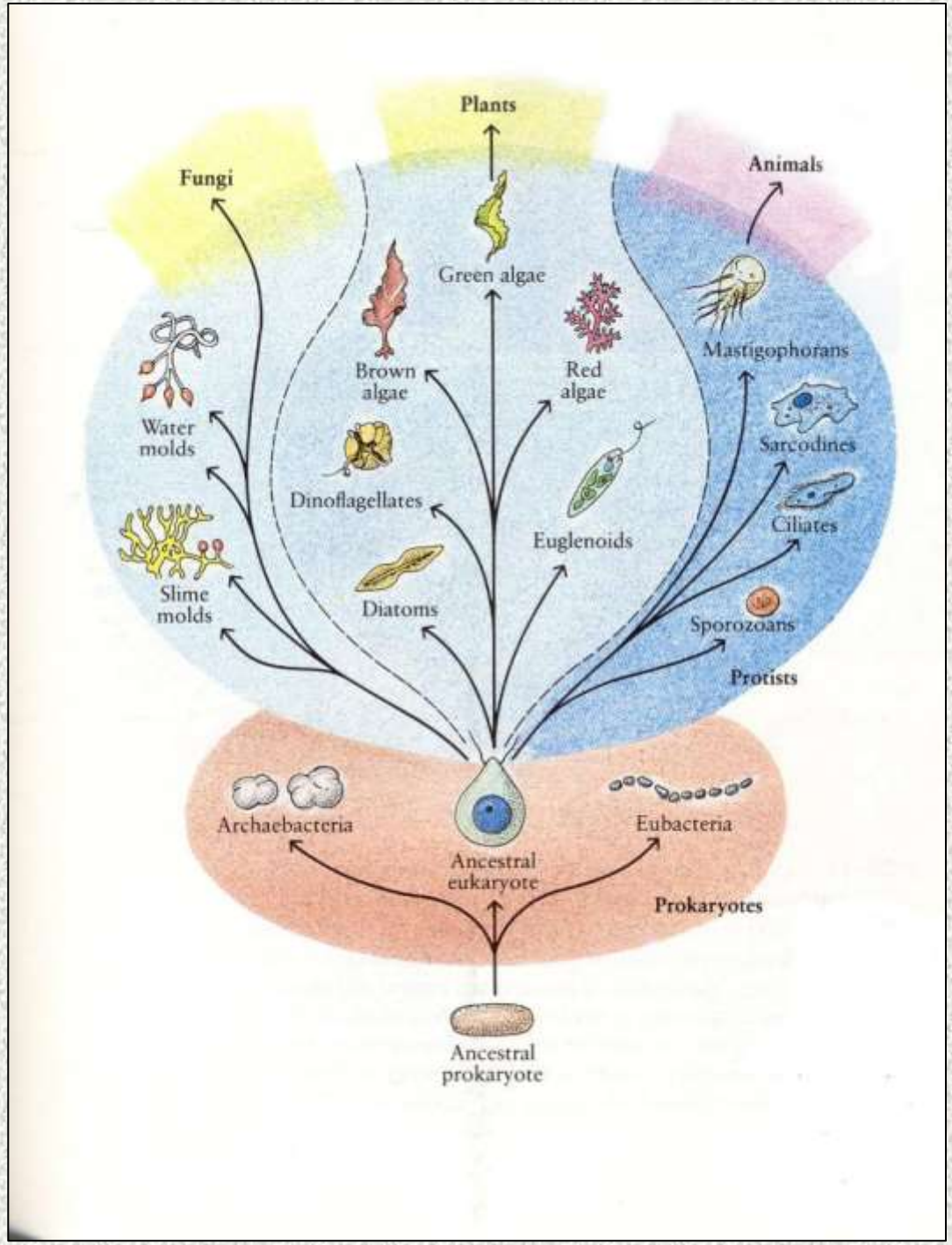
Introduction to the Fungi

General Characteristics

- Often treated as separate Kingdom Fungi, with roots in the Protista
- Once treated with plants, but lack chlorophyll, not at all related
- Heterotrophs like animals – ingest food by absorption
- Decomposers – important role in ecosystems, recycle materials
- Ancient group, among first to invade land
- Medicinal, magical, dangerous reputation

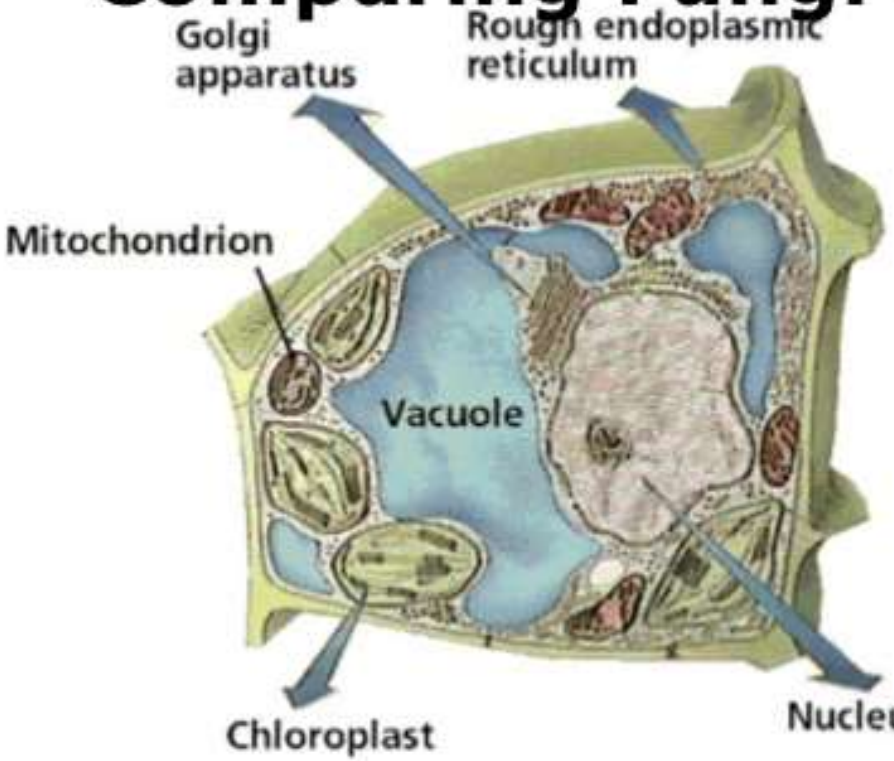
- Plants, animals, and fungi trace their ancestry to protists
- Common ancestor of animals and fungi was aquatic, flagellated, single-celled protist.

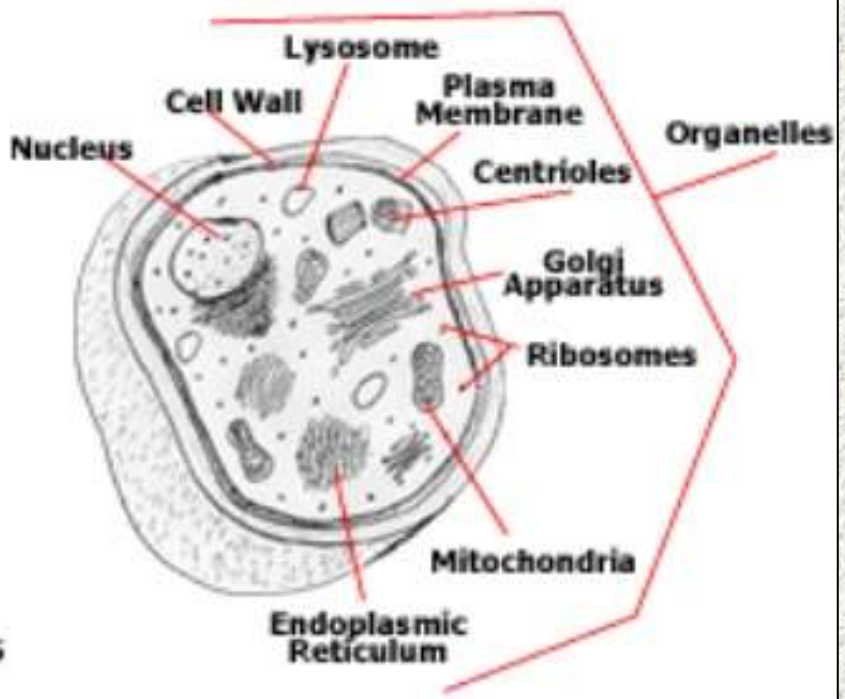


General Characteristics

- Eukaryotic
- Most are multicellular
- Filamentous body plan
- Heterotrophic by Absorption
- Produce spores by sexual and asexual reproduction
- Haploid for part or most of life cycle
- Cell wall made of chitin
- No movement: change location by growth of body or dispersion of spores

Comparing Fungi and Plant Cells



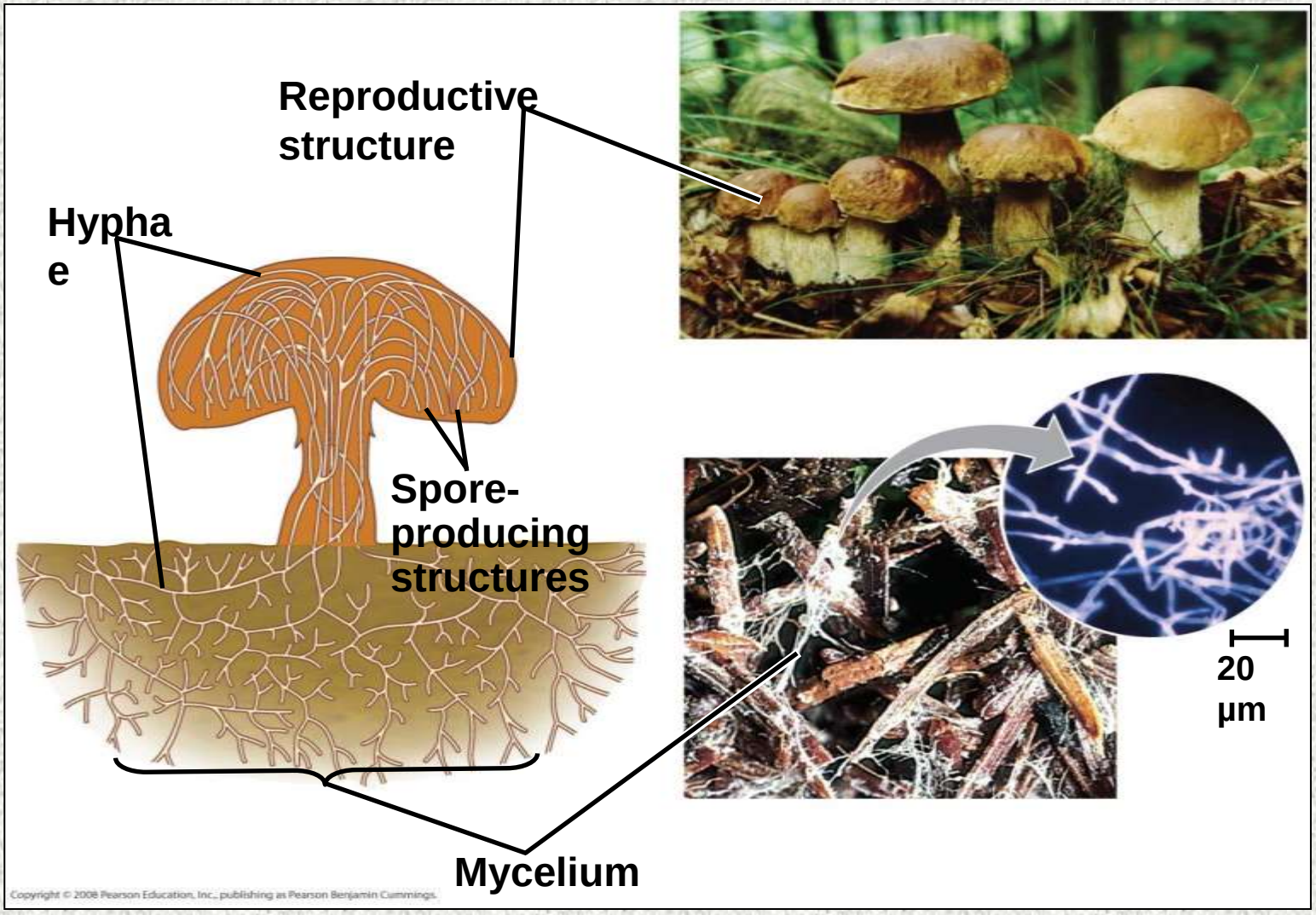


a) Fungal cells do not have chloroplasts (plants do)

b) Fungal cells are heterotrophic (plants are autotrophic)

c) Fungal cells have rigid cell walls made from chitin (plants have walls made of cellulose)

