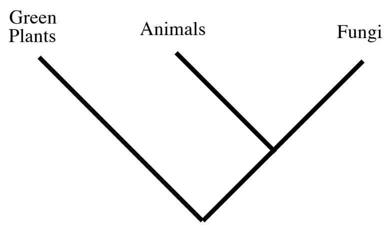
Green Plants

Include:

- Green Algae
- Land Plants

Do not include:

- Red or Brown Algae
- Fungi !



Note that fungi are more closely related to animals than to plants.

Although the *diversification* of animals (during the Cambrian Explosion) occurred before the diversification of green plants, the move towards *terrestrial life* began with the green plants.

Animal diversification:	Cambrian: about 540 million years ago
First land plants:	Silurian: over 400 million years ago
First land animals:	slightly later

The evolution of land plants was marked by important changes that permitted them to live and thrive outside of an aquatic environment.

Unlike aquatic algae, land plants must cope with:

- new ways to get water and nutrients
- new ways to transport water and nutrients
- the problem of dessication
- non-aqueous fertilization
- sudden and severe environmental changes
- gravity

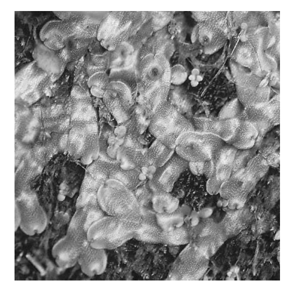
Land plants we will learn:

- Bryophytes (mosses and liverworts)
- Tracheophytes (vascular plants)
  - Lycopods
  - Horsetails
  - Ferns
  - Seed plants
    - "Gymnosperms"
      - Basal lineages
      - Conifers
    - Angiosperms (flowering plants)
      - Monocots
      - Dicots

BRYOPHYTES

- Bryophytes include mosses and liverworts
- Small bodied plants that cannot be fully independent of standing water; thus, they tend to live in damp places.
- Wet habitats provide a medium for water transport, and fertilization

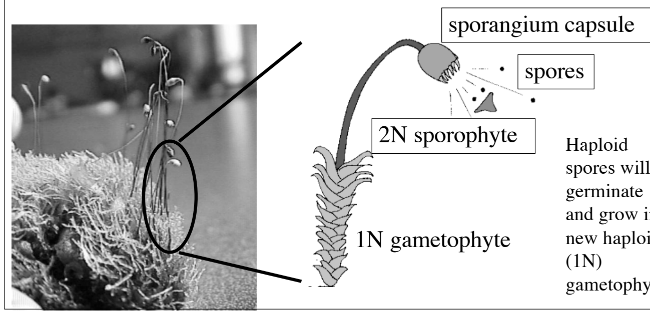
moss



liverworts

Bryophyte life cycles are characterized by alternation of generation, with the green gametophyte being the dominant phase. The haploid spores are produced in sporangia capsules during the sporophyte phase.

In a moss, the sporophyte phase performs photosynthesis but is somewhat parasitic on the gametophyte phase.



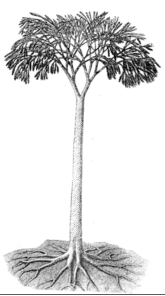
Haploid spores will germinate and grow into new haploid (1N) gametophytes

TRACHEOPHYTES: Vascular plants

- The evolution of a vascular system in the sporophyte phase made possible the transport of water and nutrients up from the soil and around the plant itself.
- This allowed land plants to become independent of standing water, and to colonize more kinds of terrestrial habitats
- All land plants except mosses and liverworts are vascular plants.

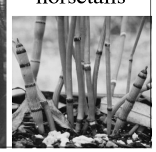
Lycopods and Horsetails: ancient lineages that still survive today

- Lycopods and horsetails were the first to evolve differentiated and specialized body parts within the sporophyte phase, resulting in true roots, stems, and leaves.

