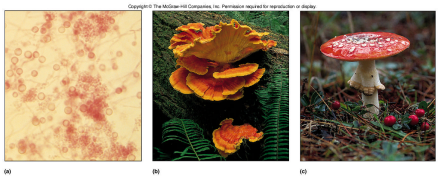
Fungi

Fungi

yeasts, molds, mushrooms

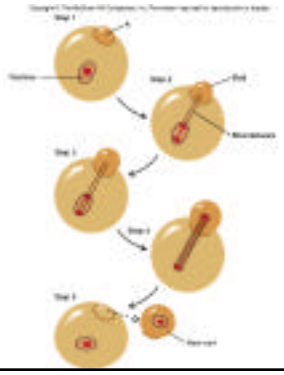
- ✓ Eukaryotic
- ✓ Uni- or multicellular
- ✓ Nutrition by absorption
- ✓ Asexual and sexual reproduction; complex life cycle



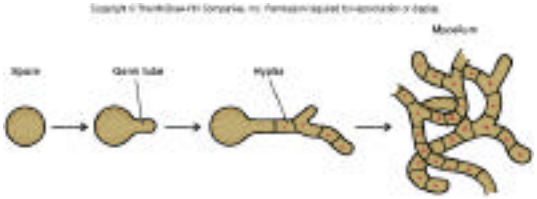
Kingdom Fungi

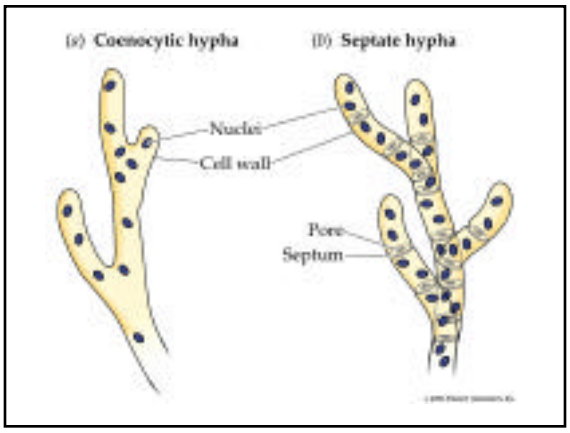
- ✓ Sexual and asexual reproduction - spores
  - ✒ Spores - dormant for years to days
  - ✒ Germination into hyphae - branched hyphae is mycelium
  - ✒ Coenocytic (non septate) or non-coenocytic (septate)
- ✓ Asexual reproduction - hyphal or mycelial fragments

Yeast cell budding

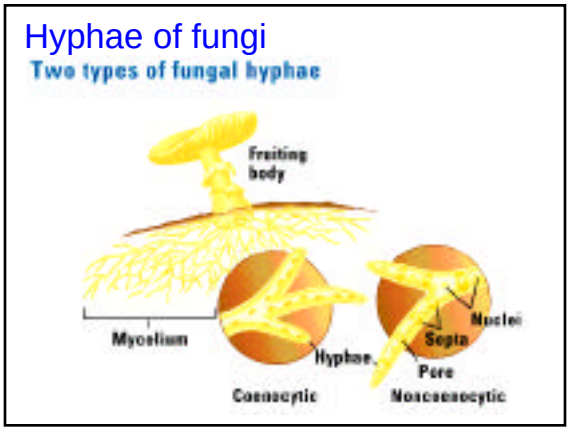


Formation of hyphae & mycelium

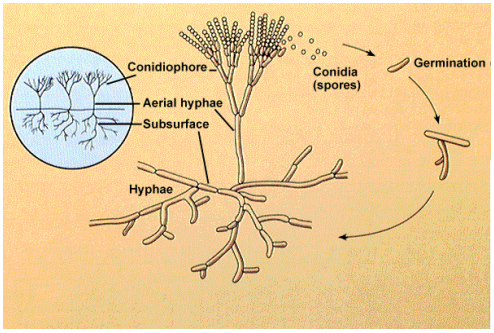




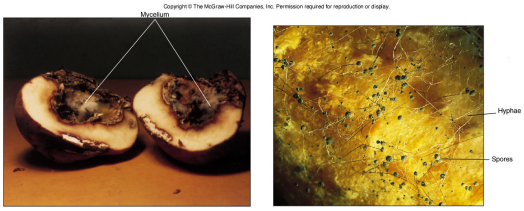
Hyphae of fungi



Fungal Hyphae

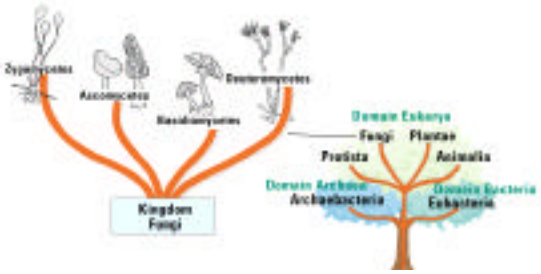


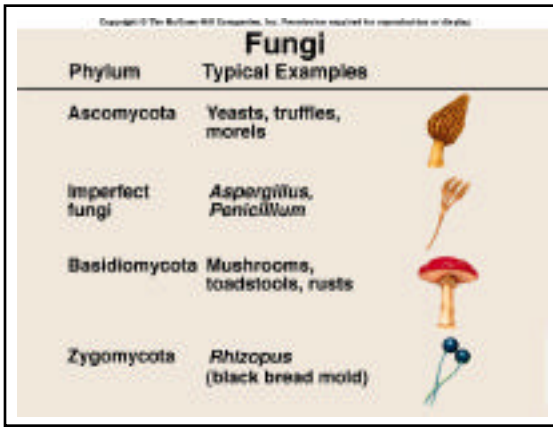
Potato and bread



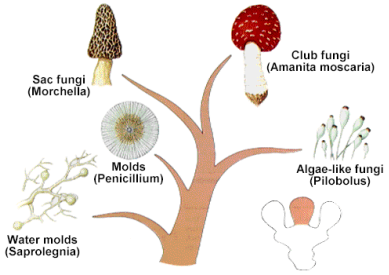
Rhizopus stolonifer

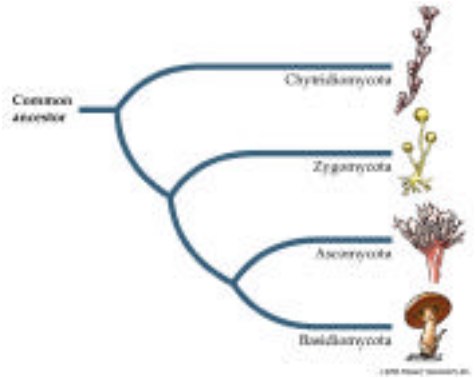
Kingdom Fungi





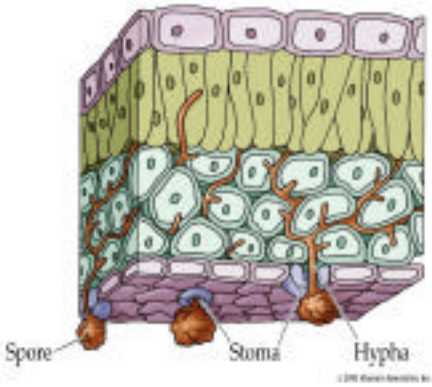
Fungi





Fungi

- ✓Haustorium
  - ➨Hyphae penetration into plant
  - ➨Usually through stomates



Fungi reproduce both asexually and sexually

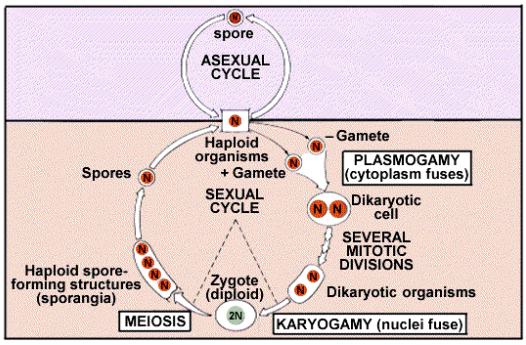


Table 12.3 Characteristics of Major Groups of Fungi

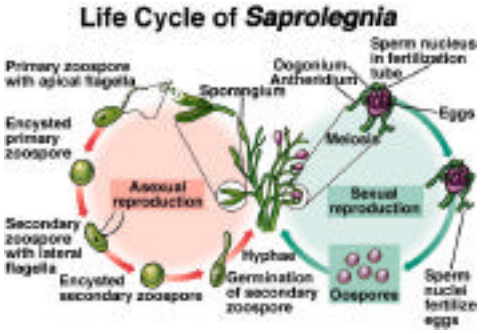
Group and Representative Member	Usual Habitat	Some Distinguishing Characteristics	Asexual Reproduction	Sexual Reproduction
Zygomycetes *Rhizopus stolonifer* (black bread mold)	Terrestrial	Multicellular, coenocytic mycelia (with many haploid nuclei)	Asexual spores develop in sporangia on the tips of aerial hyphae	Sexual spores known as zygospores can remain dormant in adverse environment
Basidiomycetes *Agaricus campestris* (meadow mushroom) *Cryptococcus neoformans*	Terrestrial	Multicellular, uninucleated mycelia. Group includes mushrooms, smuts, rusts that affect the food supply	Commonly absent	Produce basidiophores that are borne on club-shaped structures at the tips of the hyphae
Ascomycetes *Neurospora*, *Saccharomyces cerevisiae* (baker's yeast)	Terrestrial, on fruit and other organic materials	Unicellular and multicellular with septated mycelia	Is common by budding; conidiospores	Involves the formation of an ascus (sac) on specialized hyphae
Deuteromycetes (Fungi Imperfecti) *Penicillium*, *Aspergillus*	Terrestrial	A number of these are human pathogens	Budding	Absent or unknown