Structure of Fungi – hyphae, mycelium

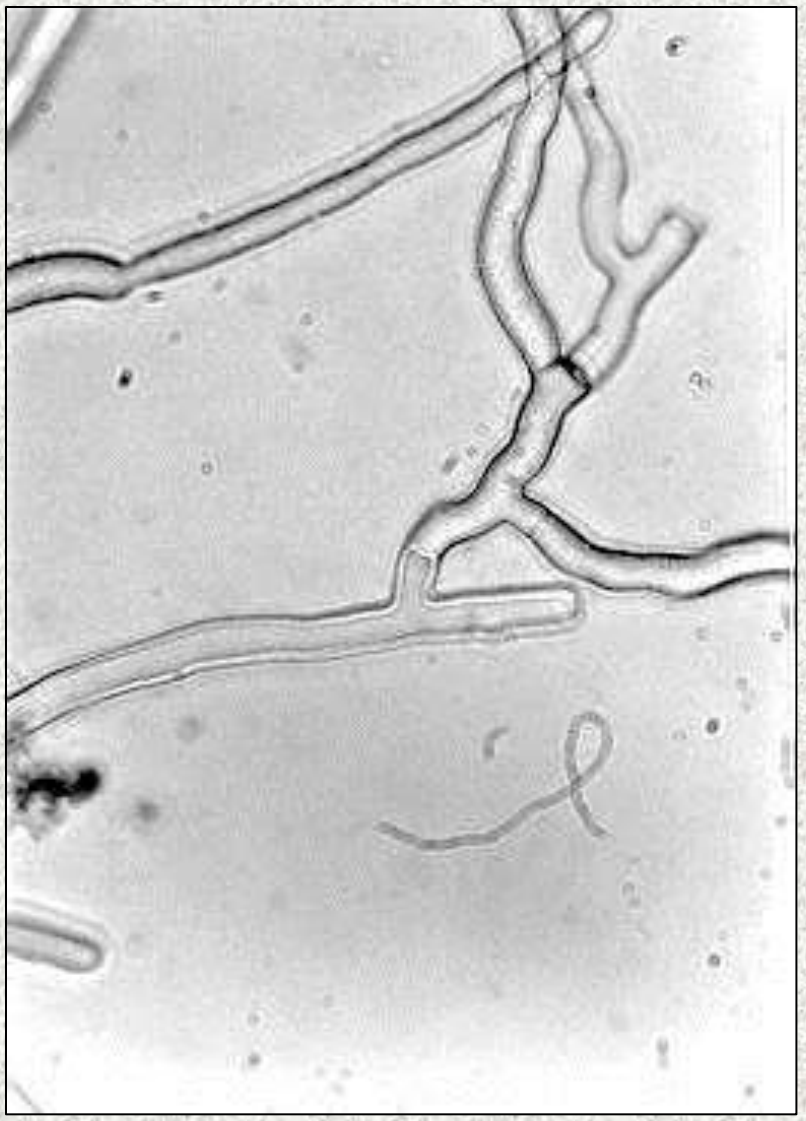


Fungal Hyphae

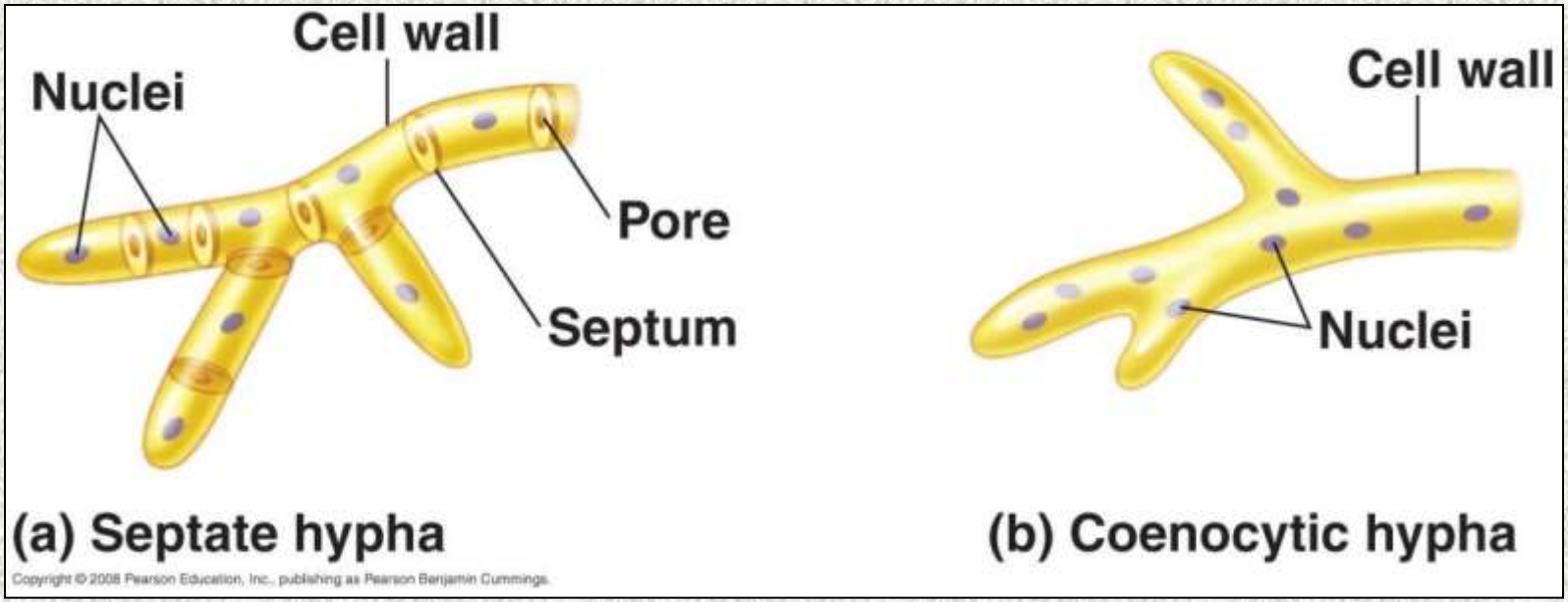
- Thread of cells
- One cell thick
- High surface area to volume ratio
- Absorb water, ions, nutrients
- Gas exchange
- Waste disposal

Fungal Hyphae

- Tubular
- Hard wall of chitin
- Grow at tips
- Sensitive to environment, grow toward food sources
- Mycelium = network of hyphae



Hyphal Types



Two kinds:

Septate – with crosswalls, form compartments

Coenocytic – multinucleate, no crosswalls

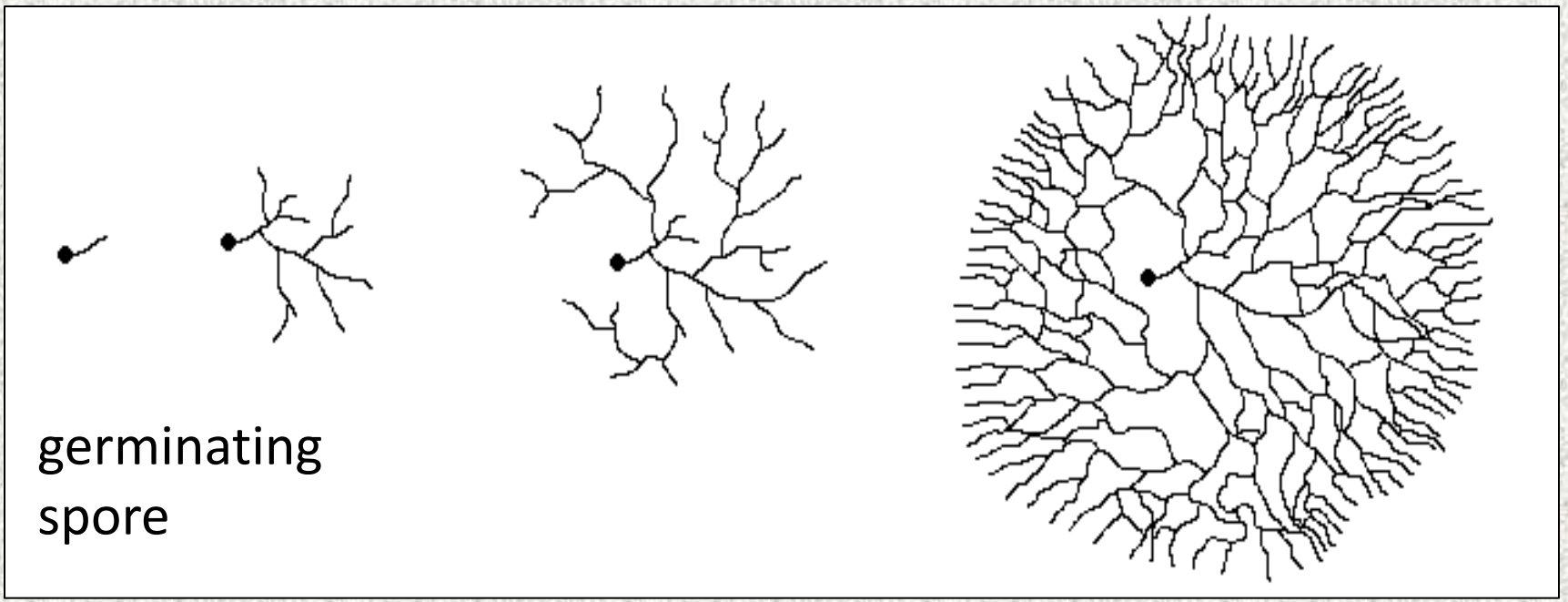
Septa have pores that allow mitochondria and material to flow quickly to tip, allowing the tip to grow quickly.

Mycelium – mass of hyphae

Oyster mushroom (*Pleurotus ostreatus*) mycelium on coffee grounds

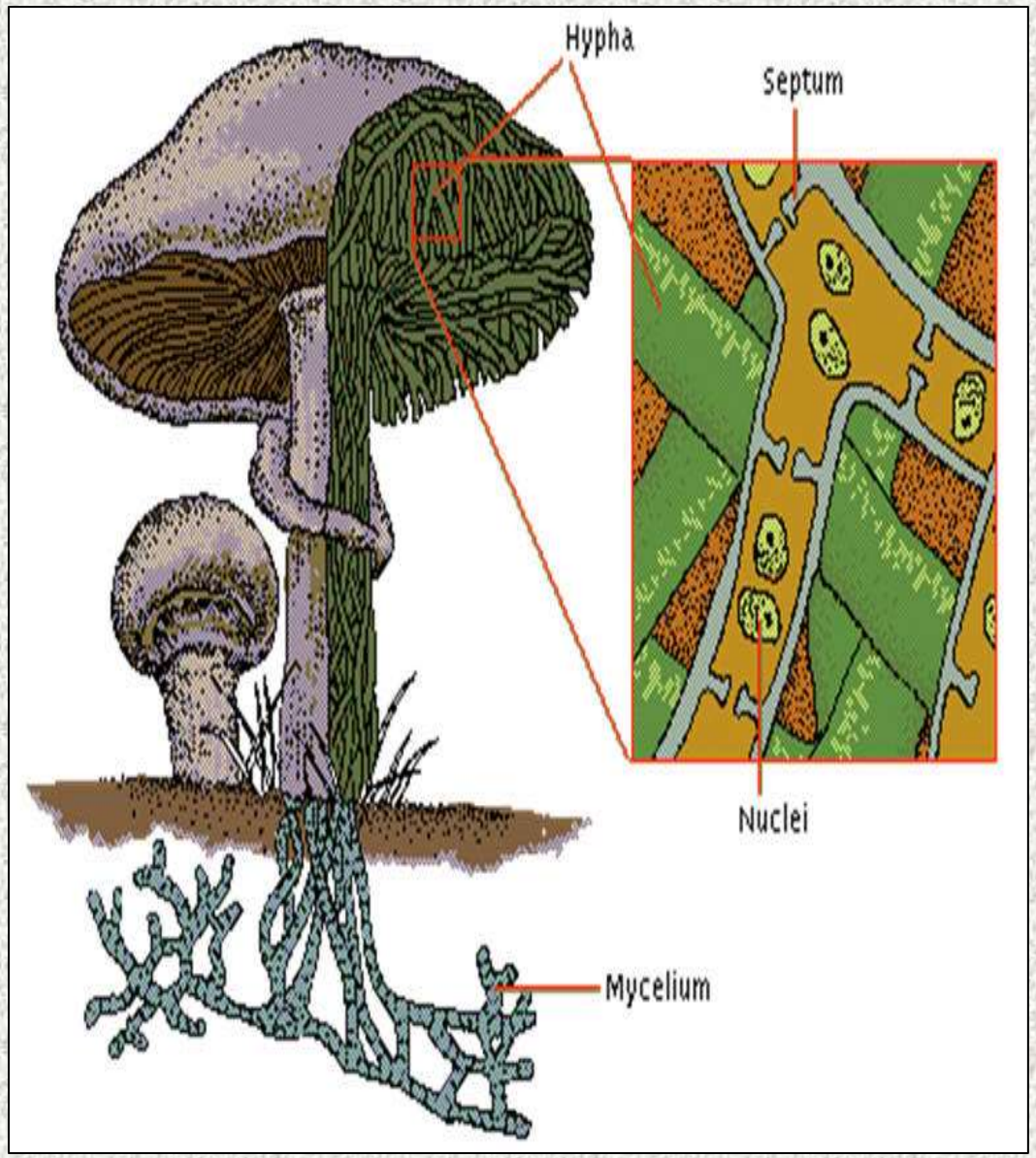
- Mycelia have a huge surface area

Hyphal growth from spore



Hyphae in some fungi are dikaryotic, have 2 haploid much of the time

The 2 nuclei fuse in sexual reproduction, meiosis occurs, new haploid spores produced

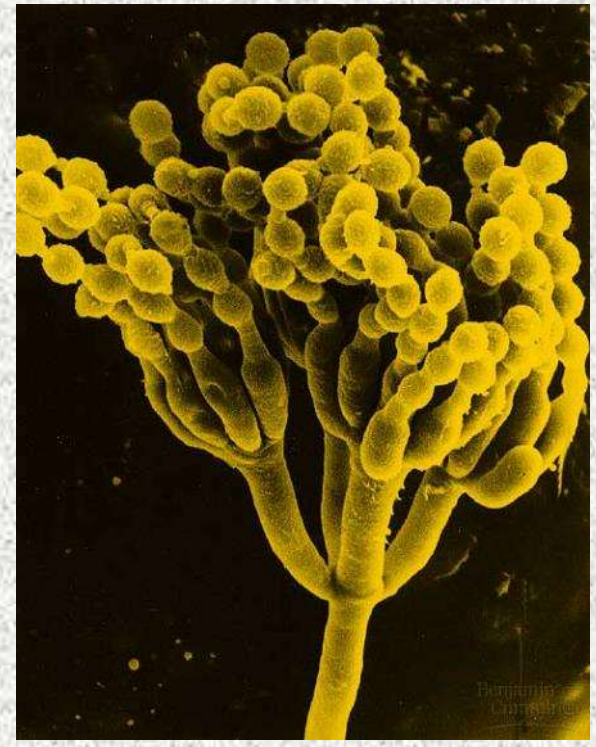


Reproduce by spores

- Spores are reproductive cells
  - Sexual (meiotic in origin)
  - Asexual (mitotic in origin)
- Formed:
  - Directly on hyphae
  - Inside sporangia
  - Fruiting bodies

