Laboratory – Fungi

Fungi are generally classified as absorptive heterotrophs. Approximately 100,000 species have been placed into the basic taxa: chytridiomycota, zygomycota, ascomycota, and basidiomycota. This particular kingdom includes diverse organisms such as yeasts, mushrooms, toadstools, rusts and smuts as well as those that appear to live in symbiotic relationships with algae (lichens) and the roots of 90% of plants (endomycorrhizae and ectomycorrhizae). Using your photographic atlas examine the life cycles and examples of the four major taxa.

Objectives:

1. Differentiate between common members of the four taxa.
2. List characteristics of the four taxa.
3. Recognize and name some common members of the taxa.
4. Discuss life cycles of the four taxa.
5. Discuss economic significance of the four taxa.
6. Discuss distinguishing characteristics of a fungus.
7. Discuss the economic significance of fungi.
8. Discuss their significance as plant and animal pathogens.
9. Differentiate between foliose, fruticose and crustose forms of lichens.

Fungi

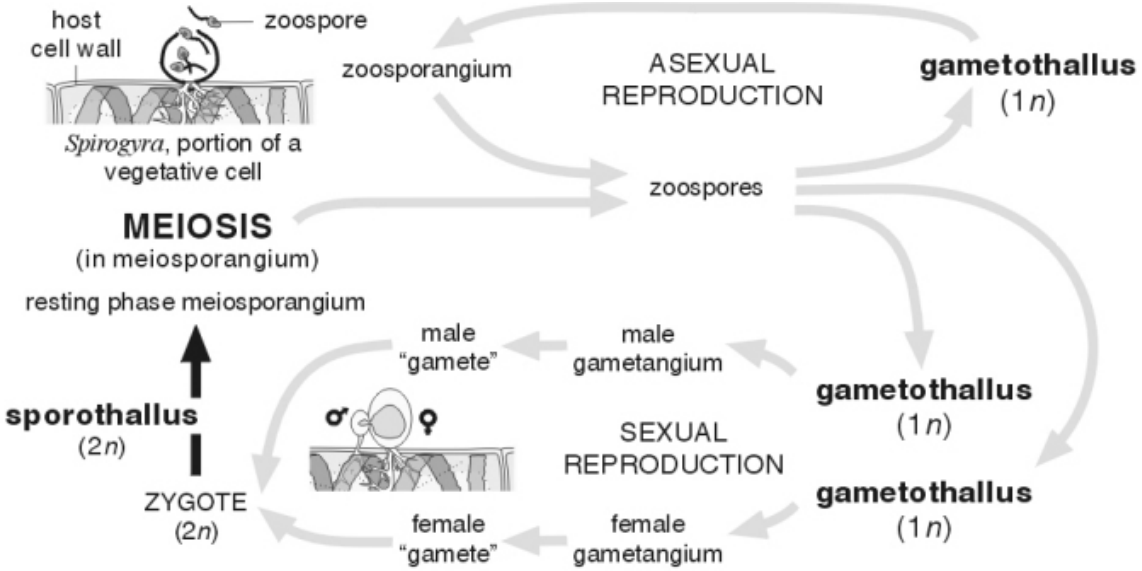
Fungi are ubiquitous eukaryotes, generally mullticellular, exhibiting rapid growth. They are absorptive heterotrophs (digestive hydrolytic enzymes are secreted into food.)

Nutritional modes include those that function as saprobes (absorb nutrients from non-living sources), parasites (absorb nutrients from living tissues - smuts, plant molds, mycoplasmas in human lungs), and mutualistic symbionts (fungi may absorb nutrients from a living source but they also provide support, water or minerals to other organisms.)

The basic structure consists of hyphae (minute tubes of chitin), most have septa with pores, some are aseptate and coenocytic, mycelium (the feeding network of hyphae), haustoria (nutrient absorbing hyphal tips found in some pathogens.)

All fungi reproduce asexually and some reproduce sexually when times are tough. Plasmogamy (fusion of the cells) precedes karyogamy (fusion of nuclei.) Dikaryon forms may exist for long periods of time. During mitosis the nuclear envelope remains intact and pinches in two after anaphase.