Fungi

✓Protists (Kingdom Chromista)

- Chydridiomycota
  - Zygotic, sporic (gametic) and asexual reproduction
  - Motile gamates and zoospores
  - Centrioles present
  - Aquatic

Oomycota

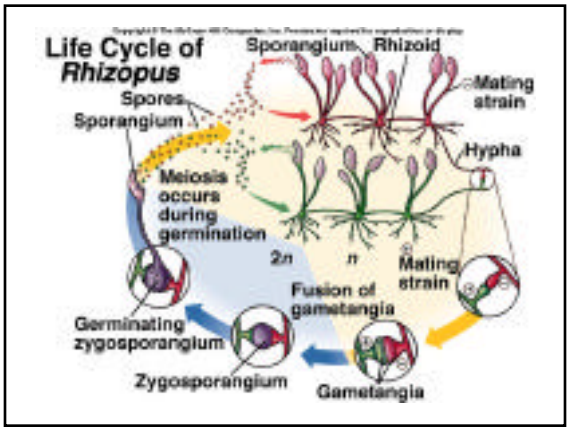


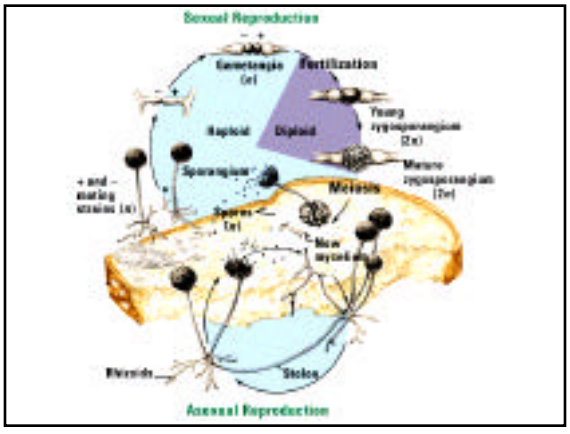
True fungi -

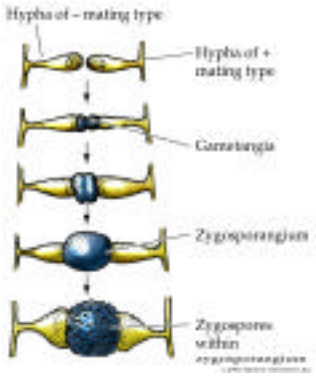
- Haploid, dikaryotic, unicellular to filamentous hyphae
- Zygotic meiosis
- Spindle pole apparatus is distinct
- Asexual reproduction
  - Sporangia - zygomycetes
  - Spores (Conidia) - ascomycetes and basidiomycetes
- Food by absorption
- Mostly terrestrial

Zygomycota

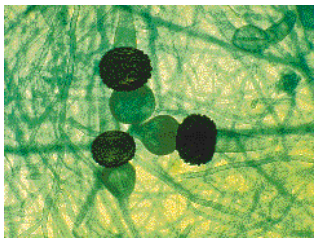
- Bread molds, mold on fruits and vegetables Zygosporangium, conjugation fungi
  - Class Zygomycetes
    - Sporangia - conidia
    - *Rhizopus* (Tempeh), *Mucor* (tofu)
    - Pilobolus (dung mold)
  - Class Trichomycetes
    - Short hyphae
    - No mycelium
    - Symbiotic - insect gut
    - Need a host



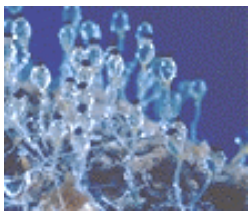




Conjugation to form Zygospores in *Rhizopus*



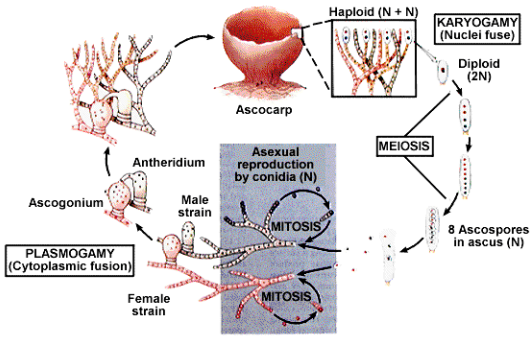
Pilobolus

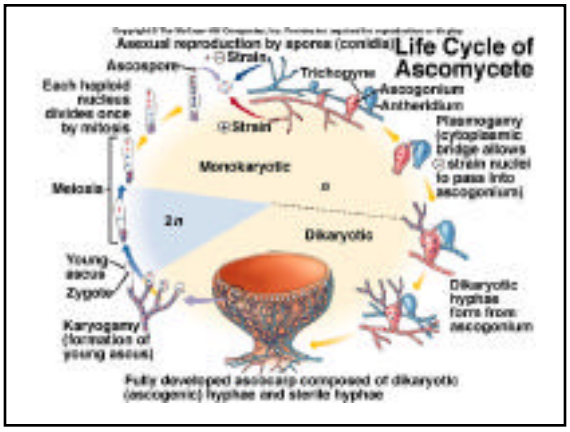


Ascomycota

- Sac fungi (sac-like structure called ascus - ascospores)
- Class Hemiascomycotina
  - Order Saccharomycetales
    - Yeast, *Saccharomyces cerevisiae*, Bakers yeast
    - Single cells make four naked ascospores
    - *Schizosaccharomyces* - fission yeasts
- Class Euascomycotina

Ascomycota reproduction





Ascoma

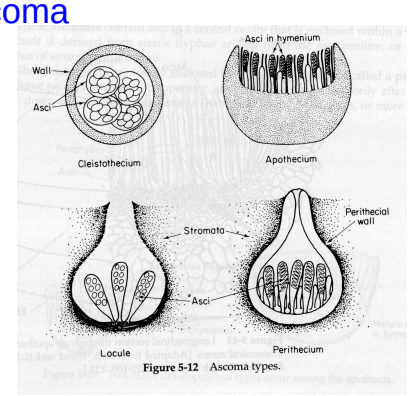


Figure 5-12 Ascoma types.

Apothecium

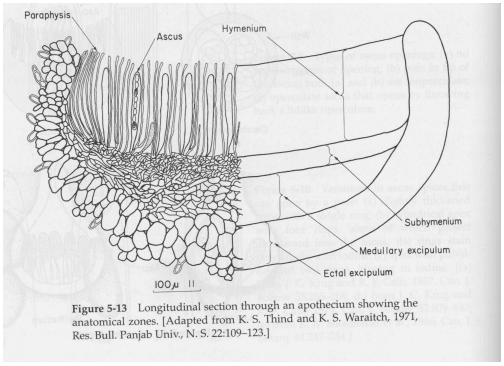


Figure 5-13 Longitudinal section through an apothecium showing the anatomical zones. [Adapted from K. S. Thind and K. S. Waraitch, 1971, Res. Bull. Panjab Univ., N. S. 22:109–123.]

Acsogonium and antheridium development

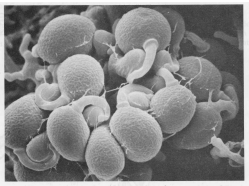
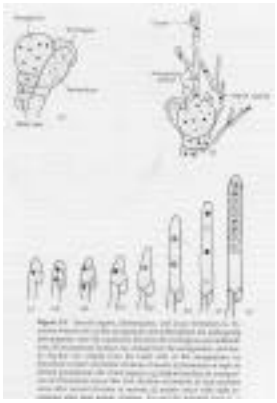


Figure 5-4 Scanning electron micrograph of the gametangia of *Pyronema domesticum*. The ascogonia are the balloonlike structures, and each is producing a tubular trichogyne that is in contact with a club-shaped antheridium. × 1000. [Courtesy K. L. O'Donnell.]