Amanita fruiting body

Pilobolus sporangia



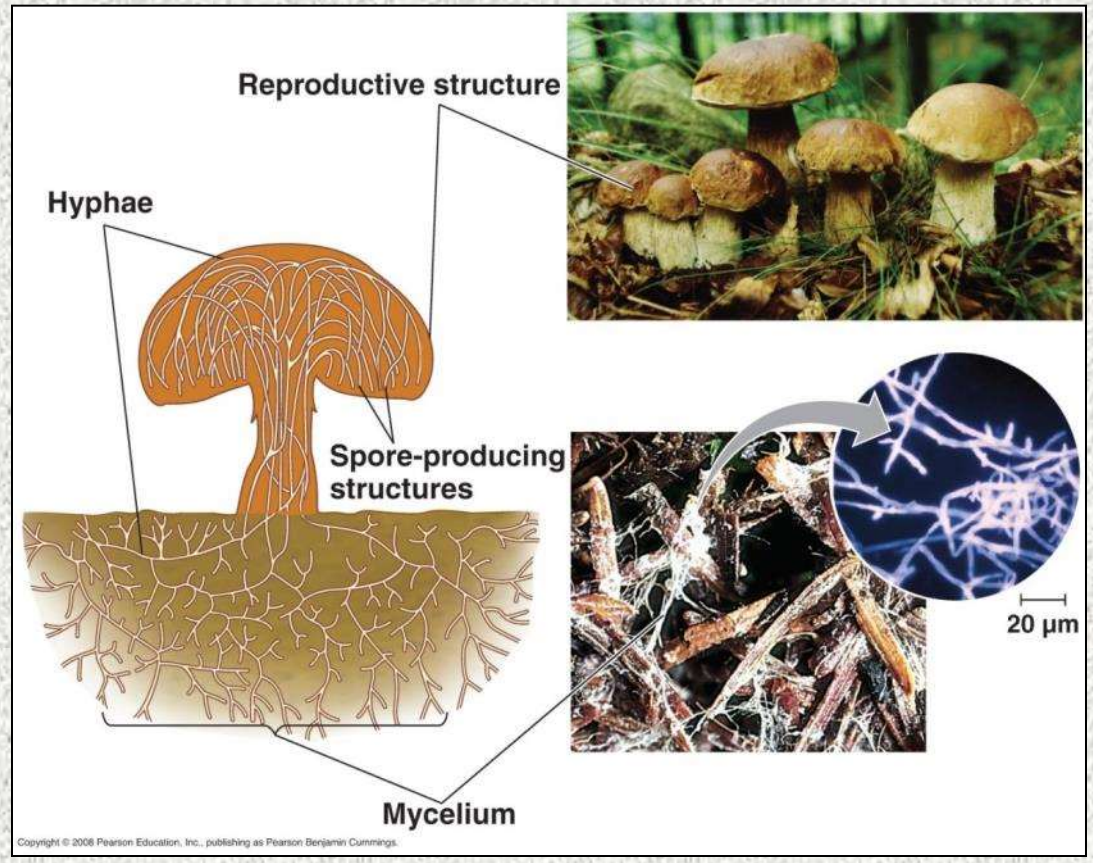
Penicillium hyphae with conidia

Reproductive Structures

- Asexual or sexual
- Make spores, either by mitosis or meiosis
- Reproductive structures are called “fruiting bodies”

Reproductive Structures

- Made of hyphae
- Produce spores
- Different shapes and sizes in different fungal groups



Fungal Nutrition

- Heterotropic by absorption
  - secrete digestive enzymes
  - digest macromolecules outside the body
  - absorb digested nutrients
- Three nutritional modes
  - Saprophytic = digestion of dead organisms
  - Parasitic = digestion of live organisms, causing disease
  - Mutualistic = beneficial relationship for two independent organisms

Fungi as Saprobes and Decomposers

Fungi as Saprobes and Decomposers

Fungi as Saprobes and Decomposers

Fungi as Saprobes and Decomposers

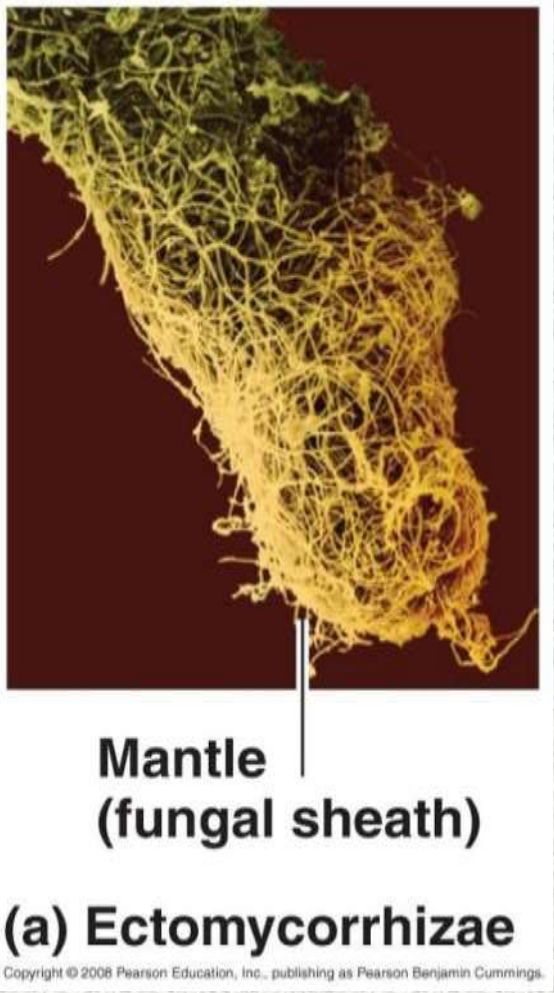
Fungi as Parasites & Pathogens

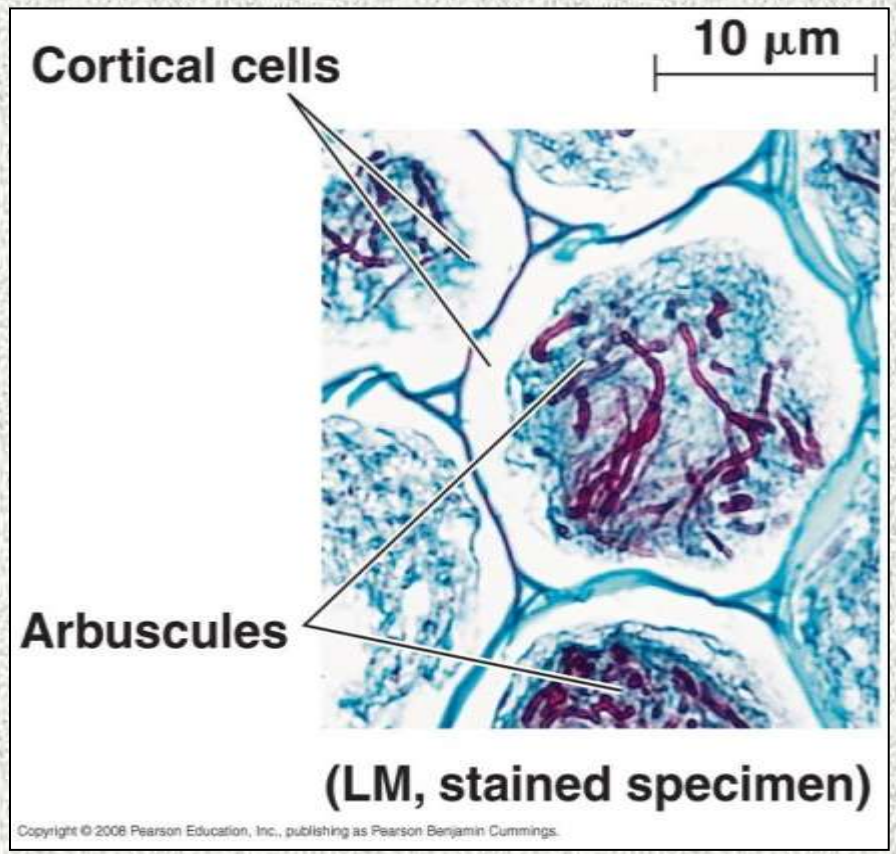
Mycorrhizae - Mutualism

- "Fungus roots"
- Mutualism between:
  - Fungus (nutrient & water uptake for plant)
  - Plant (carbohydrate for fungus)
- Several kinds
  - Zygomycota – hyphae invade root cells
  - Ascomycota & Basidiomycota – hyphae invade root but don't penetrate cells

- **Extremely** important ecological role of fungi!

Mycorrhizae

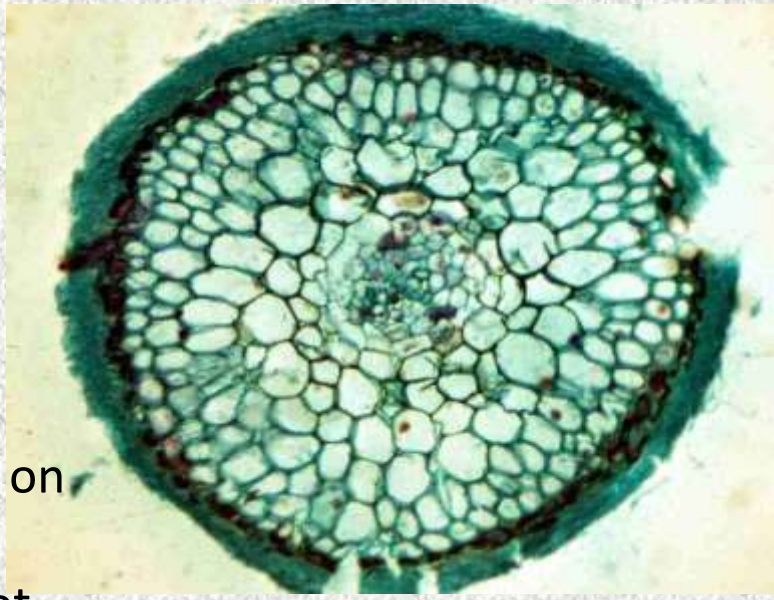




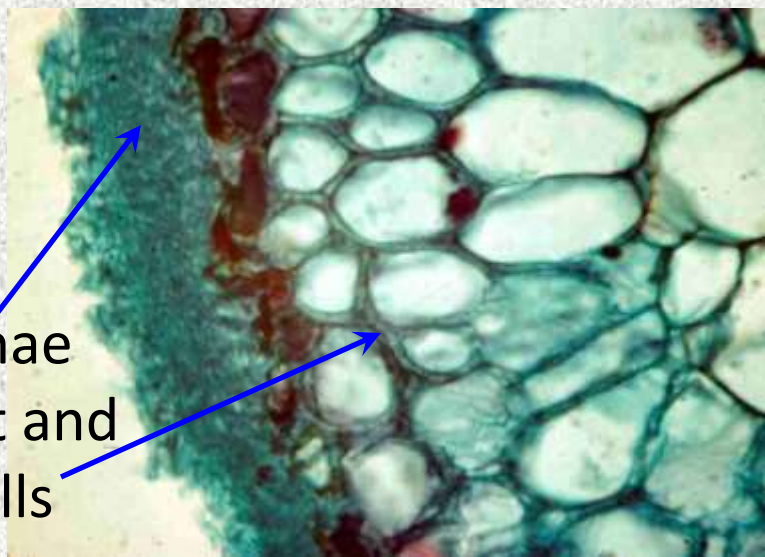
(b) Arbuscular Mycorrhizae
Formed only by Glomeromycota

“Ecto”mycorrhizae

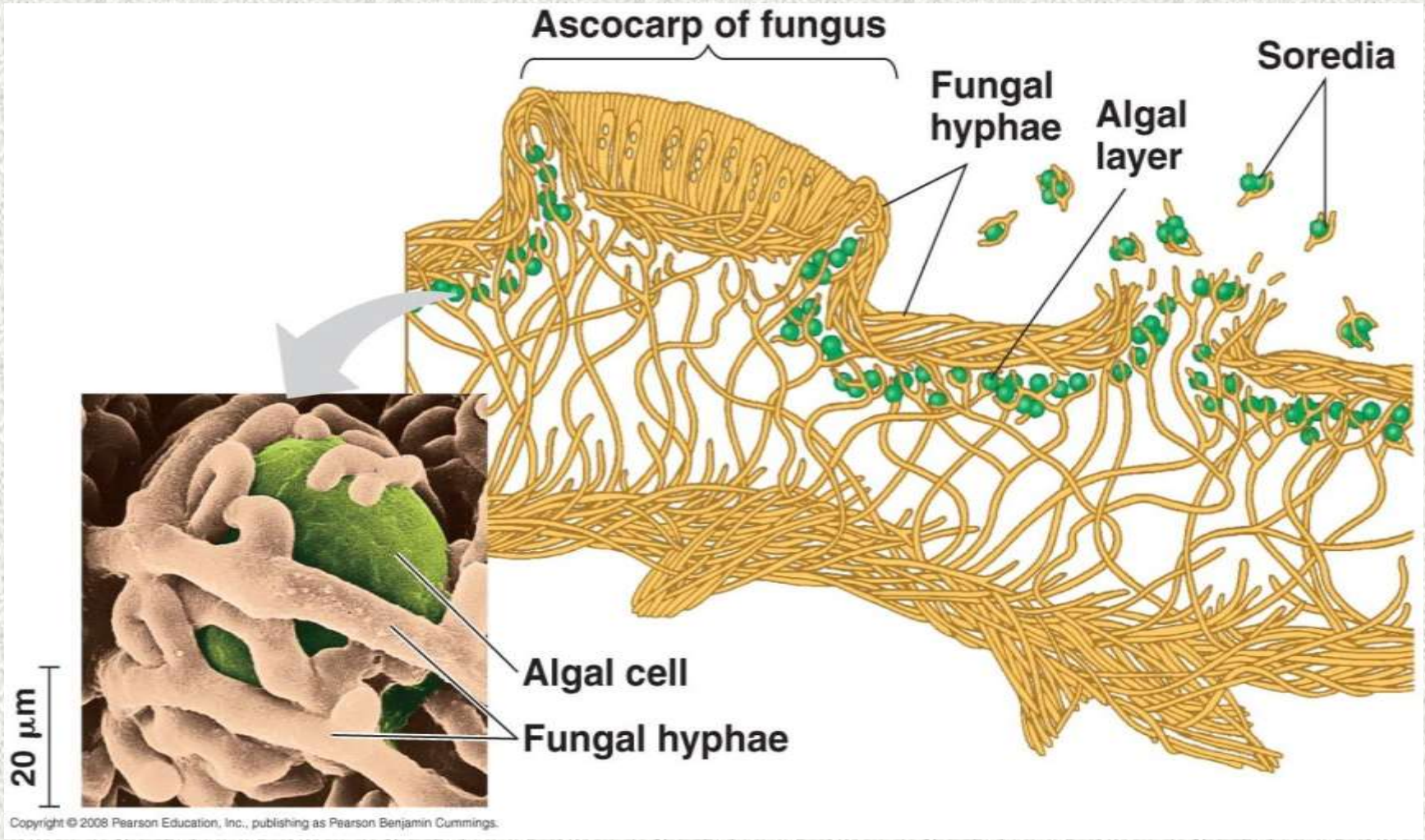
Russula mushroom mycorrhizas on Western Hemlock root