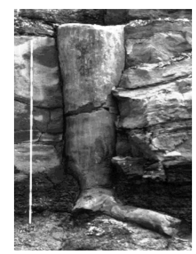


lycopods

horsetails



Giant tree-like lycopods and horsetails were some of the dominant land plants during a period of time we now call the Carboniferous, from 300 to 350 million years ago. Most of the coal we use today was formed from these extinct tree-like giants.



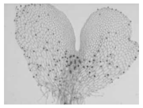
Fossil giant lycopod

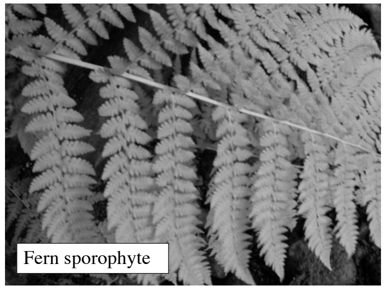
Fossil giant horsetail

< Simulated Carboniferous swamp

Ferns

Like other vascular plants, the dominant phase of the fern life cycle is the sporophyte. The gametophyte phase is small and inconspicuous.


Fern gametophyte


Fern sporophyte


On the undersides of fern leaves are clusters of sporangia called sori (singular: sorus)

THE EVOLUTION OF THE SEED

- Up to this point, no plants we have discussed have seeds
- A seed is basically an embryo (young sporophyte) packaged in a protective coat with a supply of nutrients. Seeds are much less vulnerable to unfavorable environmental conditions, and they can remain dormant for extended periods of time without germinating.
- In seed plants, the gametophyte has become even more reduced -- often tiny -- and cannot perform photosynthesis on its own. It is therefore completely dependent on the sporophyte phase.
- Seed plants have undergone even more extensive specialization of tissues and structures, including:

  Meristem tissue, where growth occurs
  Surface tissues (e.g. epidermis) for protection
  More specialized vascular tissues that can transport water and nutrients to great heights, and are also used as support

"GYMNOSPERMS": Basal Lineages and Conifers

- Are not monophyletic
- Includes basal lineages that were once dominant and widespread, such as cycads and ginkgos (both still extant)


A cycad or "sago palm"


Ginkgo biloba

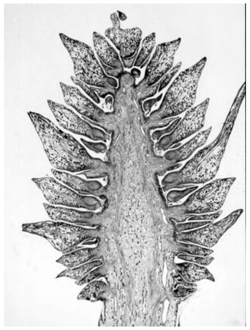
CONIFERS (Gymnosperms): pines, spruces, firs, cedars, and others

- Have unique evergreen leaves commonly called needles
- Have large female cones and small male cones that produce haploid F. megaspores and M. microspores, respectively

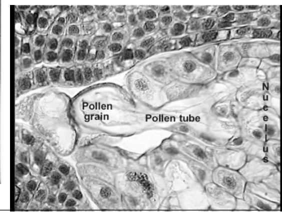
By this point in plant evolution, the gametophytes have become highly specialized reproductive structures and cannot live alone

Female gametophytes exist in ovules within a female pine cone.

Male gametophytes exist as individual pollen grains.

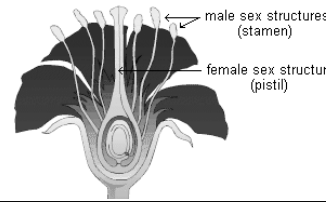


Conifers are wind pollinated. When pollen reaches an ovule, a pollen tube grows out of it, fertilization occurs, an embryo develops, and the ovule is shed as a seed.



THE EVOLUTION OF THE FLOWER

- Up to this point, no plants we have discussed have flowers
- A flower is a unique reproductive structure totally different from the cone of a conifer. Its parts are made up of modified leaves, and in fact are homologous to leaves.
- In flowering plants, female gametophytes are completely encased within ovaries that are encased in carpels.
- Male gametophytes are highly reduced pollen grains
- Fertilization occurs through the aid of specialized flower structures including male stamens and female pistils.