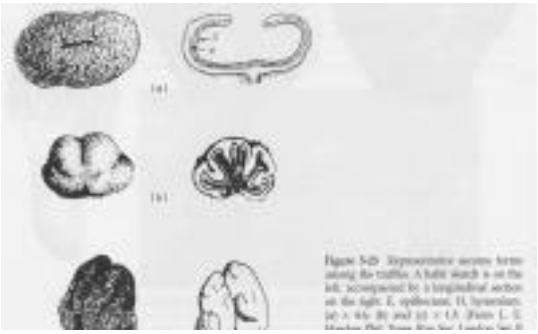


Cup fungus (apothecium)

Figure 5-21 Apothecia of *Sarcoscypha coccinea*, the scarlet elf cup, a member of the Pezizales. These apothecia are conspicuously colored, with an orange-red hymenium and a white exterior. About natural size. [Courtesy Plant Pathology Department, Cornell University.]

Order Pezizales

Truffles

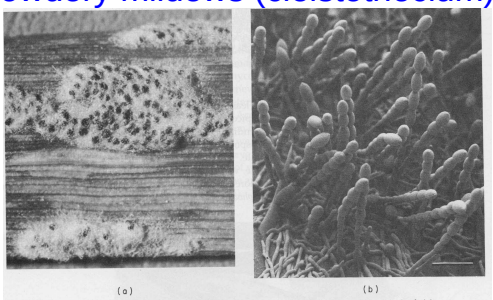


Morels

Ascommycetes

Peziza (pigs ears)

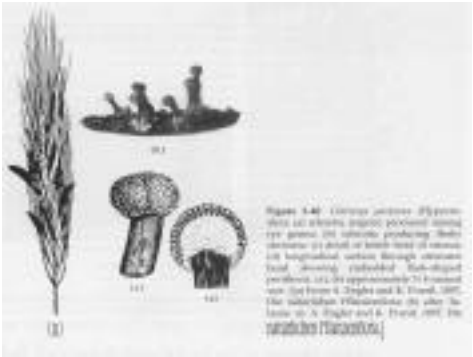
Powdery mildews (cleistothecium)



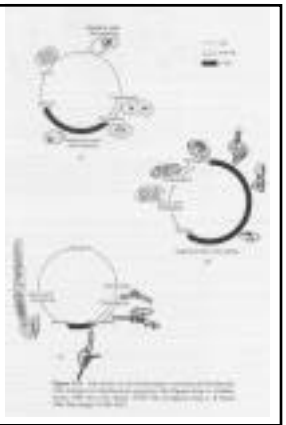
(a) (b)

Figure 5-30 Powdery mildew fungus, *Erysiphe graminis* on a leaf. (a) The dark cleistothecia are immersed within the light mycelium and conidia. Approximately × 10. (b) Scanning electron micrograph of conidia. Scale bar = 50 μm. [(a) Courtesy Plant Pathology Department, Cornell University; (b) courtesy Richard J. Howard.]

Claviceps purpurea (perithecium)

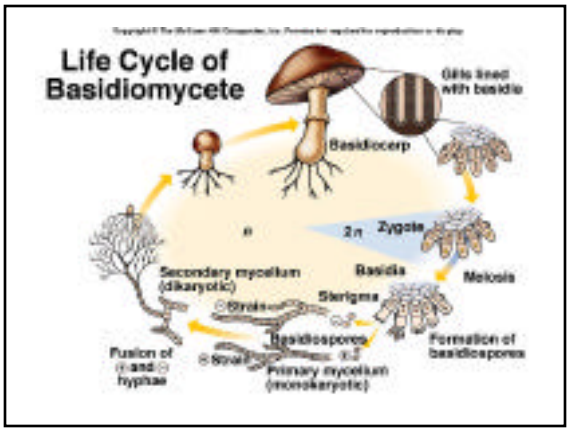


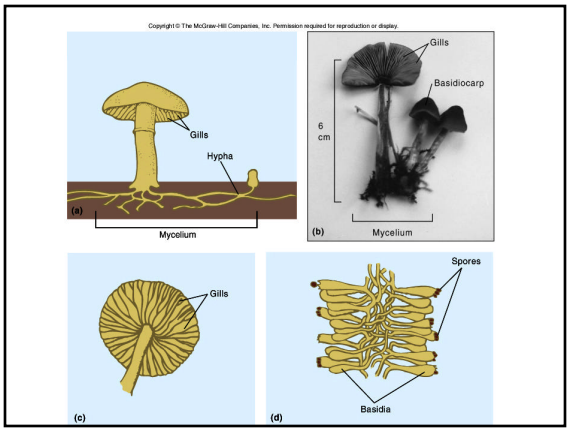
Saccharomyces cerevisiae

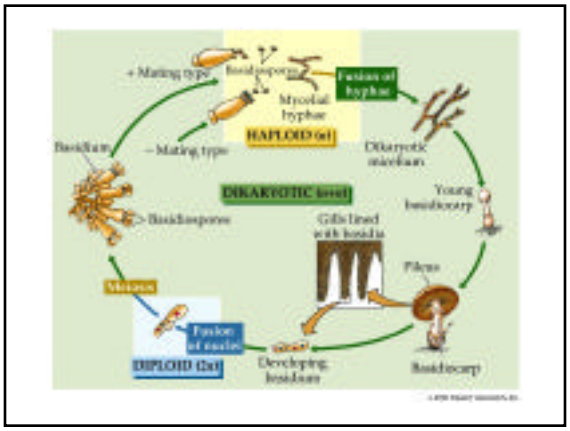


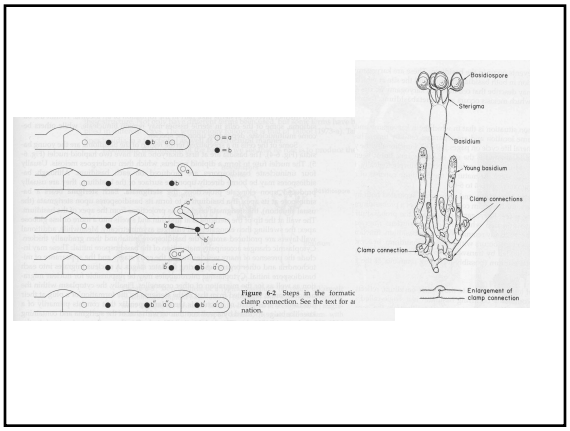
Fungi

- ✓Basidiomycota
  - ✒Club fungi (clubbed shaped sexual structures called basidia-basidiospores)
  - ✒Mushrooms such as *Amanita*, Rust; *Cryptococcus neoformans*
- ✓Deuteromycota
  - ✒Fungi imperfecti - most human pathogens
  - ✒*Coccidioides immitis*, *Aspergillus*, *Penicillium*,





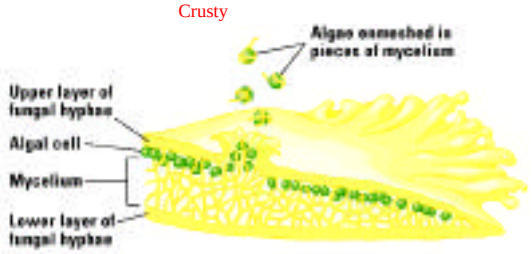


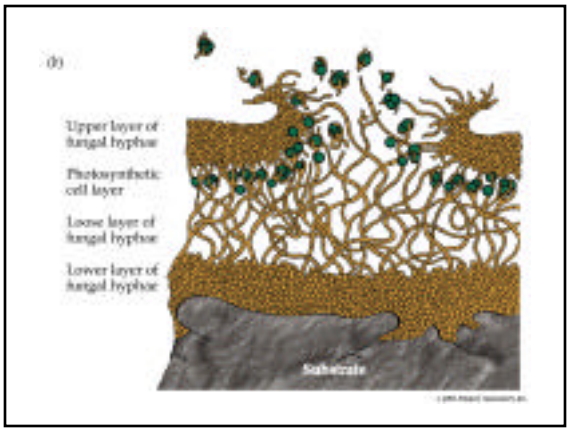


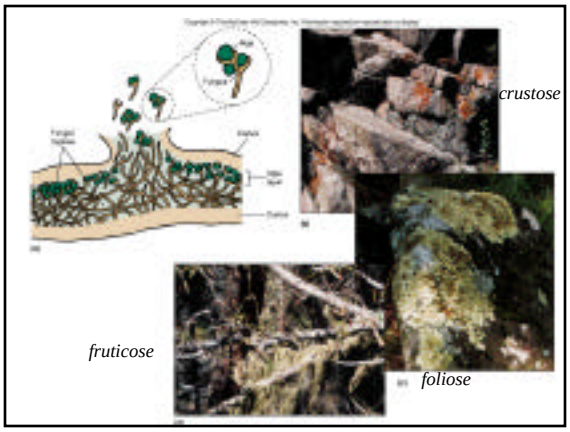
The gills of a basidiomycete are like the pages of a book