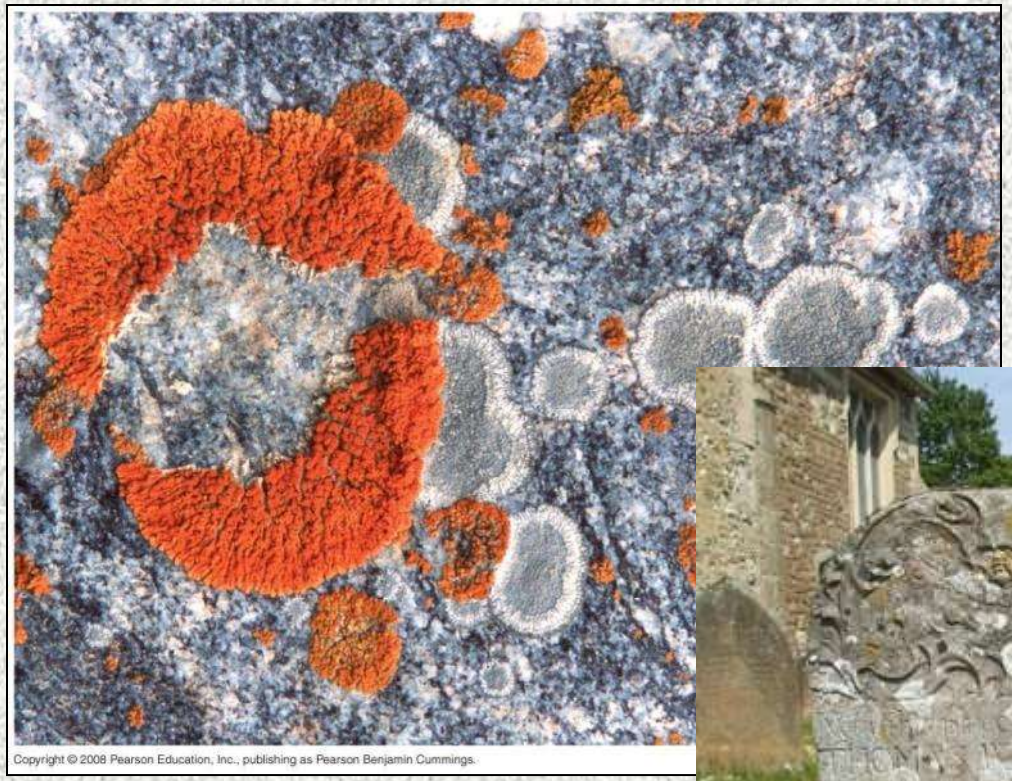
Mycorrhiza cross sections



Fungal hyphae around root and between cells



Crustose Lichens

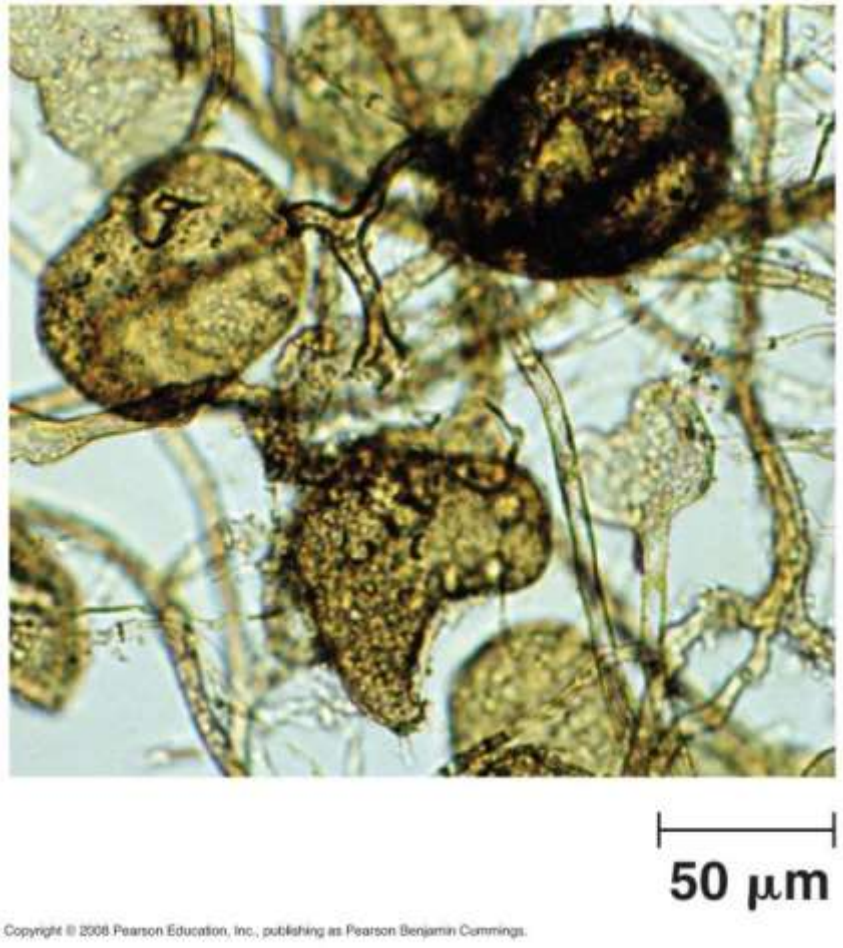


Foliose Lichens

Fruticose Lichens

Evolution of Fungi

- Earliest fossil fungi
  - Fungal spores
  - 460 million years old



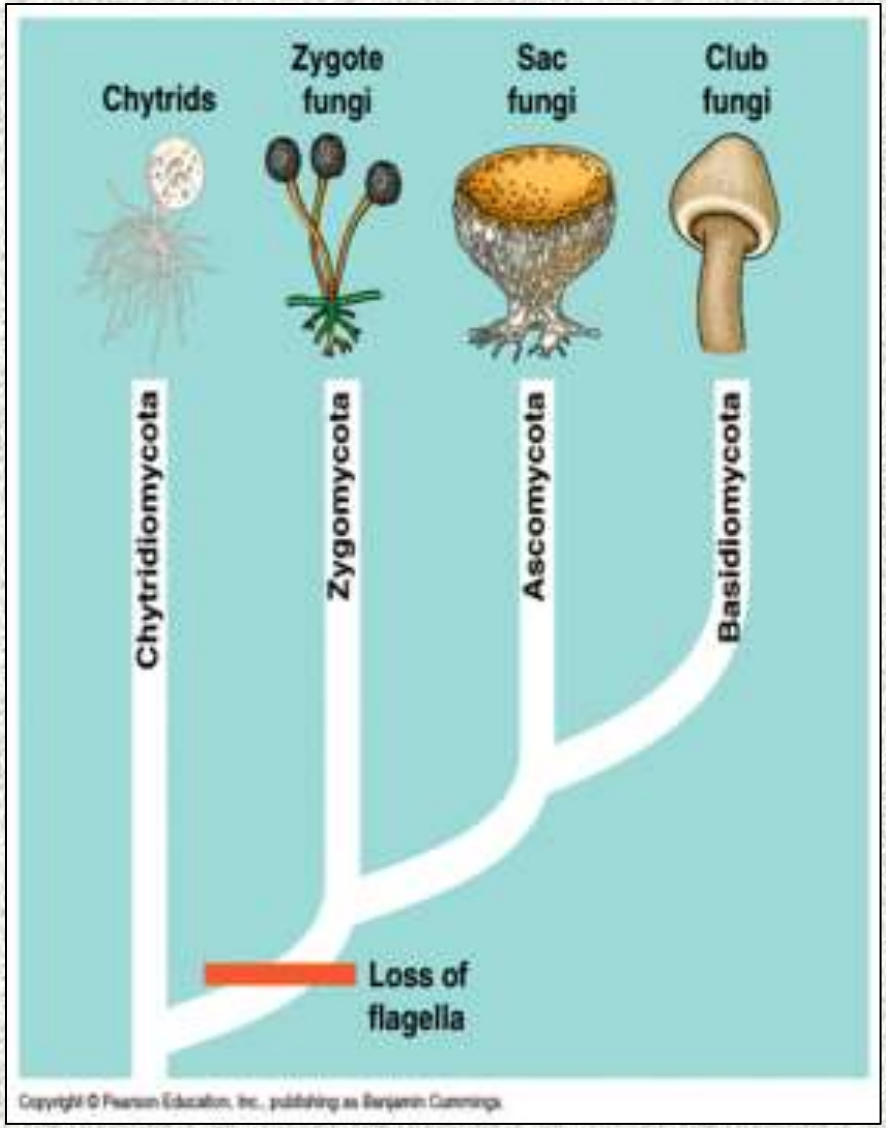
First forests? Prototaxites fungus as it may have looked during the early Devonian Period, approximately 400 million years ago.

Painting by Mary Parrish

Classification of Fungi

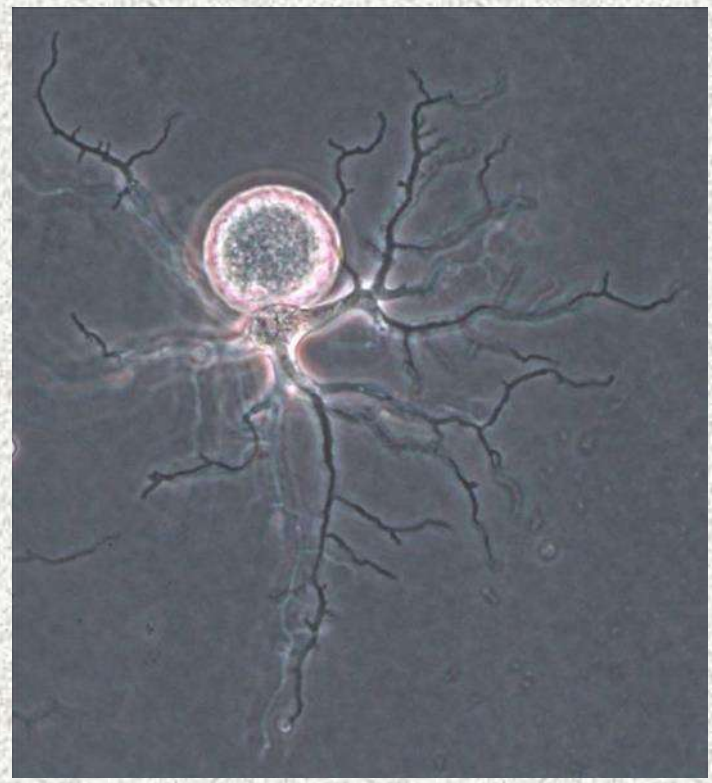
Major Groups

- Chytrids
- Zygomycetes
- Ascomycetes
- Basidiomycetes



Chythrid Fungi

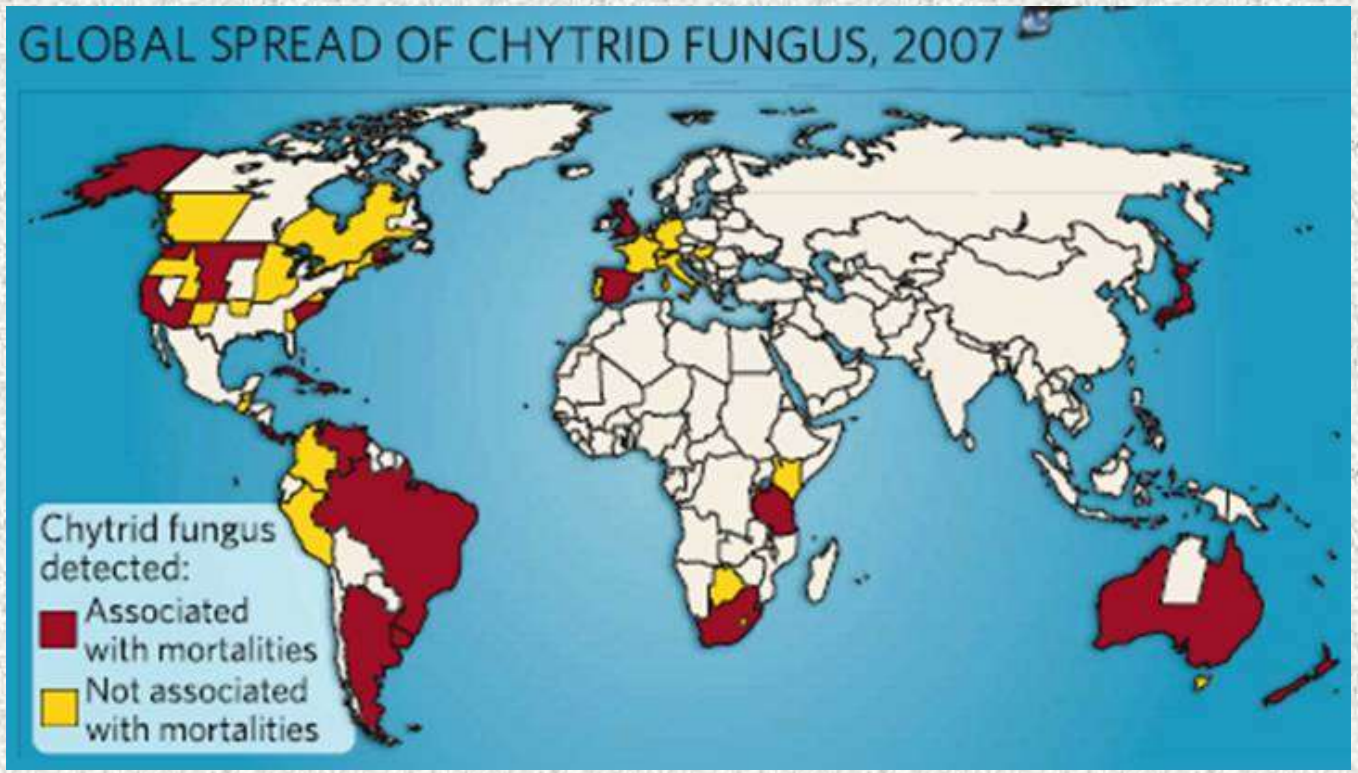
- Spores flagellated, swimming spores require water for dispersal
- Ancestral group, gave rise to modern fungi



Amphibian Chytrid Disease

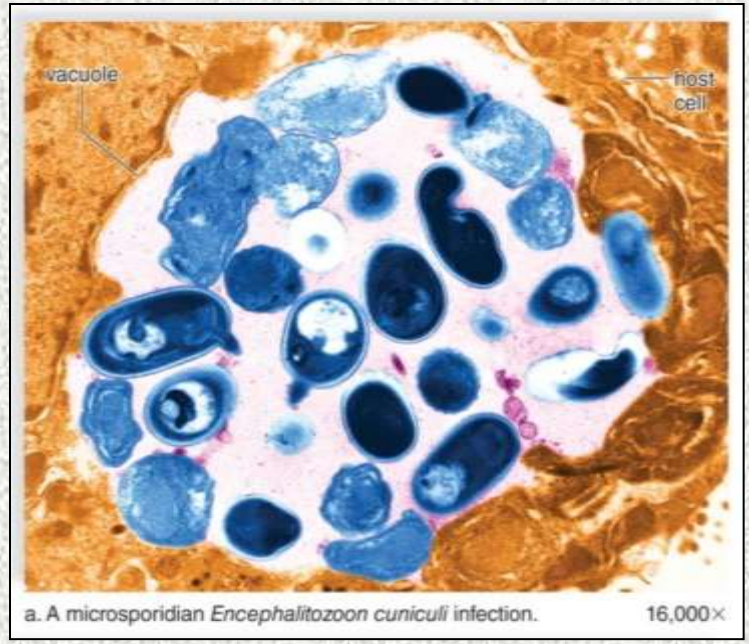
- Infects the skin
- Devastating species
- Causing extinctions