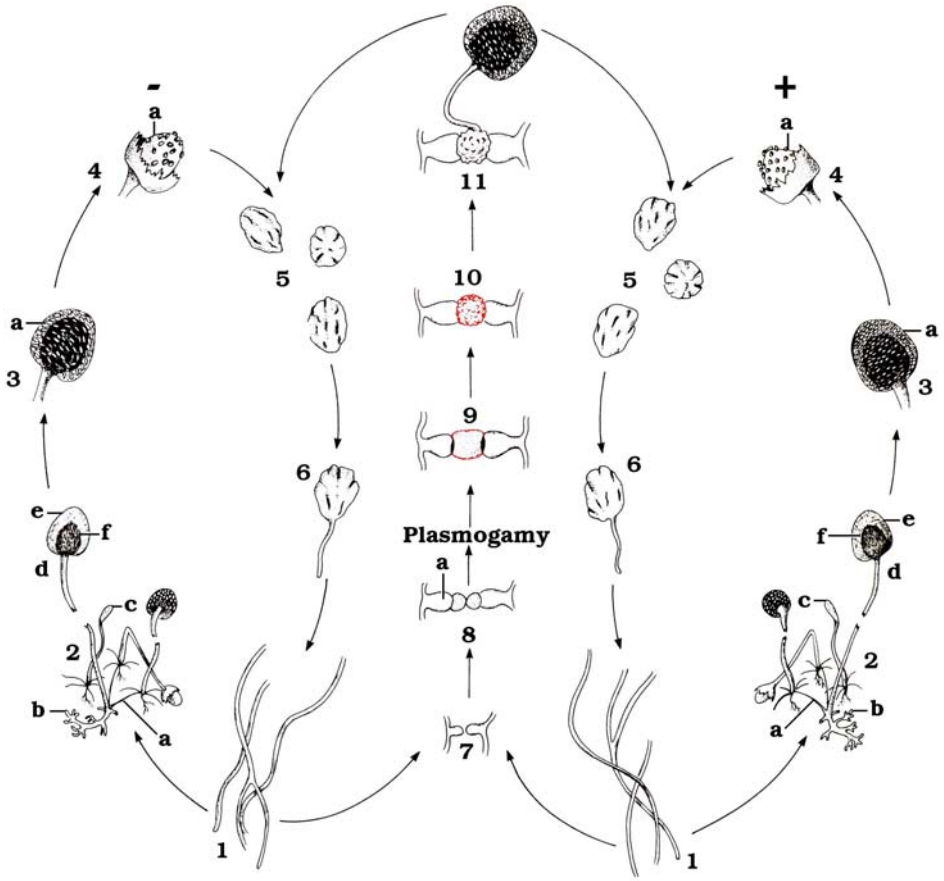
Members of the division Chytridiomycota were once classed as protists based on the fact that they have flagellated zoospores. Recent molecular data from protein and nucleic acid analyses indicate that chytrids are true fungi. Consequently, they have been moved from being protists and are now considered fungi. They are thought to be the link between protists and fungi. They are aquatic fungi which play an important role in decomposition as saprobes or as parasites of plants and invertebrates. Parasitic chytrids have been implicated in the world-wide decline of amphibians.



LIFE CYCLE OF *RHIZOPHIDIUM*: an example of Alternation of Generations.

Division Zygomycota includes 600 varieties. It is largely terrestrial and coenocytic with zygosporangia formed during sexual reproduction. Asexual reproduction occurs via sporangia yielding haploid spores which air currents disseminate. *Rhizopus* is a common bread mold.