Lichen

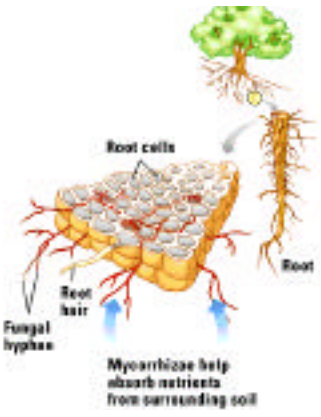
Leafy
Shrubby
Crusty

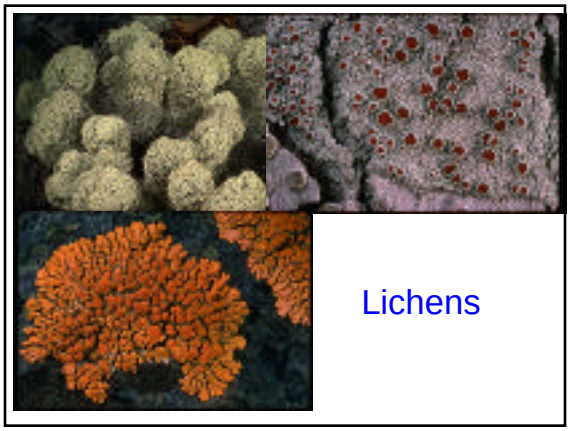






Mycorrhizae grow inside of the roots of trees and other plants





Lichens

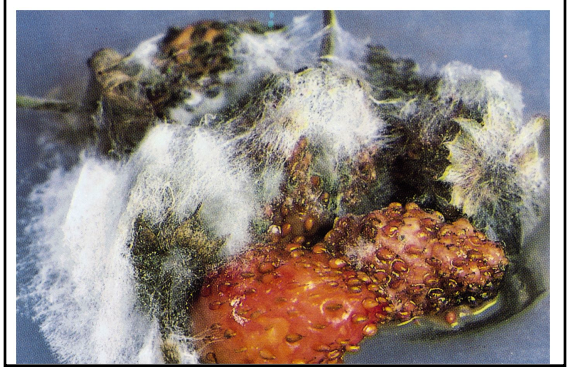
Mushrooms

Mushrooms

Puffball

Mycelium

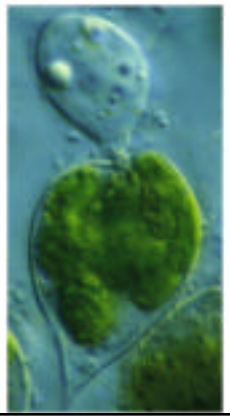
Rhizopus



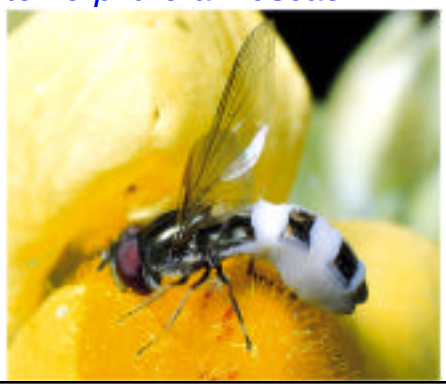
15–1 Major Characteristics of Fungal Phyla

Phylum	Representatives	Nature of Hyphae	Method of Asexual Reproduction	Type of Sexual Spore	Common Plant Diseases
Chytridiomycota (790 species)	*Allomyces*, *Coelomomyces*	Aseptate, coenocytic	Zoospores	None	Brown spot of corn, crown wart of alfalfa, black wart of potato
Zygomycota (1060 species)	*Rhizopus* (common bread mold), *Glomus* (endomycorrhizal fungus)	Aseptate, coenocytic	Nonmotile spores	Zygospore (in zygosporangium)	Soft rot of various plant parts
Ascomycota (32,300 species)	*Neurospora*, powdery mildews, *Morchella* (edible morels), *Tuber* (truffles)	Septate	Budding, conidia (nonmotile spores), fragmentation	Ascospore	Powdery mildew, brown rot of stone fruits, chestnut blight, Dutch elm disease
Basidiomycota (22,244 species)	Mushrooms (*Amanita*, poisonous; *Agaricus*, edible), stinkhorns, puffballs, shelf fungi, rusts, smuts	Septate with dolipore	Budding, conidia (nonmotile spores, including urediniospores), fragmentation	Basidiospore	Black stem rust of wheat and other cereals, white pine blister rust, common corn smut, loose smut of oats, *Armillaria* root rot

The chytrid *Polyphagus euglenae*



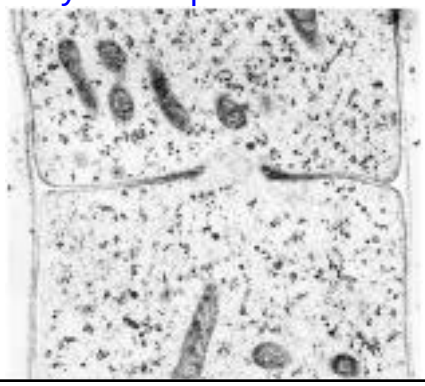
Entomorphthora muscae



Morchella esculenta

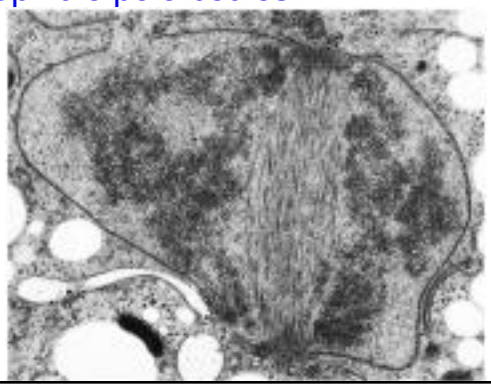
Hygrocybe aurantiosplendens

Ascomycete septum



Haustorium

Spindle pole bodies

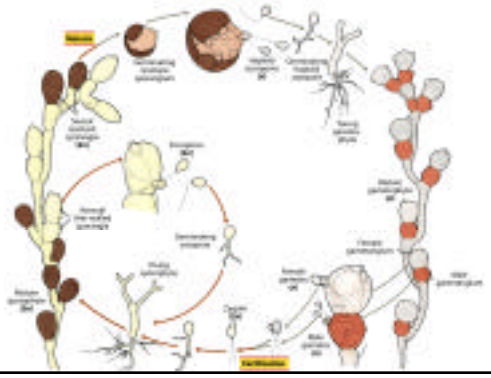


Choanocytes (ancestral protist)