Batrachochytrium dendrobatidis

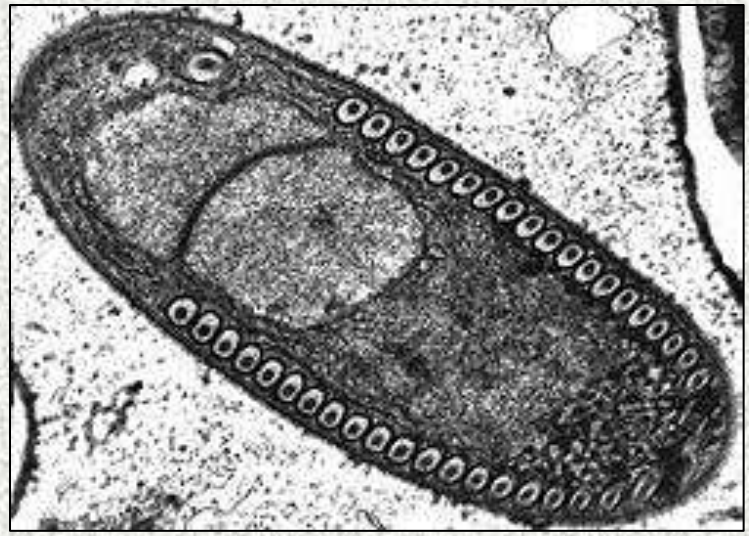


Microsporidians – Parasitic Fungi

- Single-celled, once thought to be primitive Protistans
- Infect animals, usually one species or group of species
- Lack mitochondria, probably lost them, get energy from host
- Non-motile, Lack flagella
- Smallest eukaryotic genome

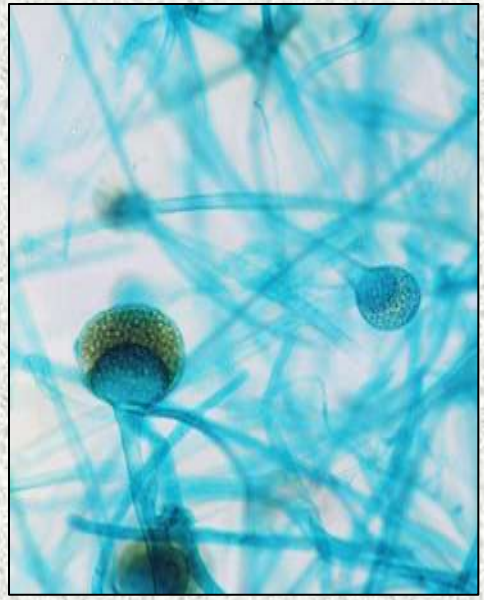


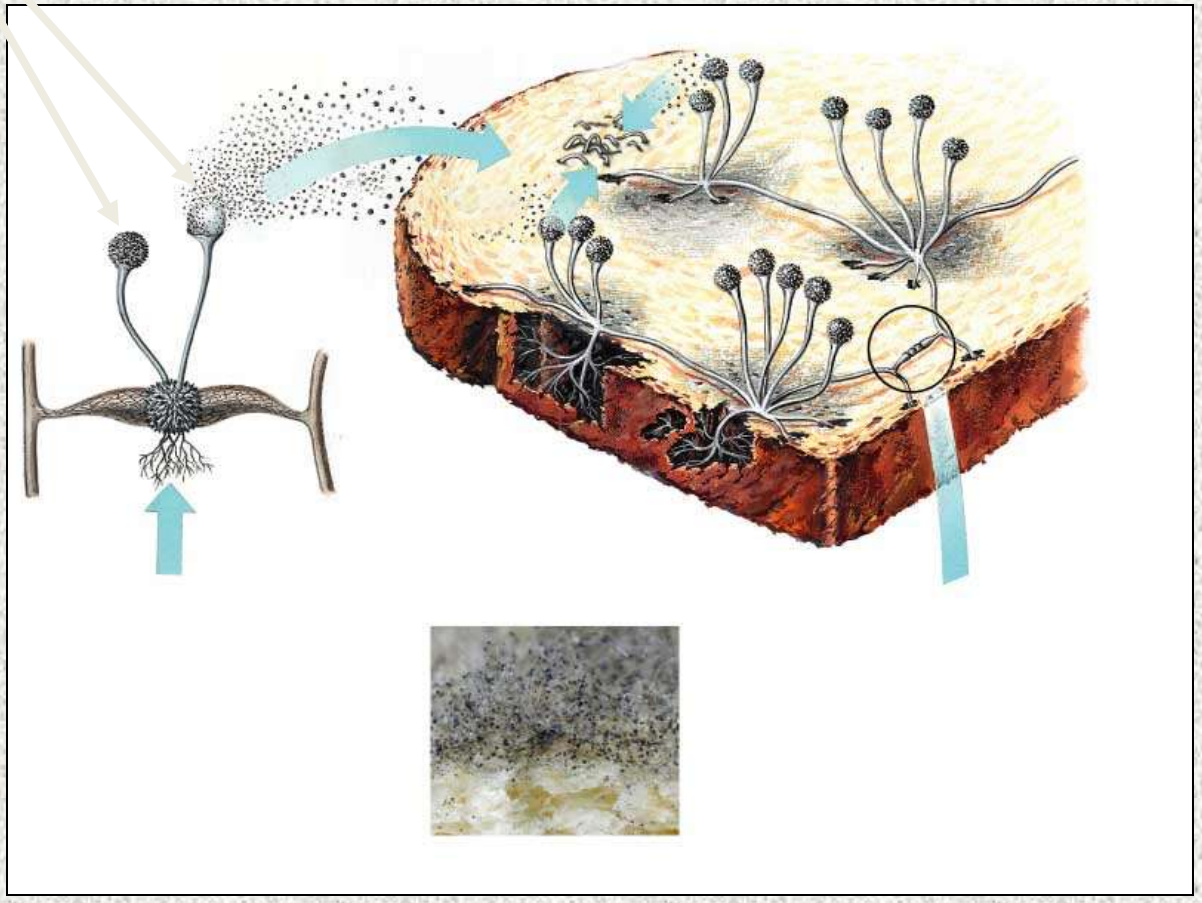
a. A microsporidian *Encephalitozoon cuniculi* infection. 16,000×



Zygomycetes - Zygote Fungi

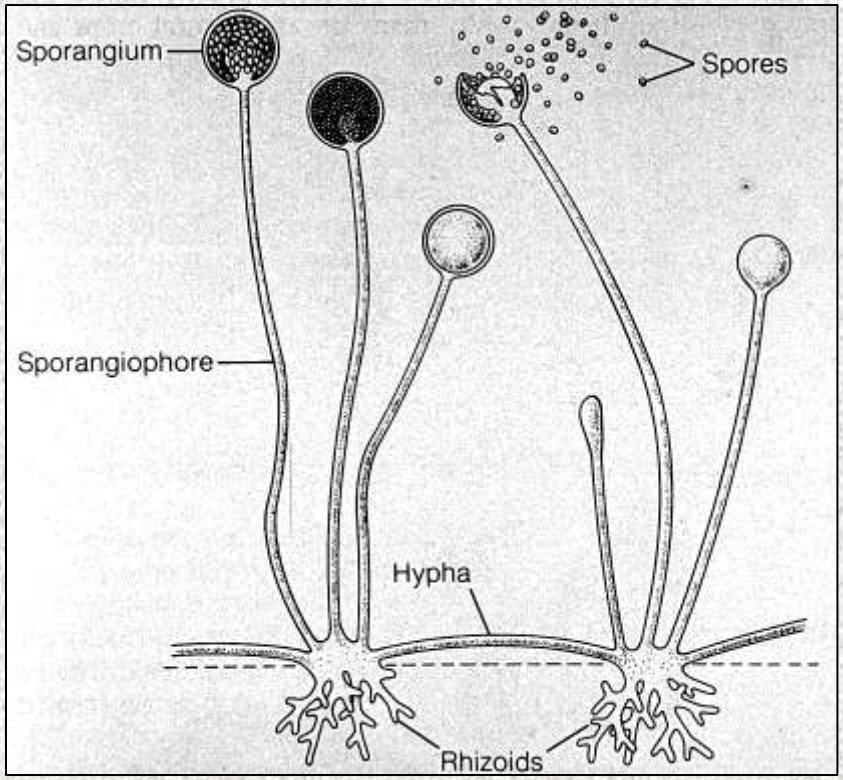
- Live in soil and on decaying plant matter
- Zygosporangia = reproductive structures producing haploid spores





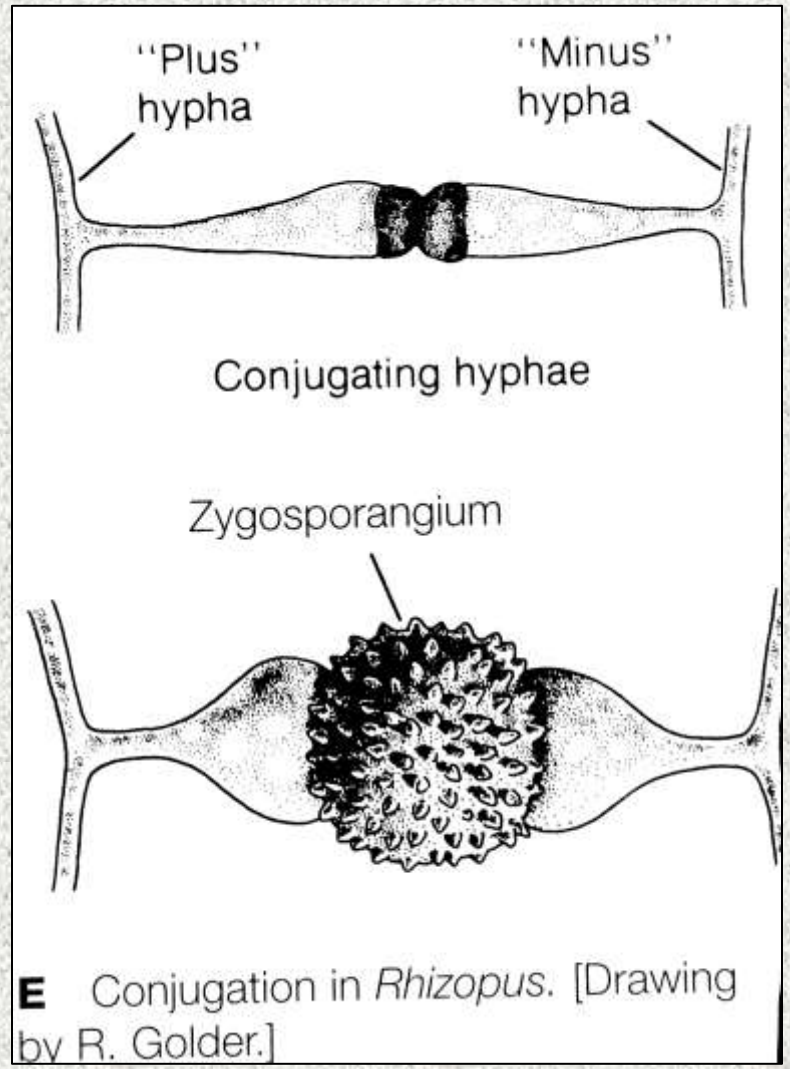
Bread Mold – a Zygomycete Fungi

Sporangium – asexual phase of reproduction

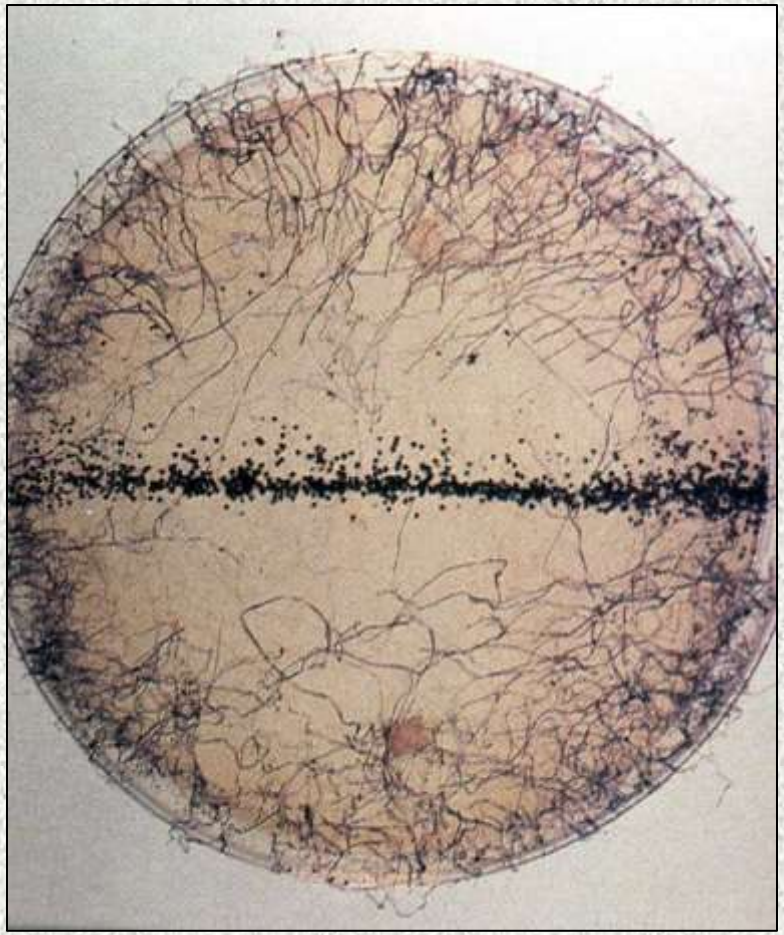


Stolons rhizoids

Rhizopus sexual reproduction



E Conjugation in *Rhizopus*. [Drawing by R. Golder.]

