants
- Convergent lifestyles of major terrestrial phyla
- Important plant-fungal interactions include mycorrhizae, lichens and diseases
- How do phylogenetic relationships affect the ability of the fungi to act of pathogens of plants? Of animals?
- How do humans use the fungi?