Angiosperms have become the most diverse plants on Earth

There are over 250,000 known species of angiosperms, with new species being discovered all the time.

Why are angiosperms the most diverse plants on Earth?

- Coevolution with insect (and other kinds of) pollinators
- Coevolution with insects that eat them (evolutionary arms race)
- Better vascular systems allow more rapid movement of fluids
- Seeds dispersed by animals that eat their fruits
- Seeds are highly protected and can remain dormant
- Deciduous lifestyles allow seasonality

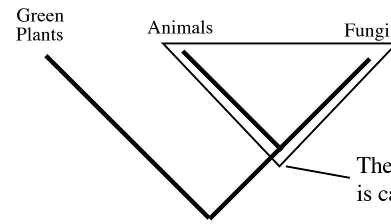
In short, there are likely to have been many diversifying adaptive radiations during the evolutionary history of angiosperms

Why plants are required by other Eukaryotes:

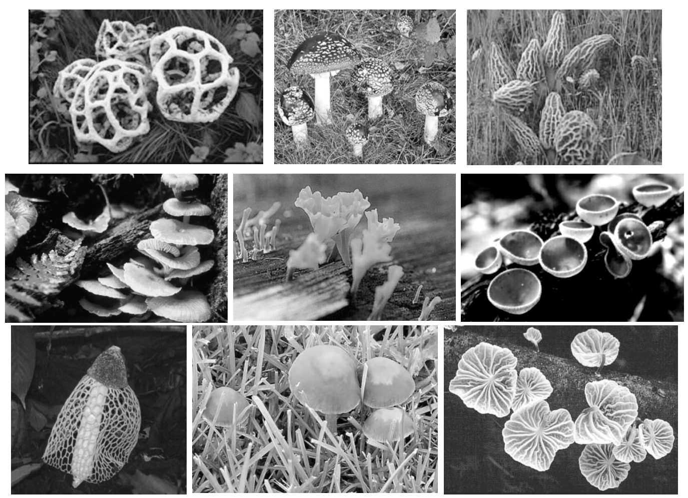
- Plants produce the oxygen that other Eukaryotes need
- Plants live symbiotically with nitrogen-fixing bacteria and are the first organisms that assimilate fixed nitrogen
- Plants form the basis of food chains within all ecosystems

Our Cousins the Fungi

- Fungi and animals are more closely related to one another than either group is to plants.
- This has been determined through molecular phylogenetic analyses.



The clade of fungi and animals is called the **opisthokonts**

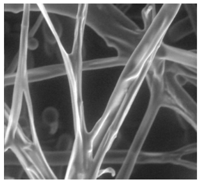


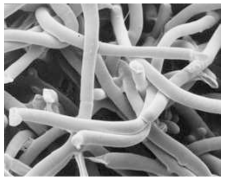
GENERAL CHARACTERISTICS OF FUNGI

- Multicellular or **multinucleate** eukaryotes
- Cell walls contains the polysaccharide **chitin** (what else has chitin?)
- Heterotrophic, and tend to be parasites or **saprophytes**
- Feeding is through **external digestion** and **absorption**
- Many **symbioses** with plants and animals are known
- Two life phases: **somatic** and **reproductive**
- **No** roots, stems, leaves, vascular system, or photosynthesis
- Reproduction is both **sexual** and **asexual**, even in the same species
- **Relatively little** tissue differentiation or specialization

Basic Fungal Anatomy

Fungal cells are organized into tube-like filaments called **hyphae**.

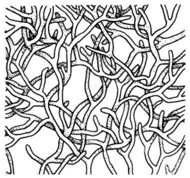


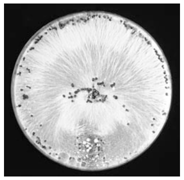


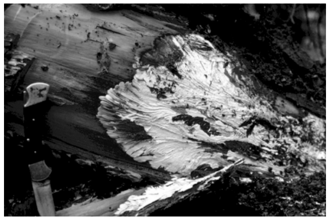
Hyphae are surrounded by a **cell wall**, and grow from the tips.