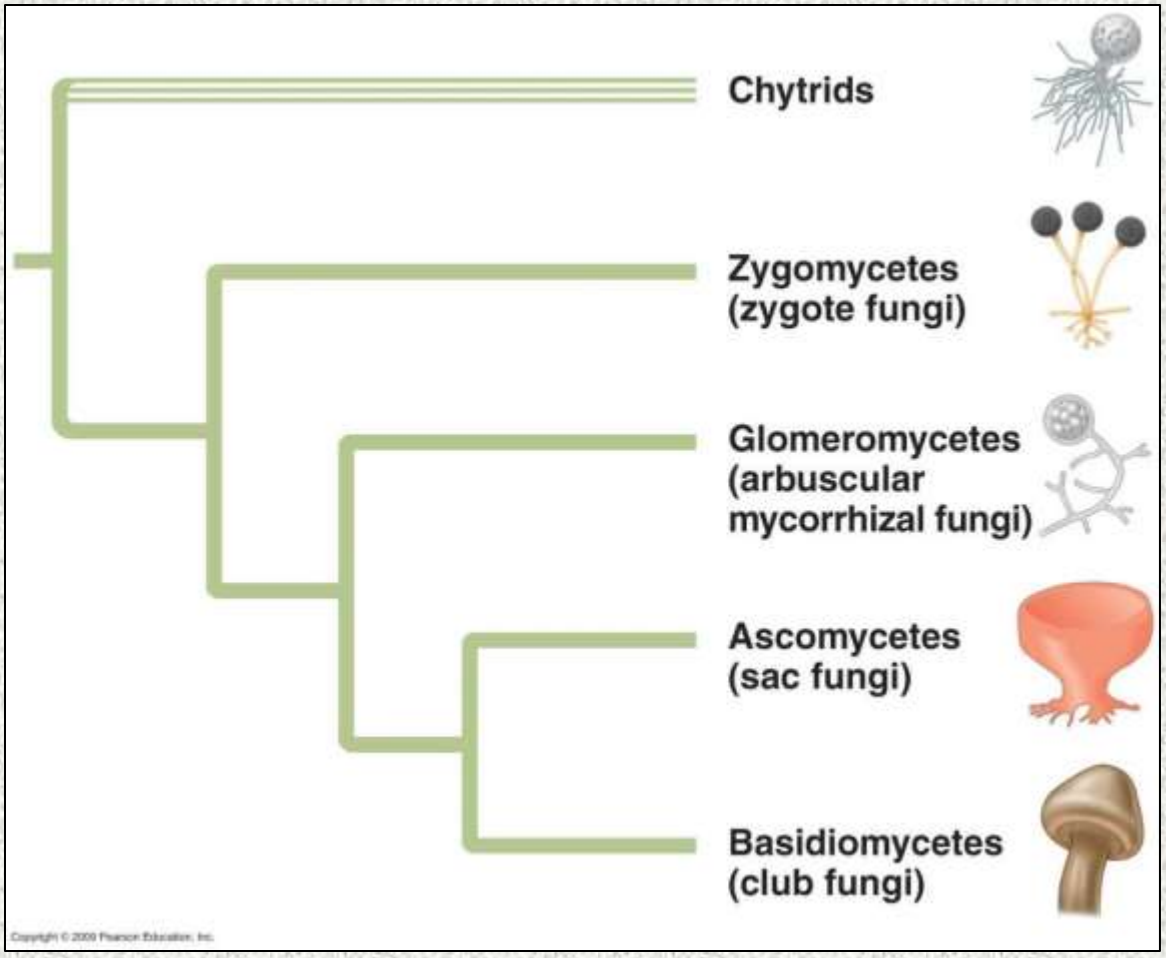


Mating Strains
Forming zygosporangia

Arbuscular Mycorrhiza = Glomeromycota

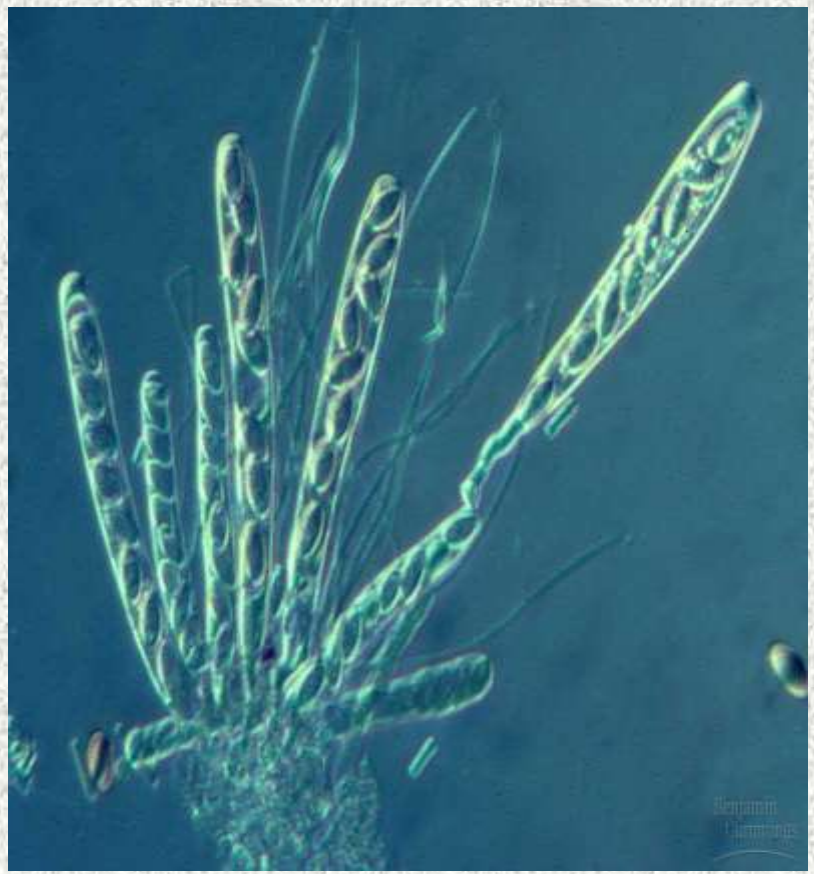
- Classified with Zygomycota for a long time
- Highly evolved mutualistic association
- 80% of plant species have them

Form tree-shaped structures (arbuscules) within the root cells



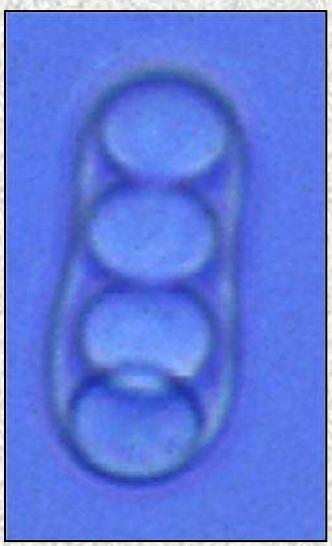
Ascomycota – “sac fungi”

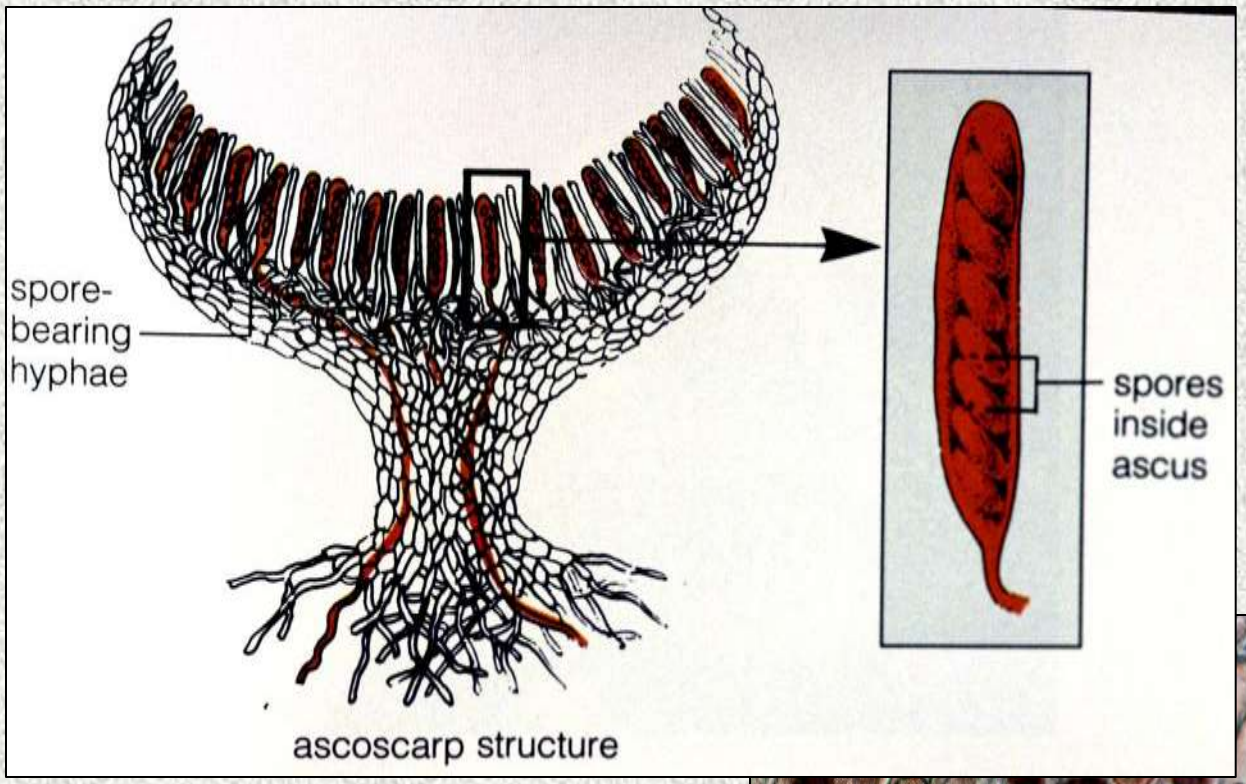
- Sexual Reproduction – asci (sing.=ascus)
- Asex. Reprod. – common
- Cup fungi, morels, truffles
- Important plant parasites and saprobes
- Yeast - *Saccharomyces*
- Decomposers, pathogens, and found in most lichens