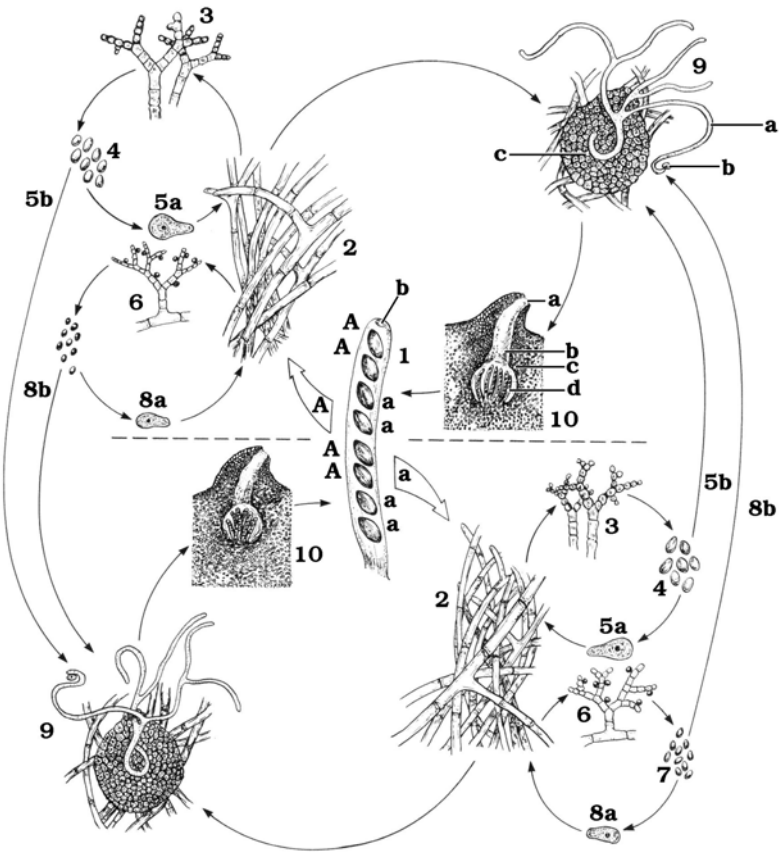
RHIZOPUS LIFE CYCLE



1. Hyphae (coenocytic)
2. Colony
   a. Stolon
   b. Rhizoid
   c. Young sporangium
   d. Sporangiophore
   e. Sporangium
   f. Columella
3. Mature sporangium
   a. Spore
4. Dehisced sporangium
   a. Columella
5. Spore (aplanospore)
6. Germinating spore
7. Progametangia
8. Gametangia
   a. Suspensor
9. Zygote
10. Zygospore
11. Sporgangium

Division Ascomycota contains approximately 60,000 species of sac fungi, leaf fungus, yeasts, truffles and many plant pathogens.

NEUROSPORA LIFE CYCLE



1. Ascus
   a. and A. Ascospores
   b. Ascal pore
2. Somatic hyphae
3. Macroconidiophore
4. Macroconidia

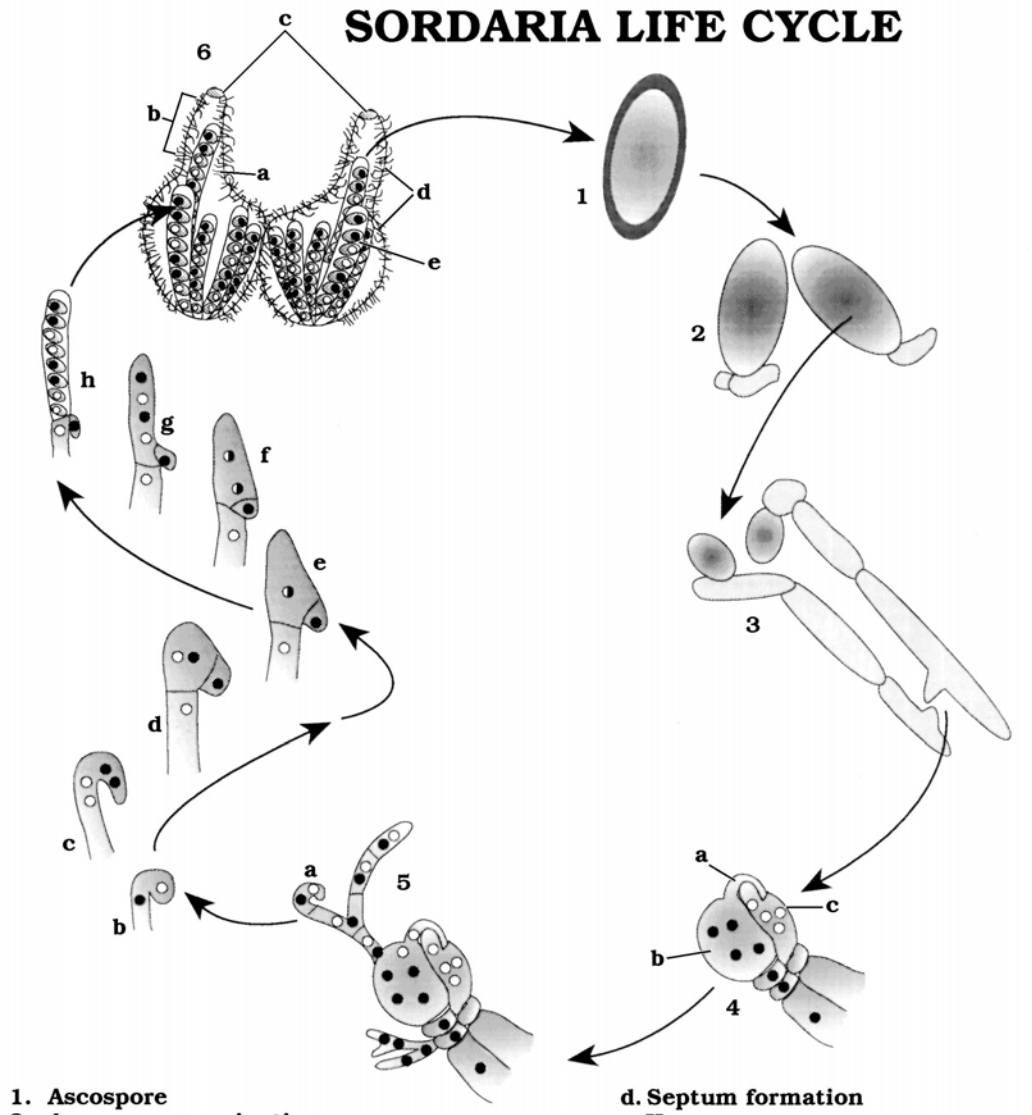
5a. Germination
5b. Conidiation
6. Microconidiophore
7. Microconidia