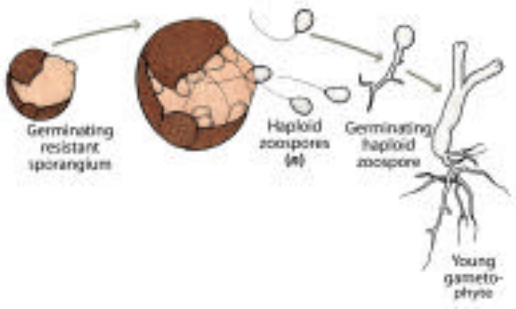
Uniflagellated zoospore of chytrid

Chytridium confervae with rhizoids

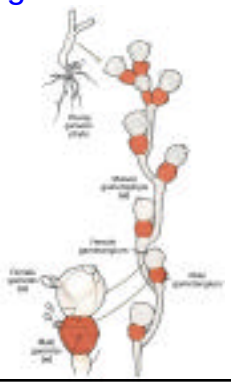
Chytrid *Allomyces arbusculus*



Zoospores



Gametophyte stage



Sexual stage

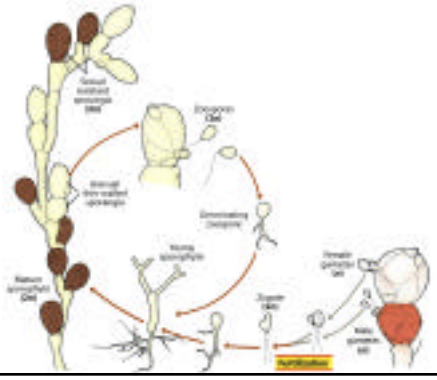
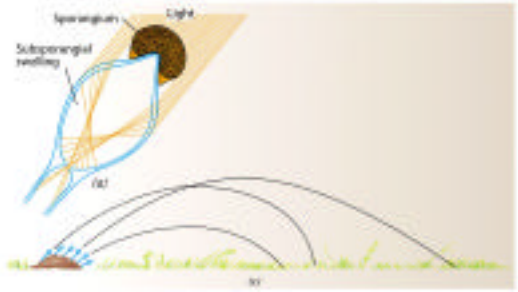
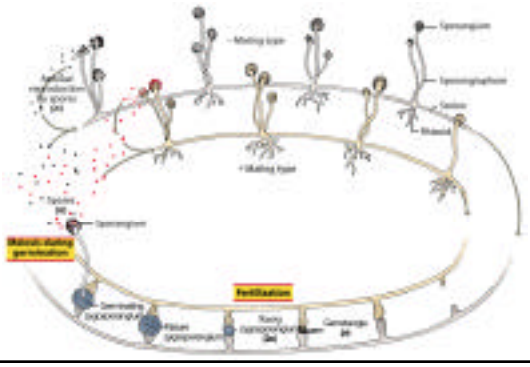