A cluster of asci with spores inside

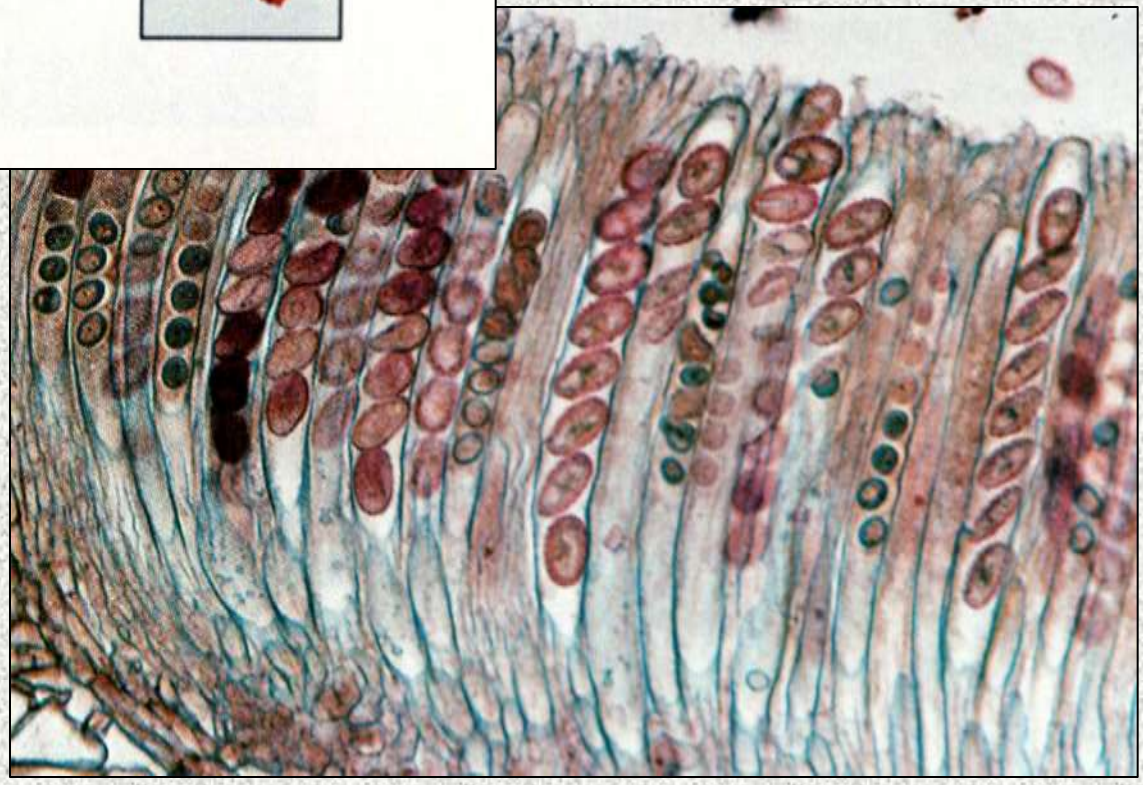
Sac fungi diversity





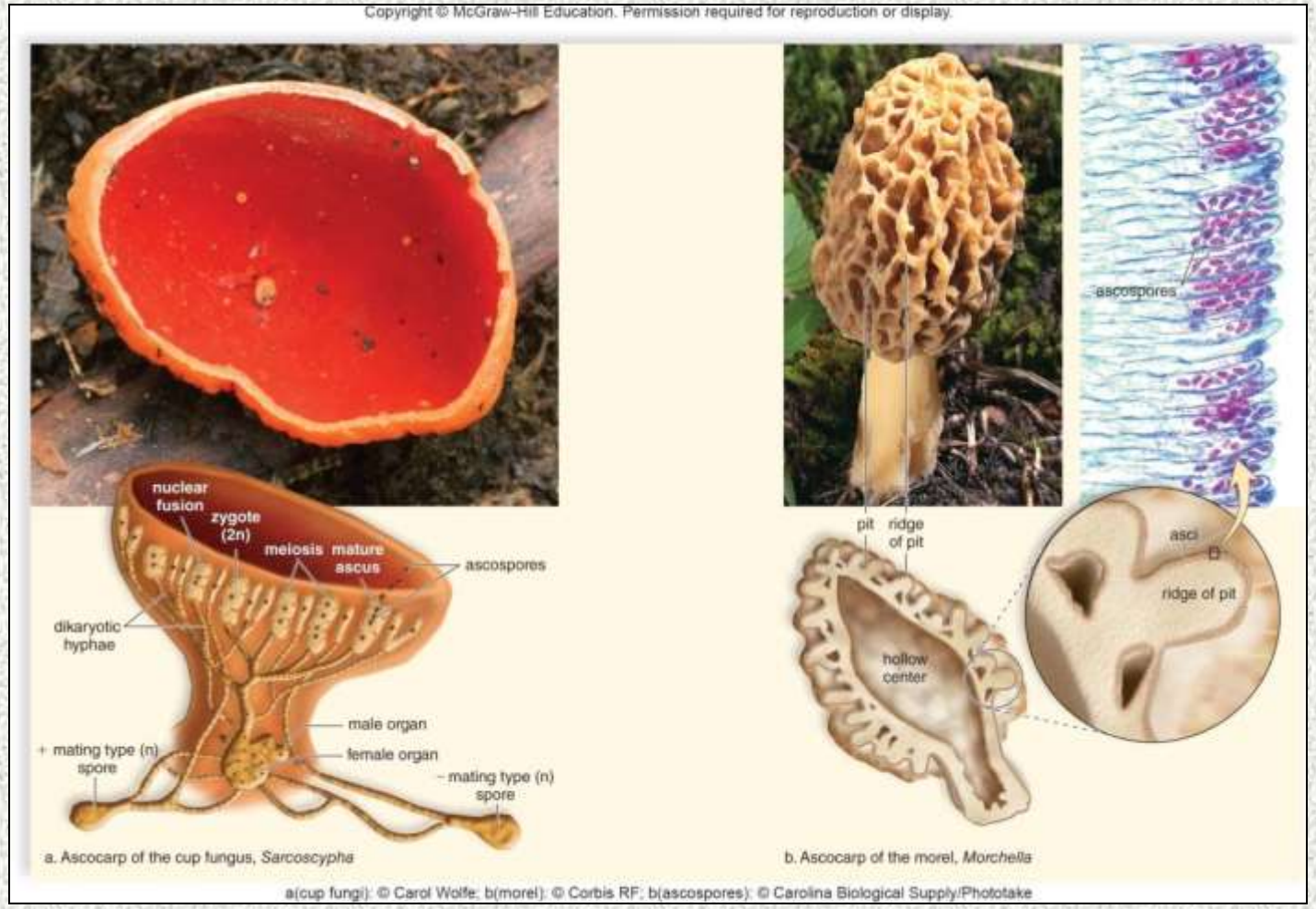
Ascomycetes

- Ascocarp
- Ascus
- Ascospores



Sexual Reproduction in Sac Fungi

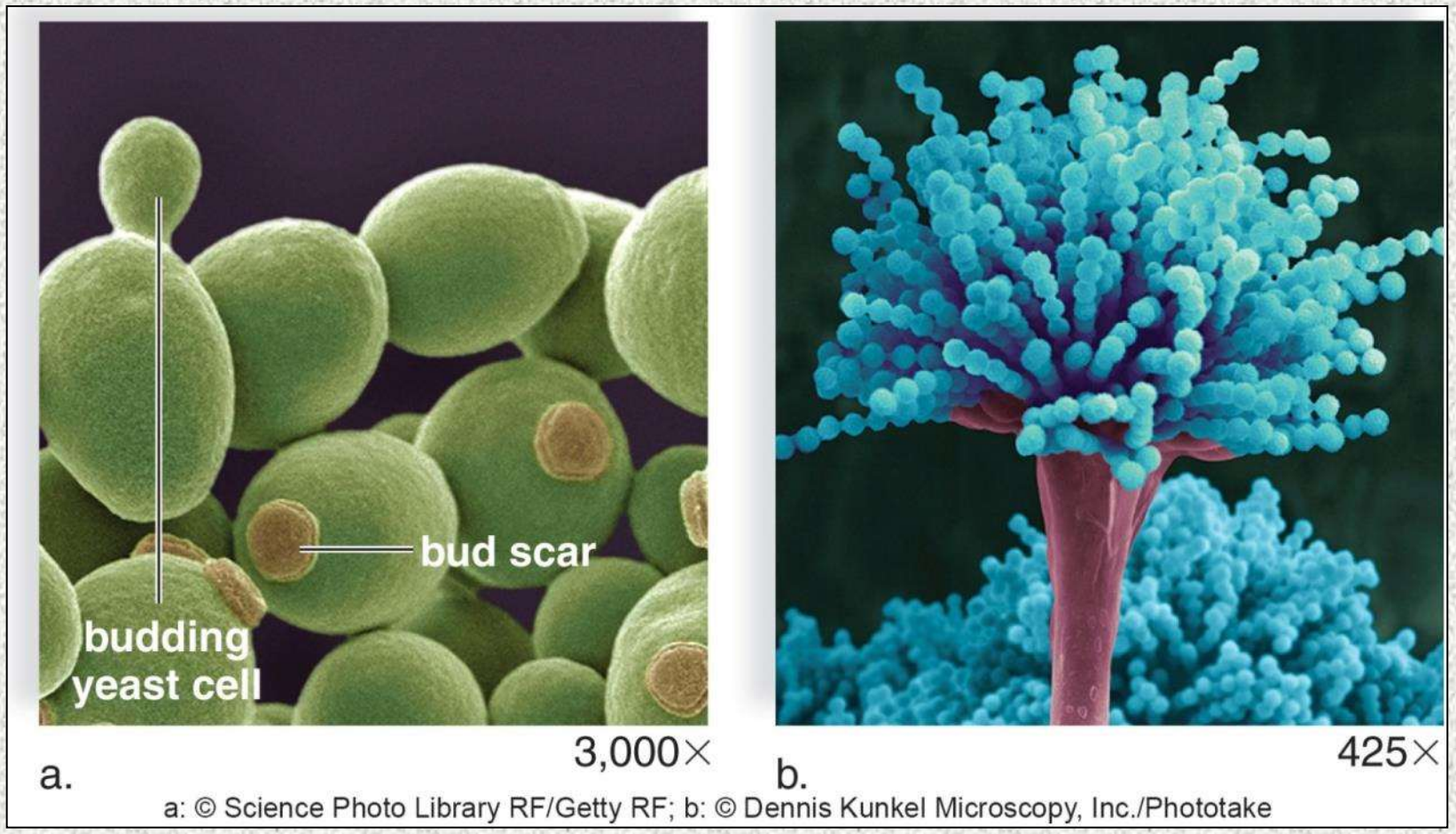
Dikaryotic nuclei in hyphae fuse
Meiosis takes place
Haploid spores produced in asci



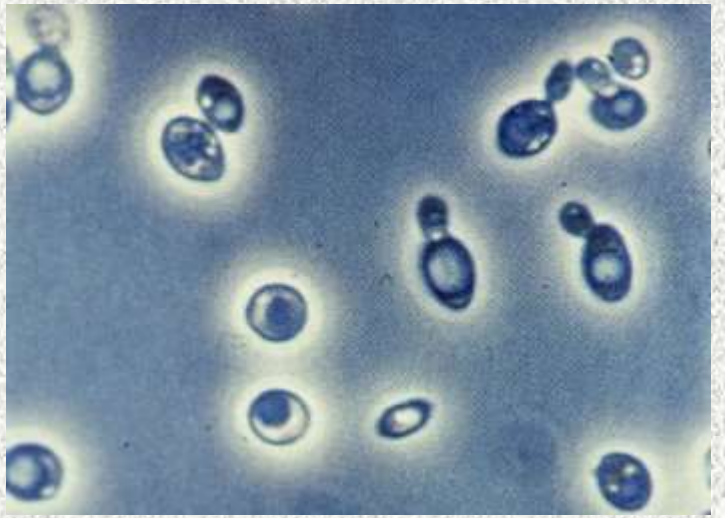
Asexual Reproduction in Sac Fungi

Yeast Budding

Asexual spores, conidia



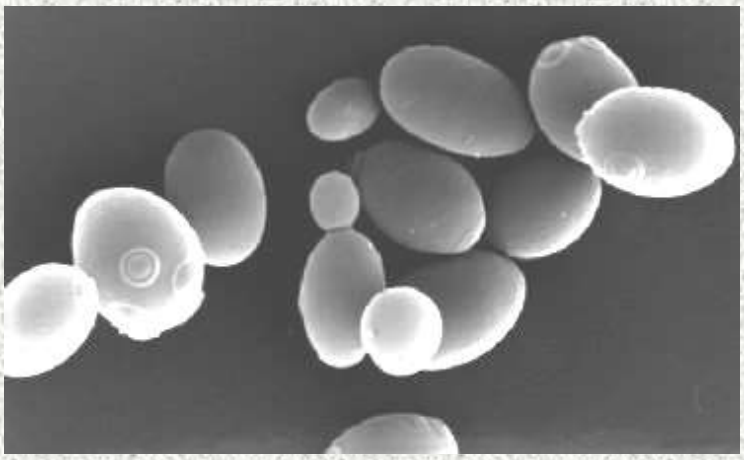
Yeast is an Ascomycete Fungus



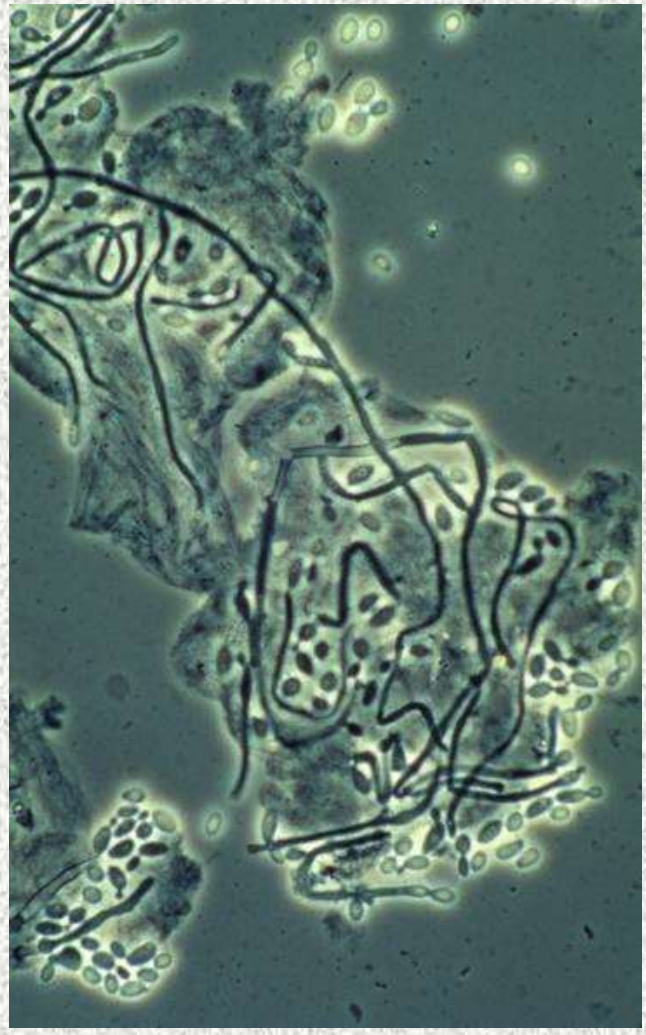
Saccharomyces cerevisiae
Used in baking and brewing

Yeasts

- Single celled fungi
- Adapted to liquids
  - Plant saps
  - Water films
  - Moist animal tissues



Saccharomyces



Candida

Leaf cutter ants farm sac fungi. Fungal gardens used to feed larvae

White nose syndrome in bats, disrupts hibernation *Geomyces destructans*

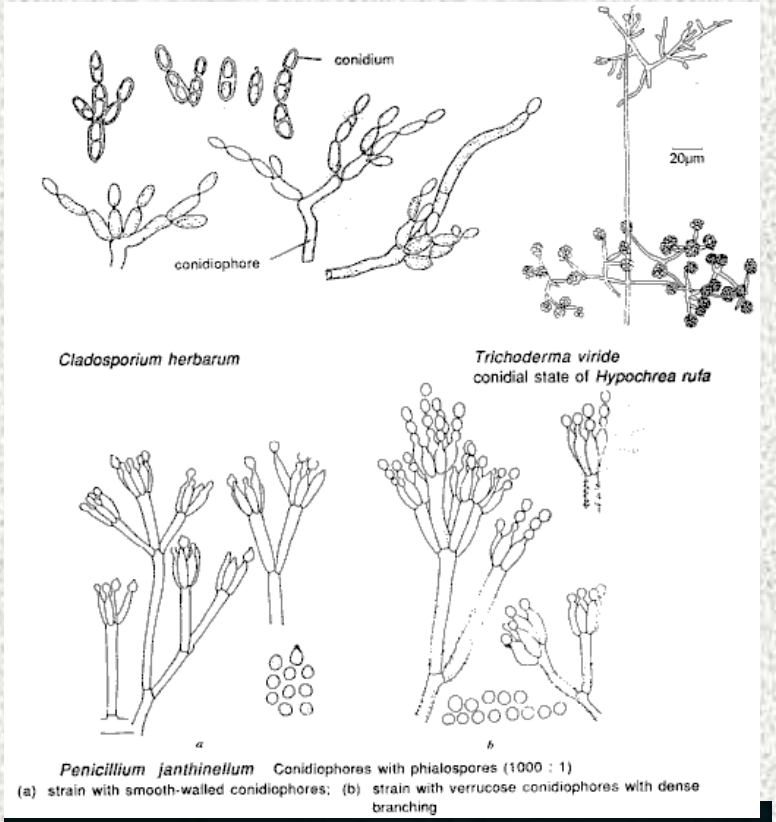
a.

b.

a: © Alex Wild Photography; b: © New York State Department of Environmental Conservation, Al Hicks/AP Images

Molds

- Rapidly growth
- Asexual spores
- Many of human importance
  - Food spoilage
  - Food products
  - Antibiotics, etc.