Basic Fungal Anatomy

The hyphae are organized into a branching mass called the **mycelium**







mycelia on a Douglas fir tree root

The mycelium represents the dominant **somatic** form of fungi:

It grows and feeds as a spreading, branching network of hyphae.

Mycelial masses can be ancient and enormous. A single mycelium in Oregon covers over 2000 acres and is over 2000 years old!

Basic Fungal Anatomy

During the reproductive phase, most fungi generate spore-producing bodies called **sporocarps**. A well known example is the **mushroom**.

Three main fungal groups

Classification is largely based on how they reproduce.

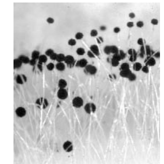
<u>**Zygomycota**</u> (Zygomycetes and Trichomycetes)
"conjugation fungi"

<u>**Ascomycota**</u> (Ascomycetes, including yeasts)
"sac fungi"

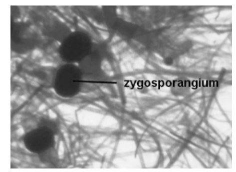
<u>**Basidiomycota**</u> (Basidiomycetes)
"club fungi", including common gilled mushrooms

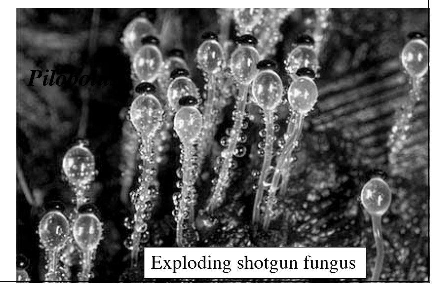
ZYGOMYCOTA
(Zygomycetes)

- **Sporangia** on stalks
- During sexual phase, two hyphae of different mating types come together to form a **zygosporangium** between them



Rhizopus
black bread mold



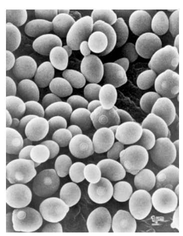


Exploding shotgun fungus

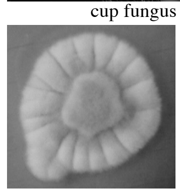
ASCOMYCOTA (Ascomycetes, "sac fungi")

- Sac-like cells called **asci** (sing. ascus) each contain 8 **ascospores**
- Most asci are produced in sporocarp structures called **ascocarps**
- Most fungi involved in **lichen symbioses** are ascomycetes
- Ascomycetes important to humans include those that produce antibiotics such as penicillin; yeasts used in baking and fermentation; and edibles such as morels

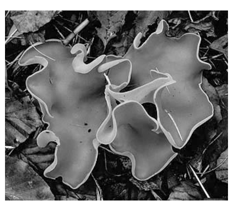
cup fungus



yeast



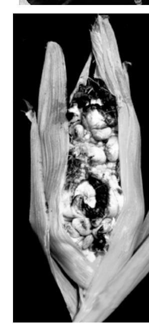
penicilli
n



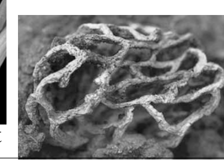
morel

BASIDIOMYCOTA
(Basidiomycetes)
"club fungi"

- Reproductive structures called **basidia** usually form 4 **basidiospores**
- **Fruiting bodies** (sporocarps) are made of hyphae. One example is a gilled **mushroom**.
- Other basidiomycetes include the plant pathogens **smut** and **rust fungi**



corn smut



A “fairy ring”