Photo sensitive

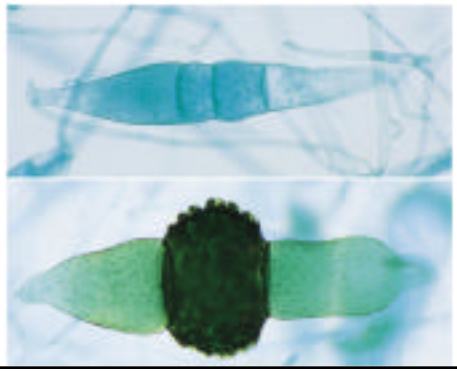


Pilobolus

Zygomycetes lifecycle

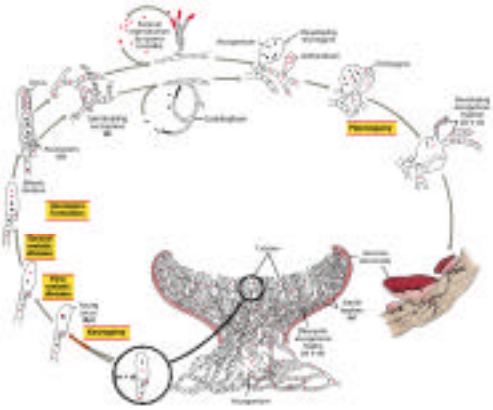


Gametangia and zygospore



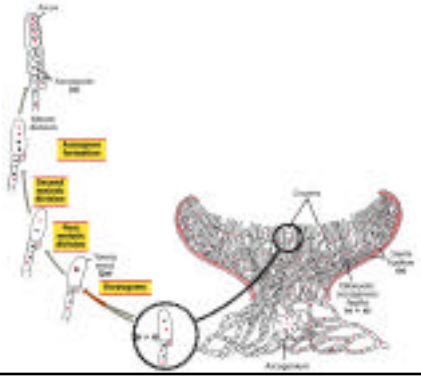
Eyelash cup and black truffle

Scutellinia scutellata *Tuber melanosporum*

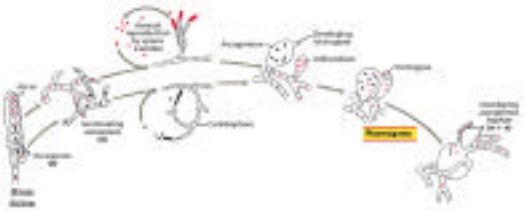


Croziers

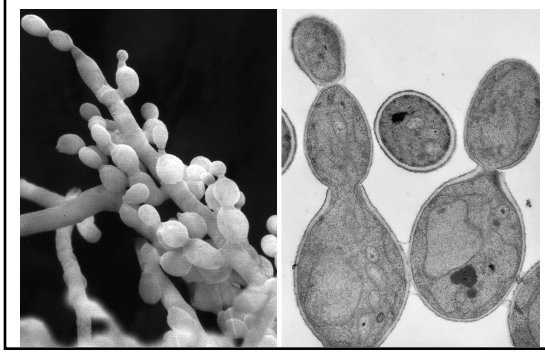
Meiosis and mitosis



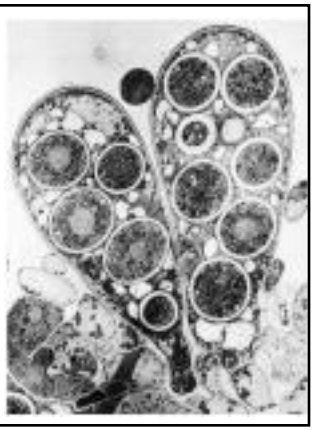
Plasmogamy



Conidia formation



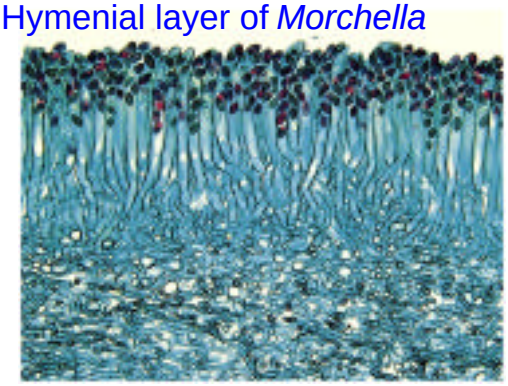
Asci and ascospores



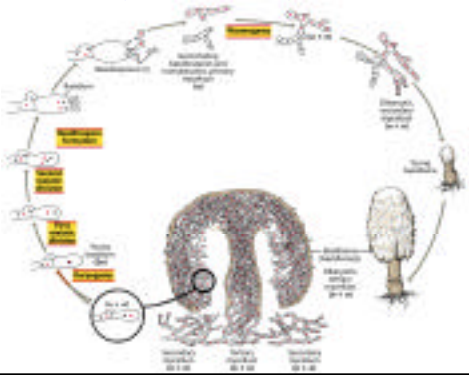
Erysiphe aggregata cleistothecium

Coniochaeta-perithecium

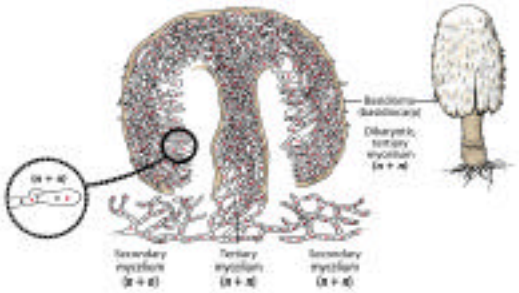
Hymenial layer of *Morchella*



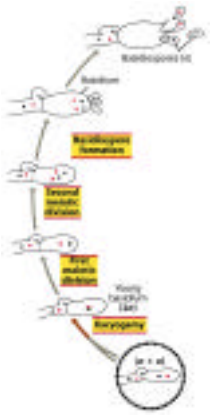
Basidiomycota life cycle



Basidioma

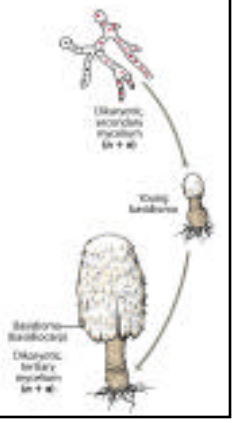


Karyogamy and meiosis

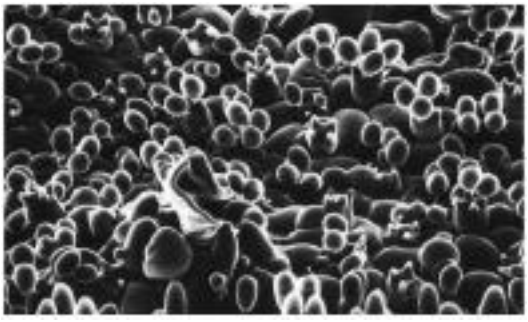


Basidiospores and plasmogamy

Basidioma formation

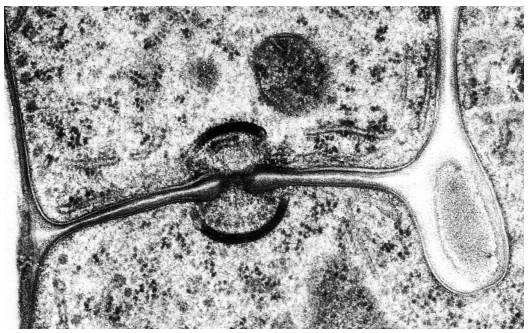


Basidium and basidiospores

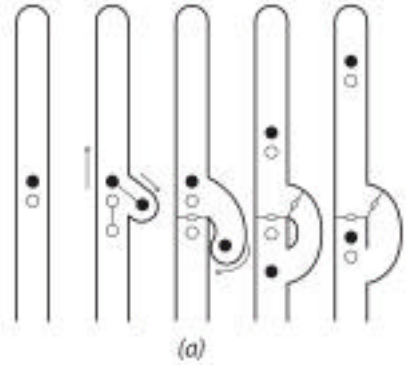


Basidiospores

Dolipore septum



Clamp connections



Clamp connection

Hymenomycetes *Amanita muscaria*

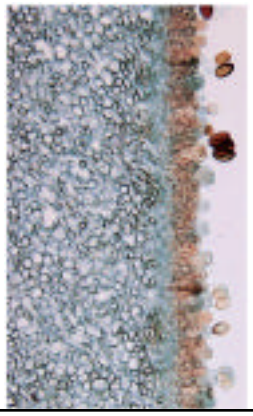
Polypore- *Polyporus arcularius*

Brachen or shelf- *Ganoderma applanatum*

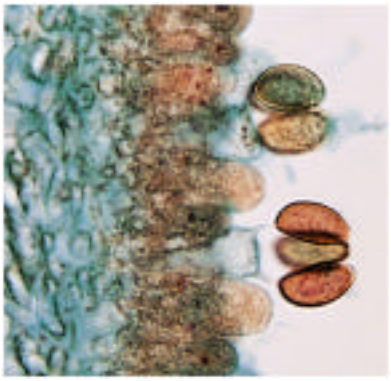
Tooth fungus- *Hericium coralloides*

Gills & hymenium

Hymenium



Basidiospores



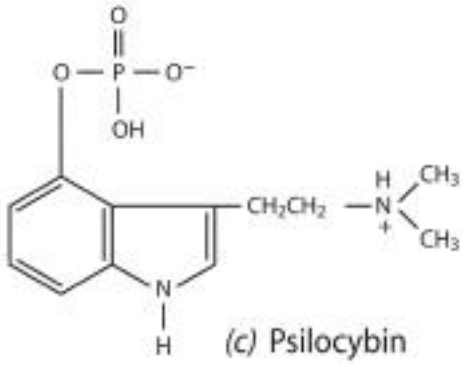
Jelly fungus-

Fairy ring

Psilocybe mexicana

Shaman

Structure analog of LSD



(c) Psilocybin

Gastromycetes

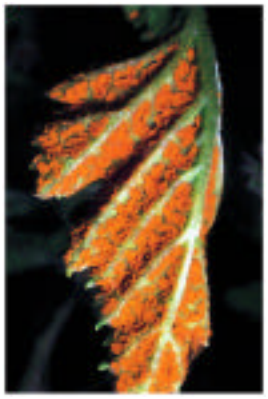
Stinkhorn- *Dictyophora duplicata*

Bird's nest fungus- *Crucibulum laeve*

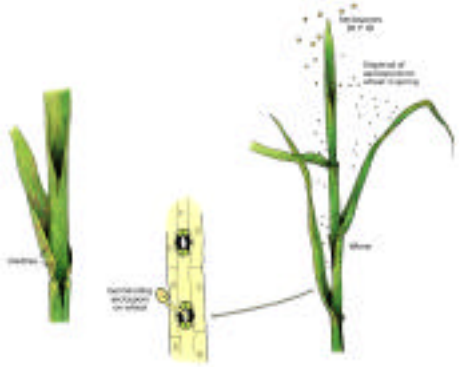
Earthstar- *Geastrum saccatum*

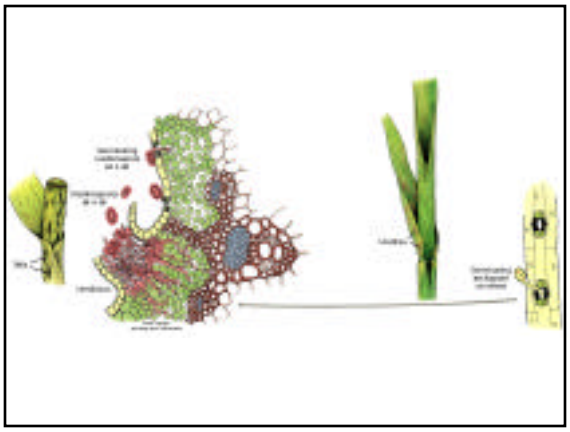
Teliomycetes: Rusts

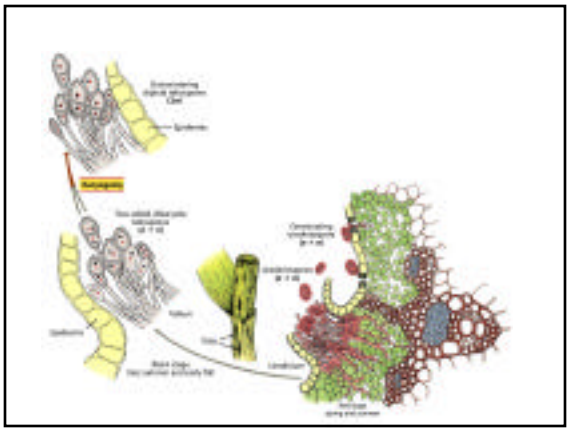
Sori of blister rust

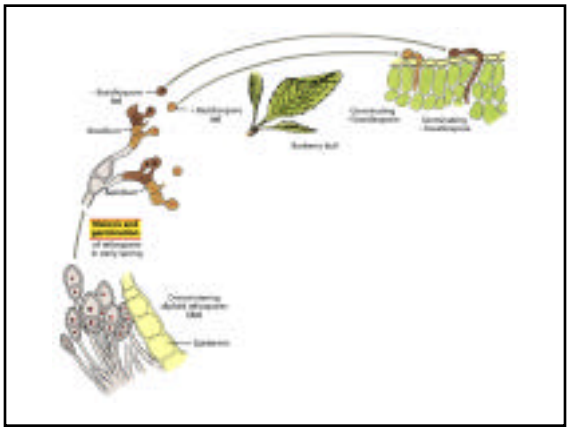


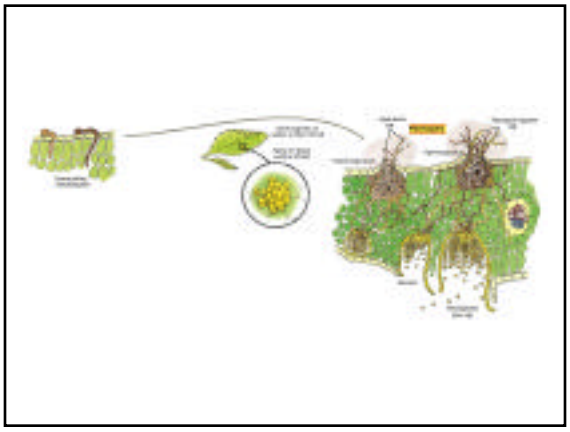
Wheat rust (heteroecious)











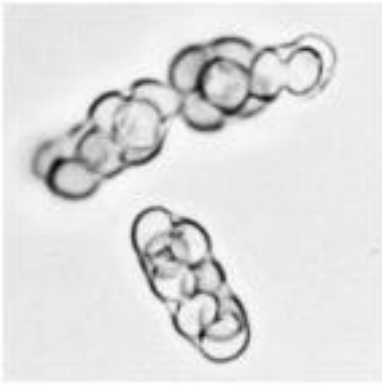
Ustomycetes - smuts (autoecious)