Noble Rot - *Botrytis*

Antibiotics - Penicillium

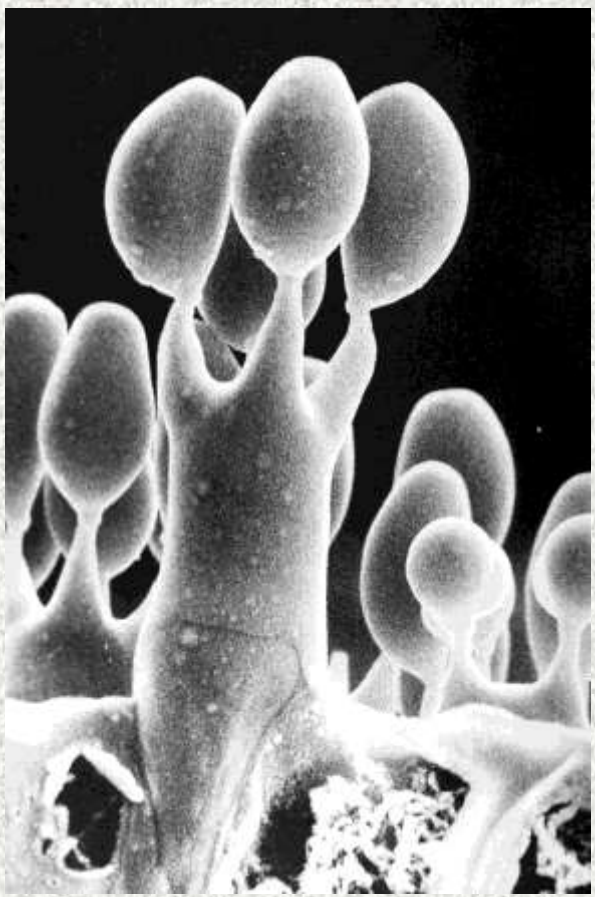
Basidiomycetes – gills or pores

Basidiomycetes - Club Fungi

- Basidium = club-shaped reproductive structure that produces basidiospores

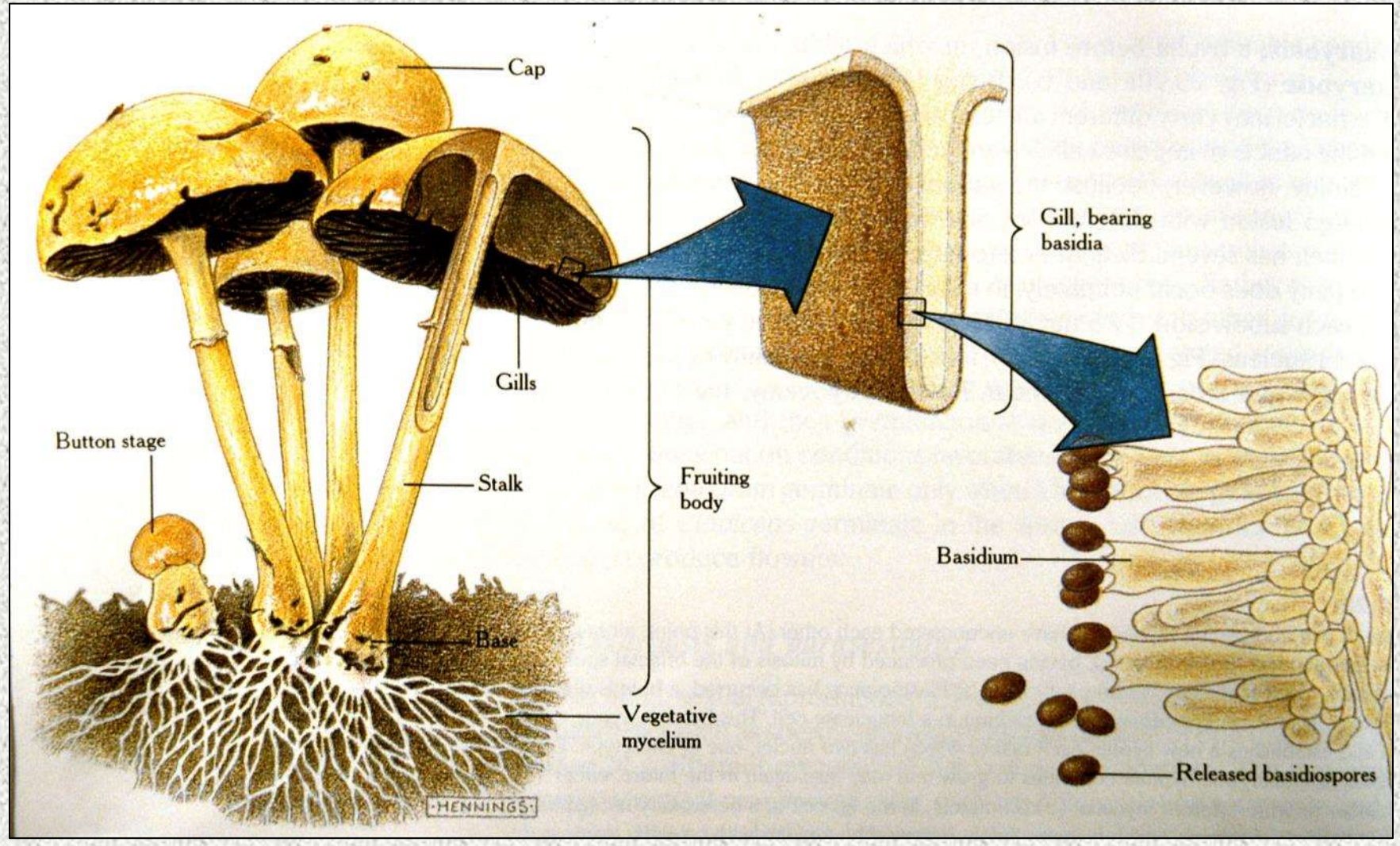
Basidiomycota – “club fungi”

- Sexual Reproduction – basidia
- Long-lived **dikaryotic** mycelia
- Enzymes decompose wood, leaves, and other organic materials
- Decomposers, pathogens, and some form mycorrhizal associations with plants
- Mushrooms, polypores, puffballs, boletes, bird’s nest fungi
- Rusts & smuts –plant parasites



SEM of basidia and spores

Basidia on gills of Basidiomycetes



Basidiomycete Sexual Reproduction

- Septate hyphae with 2 nuclei (dikaryotic)
- Nuclei fuse, undergo meisosis
- Haploid spores produced in basidium

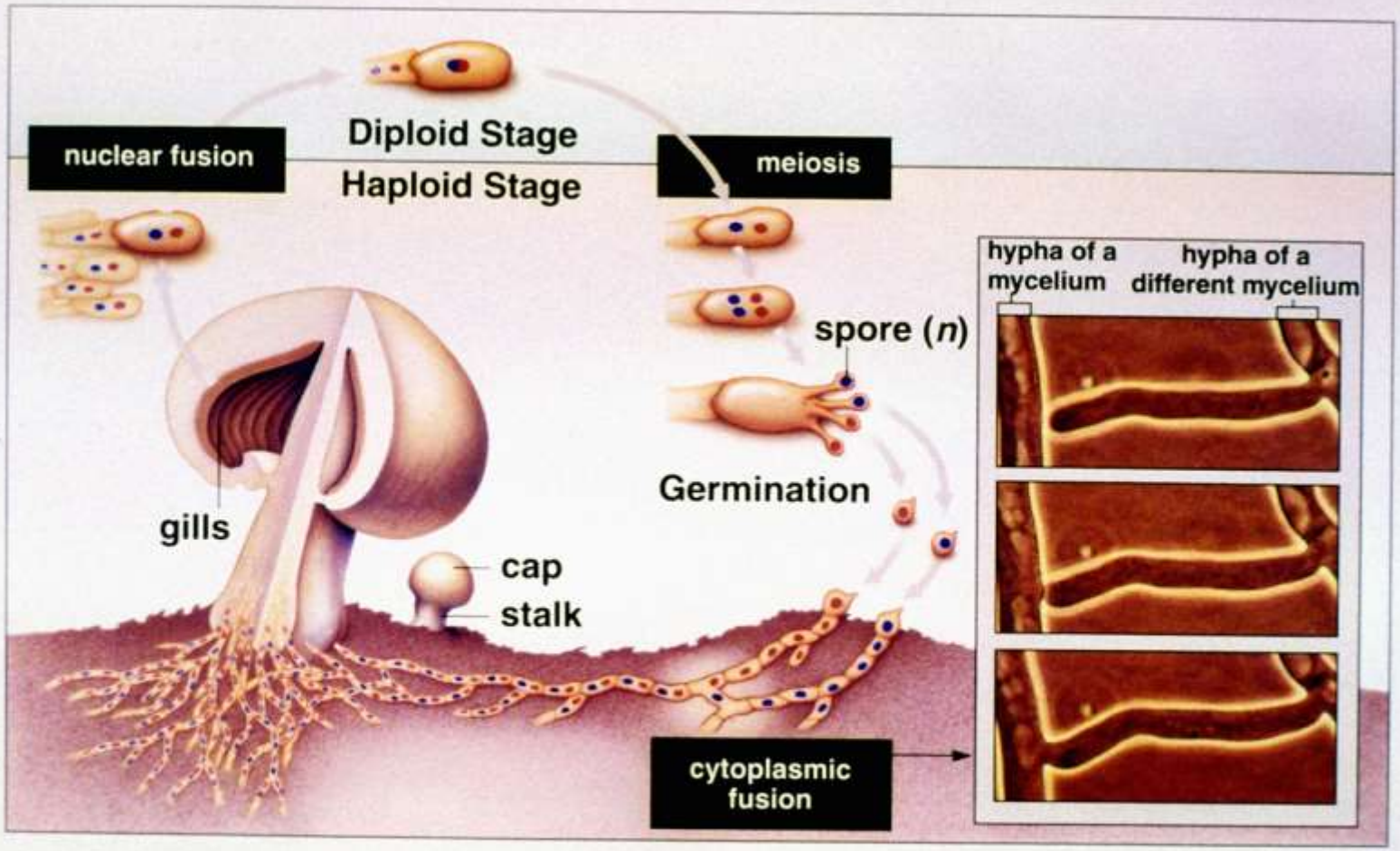


Fig. 18.8 Generalized life cycle for club fungi.

Club Fungi

a. Shelf fungus

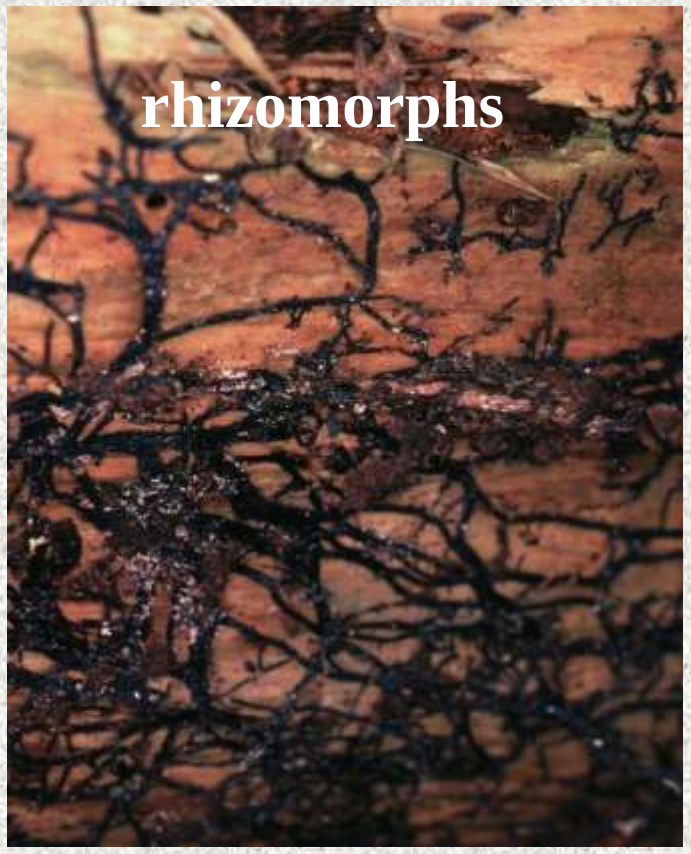
b. Pore mushroom, *Boletus*

c. Puffball

d. Bird's nest fungi

e. Stinkhorn

Some populations not what they appear to be.
Some are giant clones, all one individual



World's Biggest Individual?
Giant fungus in Oregon
Connected underground

Armillaria ostoyae
2,400 years old, killing trees as it grows. Now about 880 hectares of the Malheur National Forest in eastern Oregon.

Poisonous Mushroom, *Amanita phalloides*

- Toxin Amanitin
- Interferes with RNA polymerase, shuts down transcription of proteins.
- Liver and kidney damage causes death.

Psilocybin Mushrooms

Maria Sabina, Mexico

Ergot Infection of Rye, Caused by *Claviceps purpurea*

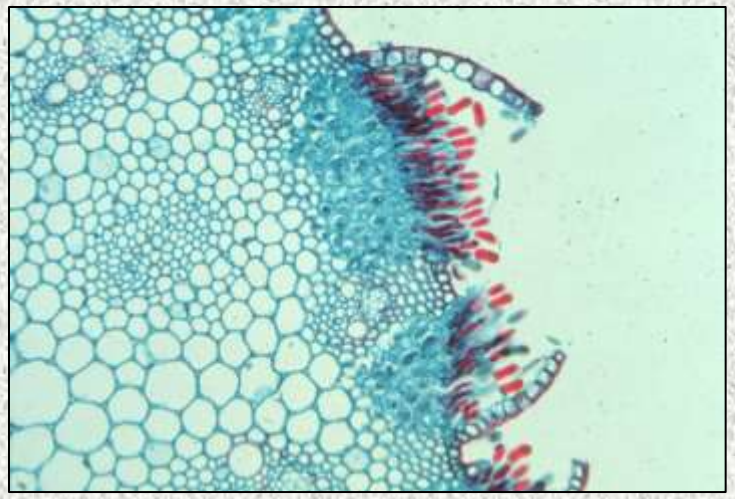
- Ergotism
- Bread made from infected rye
- St. Anthony's Fire
- Toxic alkaloids
- Feelings of Intense heat, hallucinations, lysergic acid

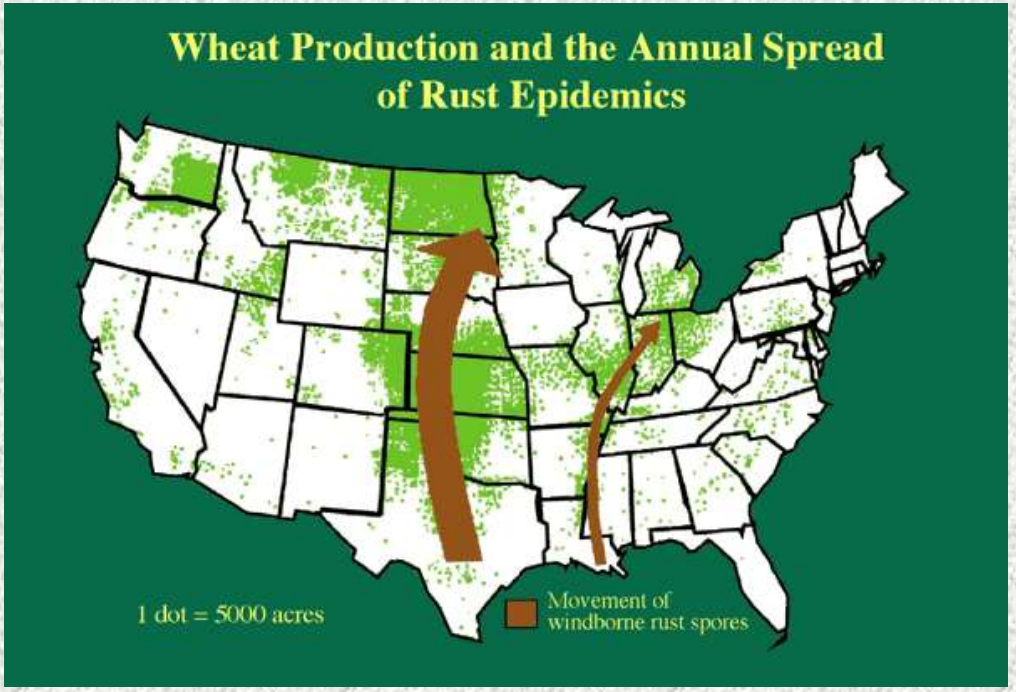
Basidiomycetes – Rusts and Smuts

Wheat Rust

Corn Smut

Wheat Rust -




Wheat Production and the Annual Spread of Rust Epidemics
1 dot = 5000 acres
Movement of windborne rust spores

Cedar Apple Rust

alternates between Juniper and Apple trees

End