8a. Germination
8b. Spermatization
9. Protoperithecium
   a. Trichogyne
   b. Macro- or microconidium
   c. Ascogonium

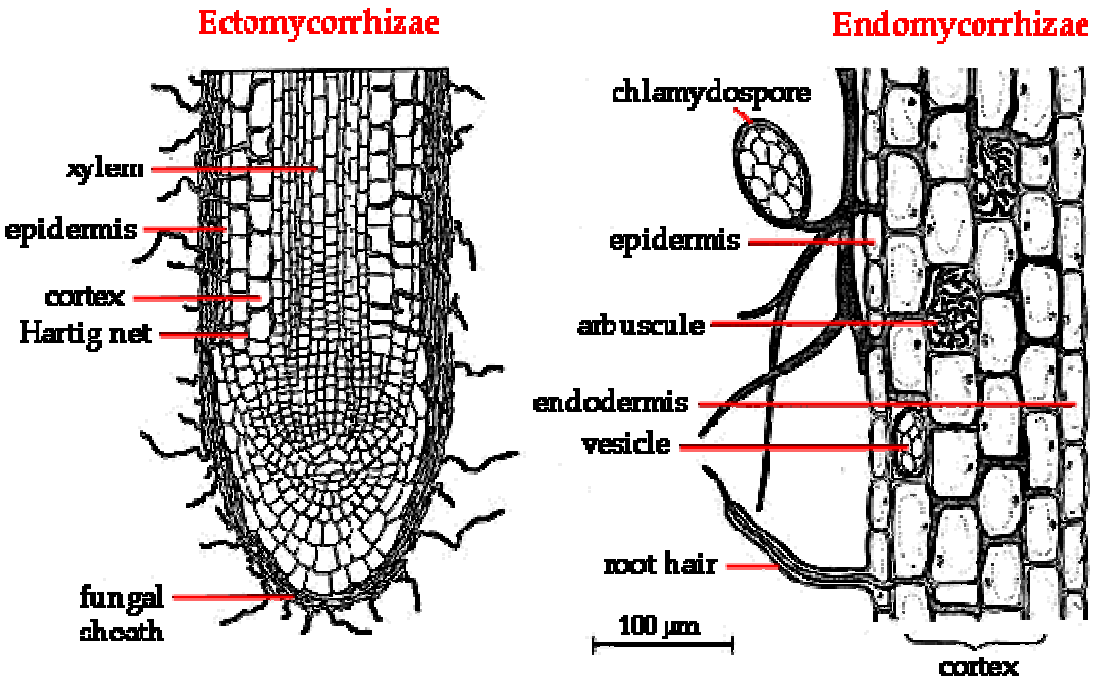
10. Young asci in perithecium
    a. Ostiole
    b. Ostiolar canal
    c. Peridium
    d. Asci

Asci are saclike structures containing ascospores found on the ascocarp (the macroscopic fruiting body.) Asci form at the tips of hyphae, karyogamy combines the two genomes meiosis follows, often yielding 8 ascospores.

Sordaria is often studied as a representative of Ascomycota. Conidia (asexual structures) are often produced at the ends of hyphae in chains or clusters. It is often found on dung.