Ustilago maydis

Yeast

Filamentous forms of bread yeast

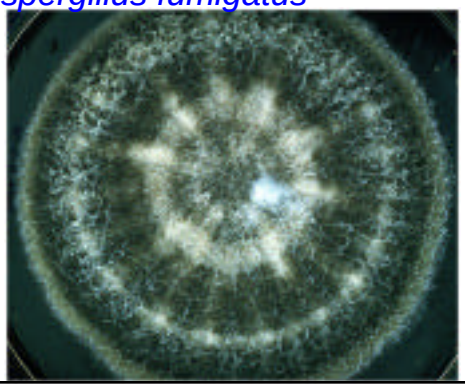
Naked asci



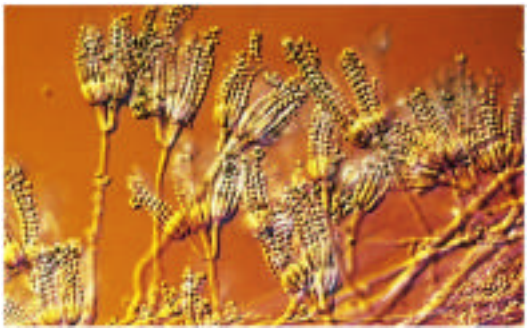
Ethanol production

Penicillium notatum

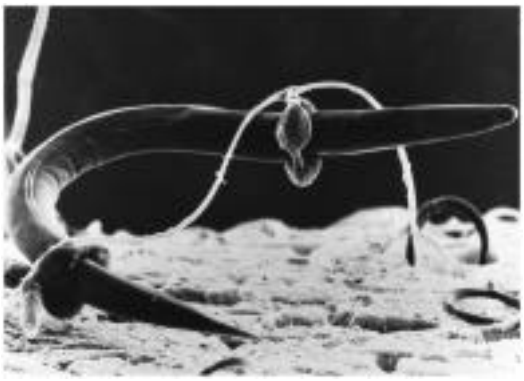
Aspergillus fumigatus



Penicillium



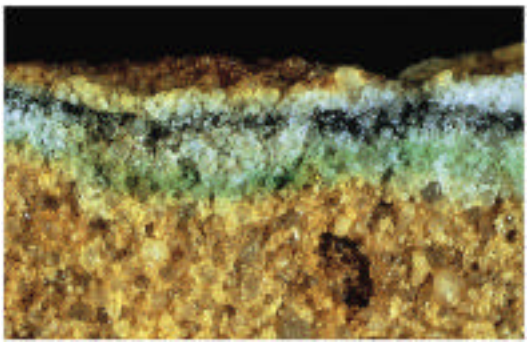
Aspergillus



Sclerotia of *Claviceps purpurea*

Lichens

Lichens in rock



Crustose

Crustose and foliose

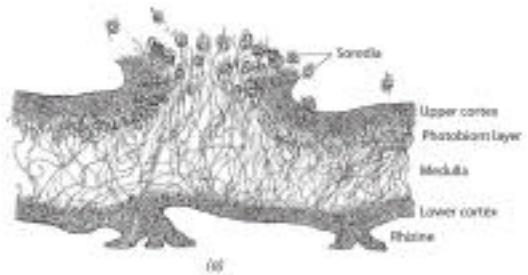
Foliose

Fruticose (shrubby)

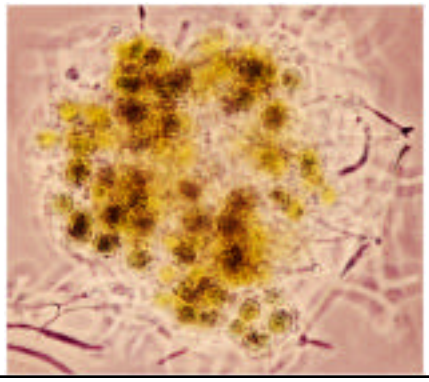
Fruticose

Spanish moss

Reindeer moss

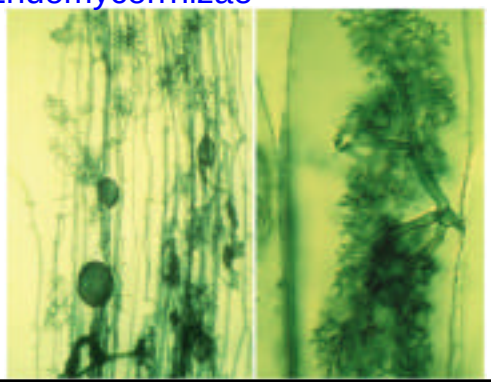


Soredium

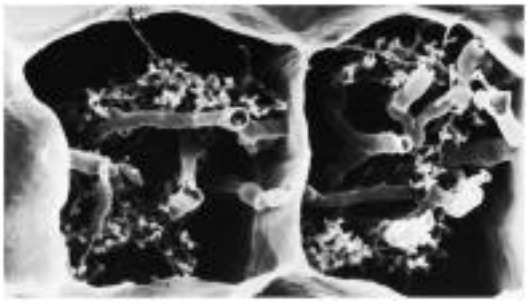


Mycorrhizae in Pines

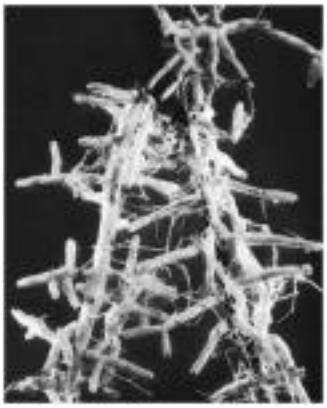
Endomycorrhizae

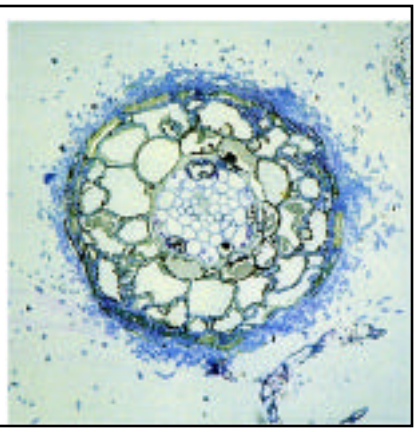


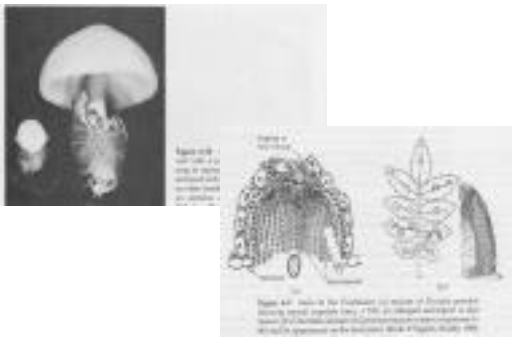
Endomycorrhizae

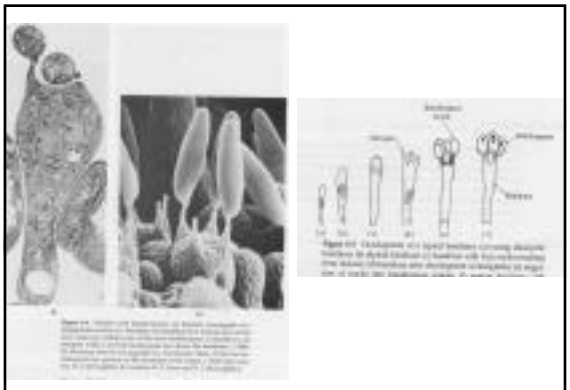


Ectomycorrhizae









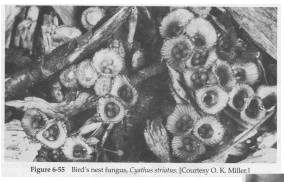


Figure 6-55 Bird's nest fungus, *Cyathus striatus*. [Courtesy O. K. Miller.]

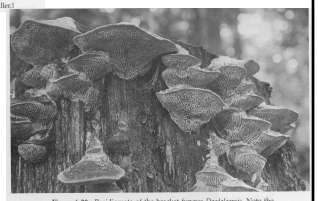


Figure 6-30 Basidiomata of the bracket fungus *Daedaleopsis*. Note the irregularly shaped pores. Basidiomata range from 3 to 15 centimeters at their widest point. [From E. J. Moore and V. N. Rockcastle, Fungi, Cornell Science Leaflet.]

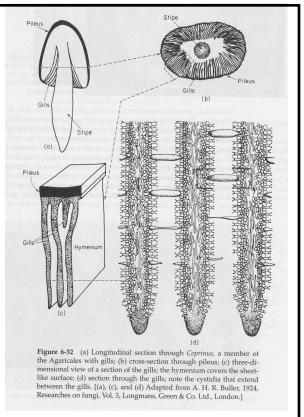


Figure 6-32 (a) Longitudinal section through *Coprinus*, a member of the Agaricales with gills; (b) cross-section through pileus; (c) three-dimensional view of a section of the gills; the hymenium covers the sheet-like surface; (d) section through the gills; note the cystidia that extend between the gills. [(a), (c), and (d) Adapted from A. H. R. Buller, 1924, Researches on fungi, Vol. 3, Longmans, Green & Co. Ltd., London.]