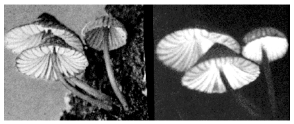
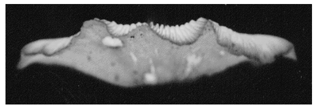
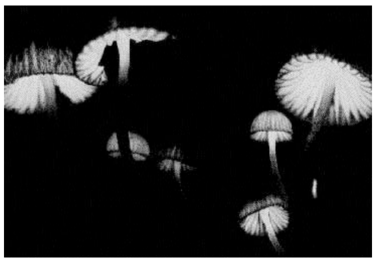
And now it’s time for some famous fungal stories

- Weird things fungi do
- Symbioses involving fungi
- Fungi significant to humans

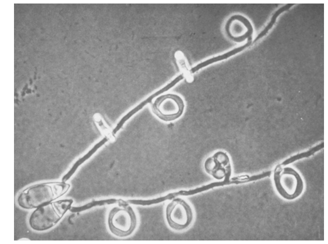
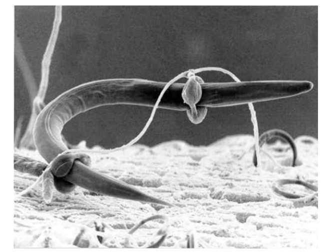
Some fungi are **bioluminescent** -- they glow in the dark!

Chemical glowing may attract insects to aid in spore dispersal

Or, it may facilitate DNA repair, or oxygen detoxification


Nematode trapping

Nematodes are tiny worms abundant in the soil.

Some fungi form loops and snares with their hyphae, and when a nematode crawls through, the snare tightens and traps the worm

Like bioluminescence, nematode trapping has evolved multiple times independently in the Fungi

Some Zygomycota are predators or pathogens of invertebrates

Rotifers caught by "lethal lollipops" of *Zoophagus* fungus

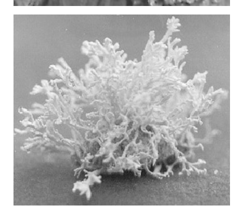
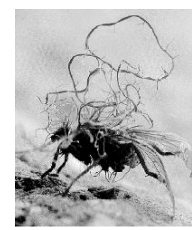
A fly parasitized by *Entomophthora*, surrounded by the released spores.

Behavioral modification in a Grasshopper infected with *Entomophaga* aids spore dispersal

Some Ascomycota are obligate pathogens of insects

for example, the genus *Cordyceps*

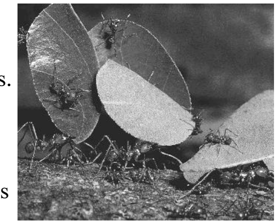
Asian athletes have long ingested caterpillar fungus for its antioxidant and stimulating properties. In the 1993 Olympics, the Chinese women's track team attributed their huge success to *Cordyceps*.


Flower mimicry

The basidiomycete rust fungus *Puccinia monoica* is a pathogen of mustard plants. It inhibits the formation of flowers in the host plant, and instead causes the growth of a yellow "pseudoflower" from the plant's leaves. This structure fools insects, and by attracting them helps complete the life cycle of the fungus.

- Leafcutter ants of the genus *Atta* live in intimate symbiosis with Basidiomycete mycelia that cannot live without the ants.
- Different species of ants tend different species of fungi.
- Termites have a similar fungal symbiosis



Some mushrooms produce mild toxins that are potent **hallucinogens**

Many traditional religions worldwide employ the use of hallucinogenic (or **entheogenic**) mushrooms for spiritual and religious purposes.

A famous example is the **Teonanacatl** ("flesh of the gods") used in Mexico and Central America, and dating back to the time of the Mayans. These mushrooms were "rediscovered" by Western scientists who visited Mexico in the 1940's.

Psilocybe mushrooms are now used recreationally around the world, but as hallucinogens, their possession is illegal in many countries including the U.S.

Psilocybe sp.

Mushroom fetish stone

Maria Sabina, a famous Mexican shaman and healer