Coral fungus

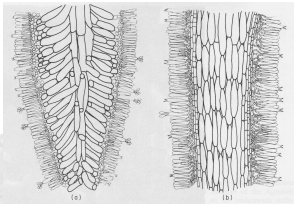


Figure 6-37 Cross-sections of gills showing two types of arrangement of the hyphae: (a) divergent type; (b) parallel type. [From A. H. Smith, 1949. Mushrooms in their natural habitat, Hafner Press, New York. Copyright GAF Corporation.]

Basidioma development

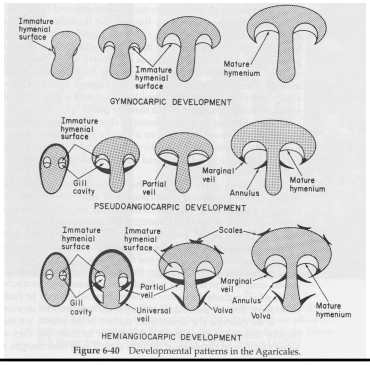


Figure 6-40 Developmental patterns in the Agaricales.

Coprinus (Inky cap)

Figure 6-41 Basidiomata of the inky cap mushroom, *Coprinus*: (a) unopened basidiomata with conical pileus; (b) autolysis of the pileus results in the dripping of a black fluid containing basidiospores. [From E. J. Moore and V. N. Rockcastle, Fungi, Cornell Science Leaflet.]

Figure 6-19 Basidiomata of *Tremella fibuliformis*, a jelly fungus. The larger basidioma is about 4 centimeters in diameter. [Courtesy J. S. Furtado.]

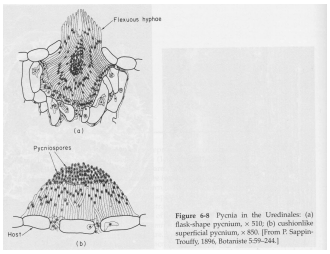
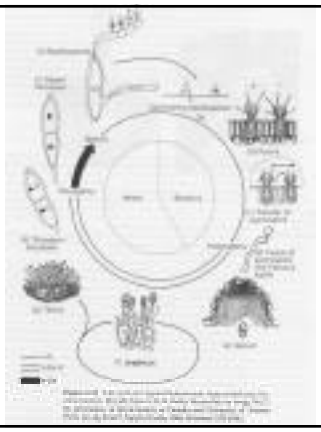


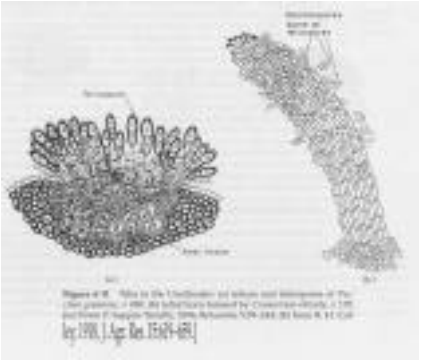
Figure 6-8 Pycnia in the Uredinales: (a) flask-shape pycnium, × 510; (b) cushionlike superficial pycnium, × 850. [From P. Sappin-Trouffy, 1896, Botaniste 5:59–244.]

Rust life cycle (Heteroecious)



Puffballs

Teliospores



Tubes in bracket fungi

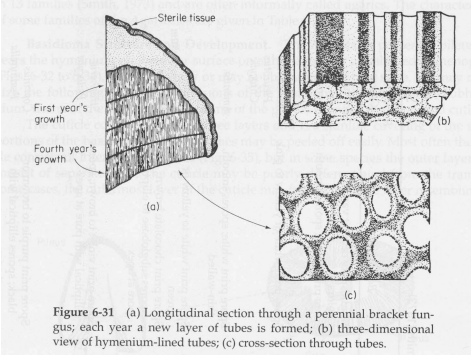


Figure 6-31 (a) Longitudinal section through a perennial bracket fungus; each year a new layer of tubes is formed; (b) three-dimensional view of hymenium-lined tubes; (c) cross-section through tubes.

Candida albicans budding

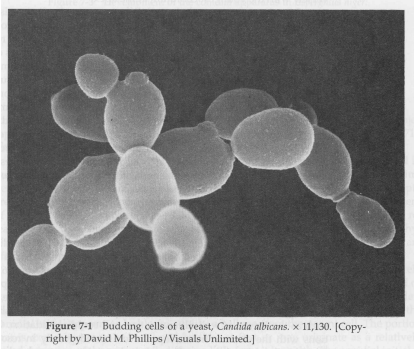
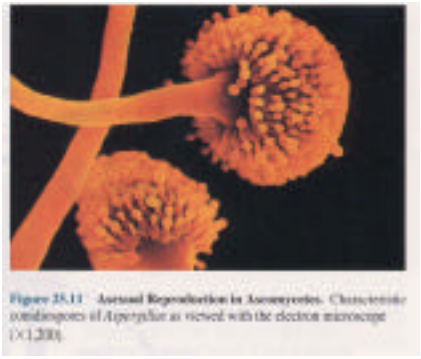


Figure 7-1 Budding cells of a yeast, *Candida albicans*. × 11,130. [Copyright by David M. Phillips/Visuals Unlimited.]

Aspergillus



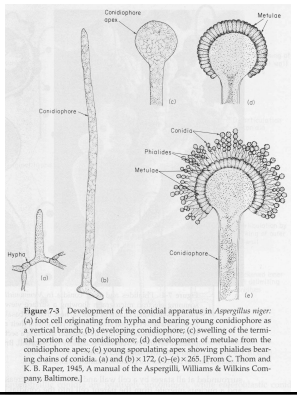
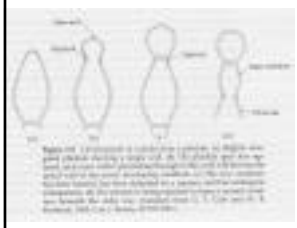
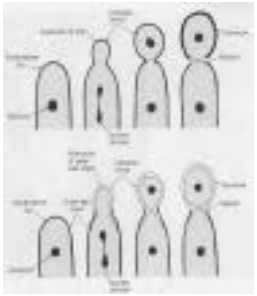


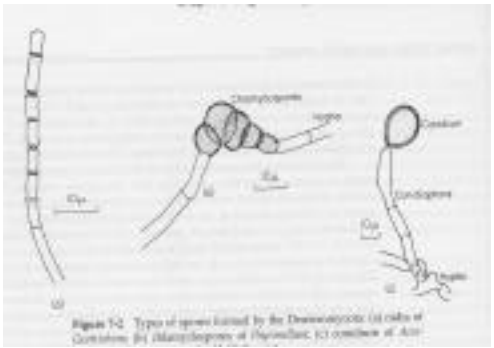
Figure 7-3 Development of the conidial apparatus in *Aspergillus niger*: (a) foot cell originating from hypha and bearing young conidiophore as a vertical branch; (b) developing conidiophore; (c) swelling of the terminal portion of the conidiophore; (d) development of metulae from the conidiophore apex; (e) young sporulating apex showing phialides bearing chains of conidia. (a) and (b) × 172, (c)–(e) × 265. [From C. Thom and K. B. Raper, 1945, A manual of the Aspergilli, Williams & Wilkins Company, Baltimore.]

Conidia development





Chlamydospores



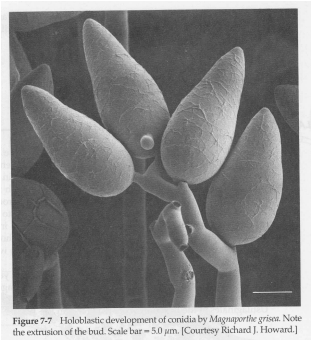
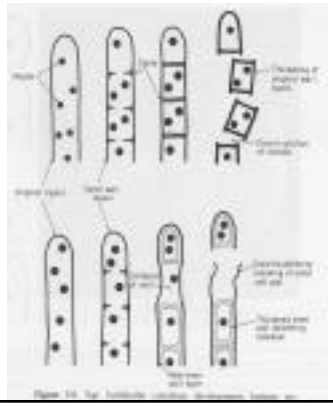


Figure 7-7 Holoblastic development of conidia by *Magnaporthe grisea*. Note the extrusion of the bud. Scale bar = 5.0 μm. [Courtesy Richard J. Howard.]



Pycnidia