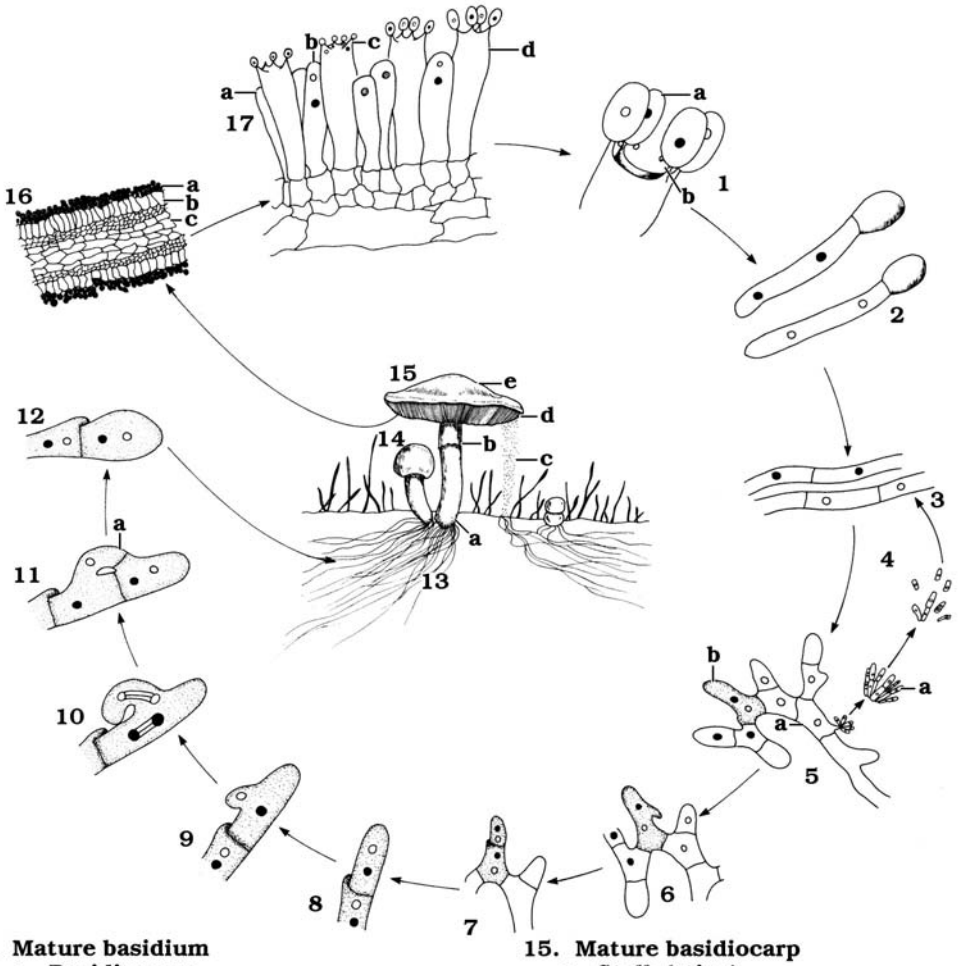


Mycorrhizae are produced by fungi that live as symbionts with plants exchanging nutrients. Truffles and morels (both ascomycetes) live in symbiotic relationships with plants. Some fungi protect plants from insects by releasing toxins. Mycorhizzae are found associated with 95% of all plants.



Basidiomycota includes 25,000 species. The basidium (clublike shape) is the diploid stage in the life cycle. These fungi are experts at decomposing lignin. Saprobes, mycorrhiza-forming mutualists and plant parasites (shelf fungi, rusts, and smuts) are found in this division. The dikaryon stage may be long-lived. Sexual reproduction produces a fruiting body (basidiocarp), the source of sexual spores. Gills may have surface area of 200 cm^2. Asexual reproduction is less common, spores produced as conidia.

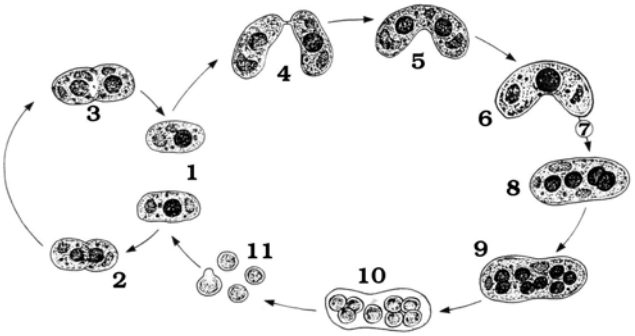
GILL FUNGUS LIFE CYCLE



1. Mature basidium
   a. Basidiospore
   b. Water drop
2. Germinating basidiospores
3. Septate uninucleate mycelium
4. Asexual cycle
   a. Oidia
5. Plasmogamy
   a. Primary uninucleate mycelium
   b. Secondary binucleate mycelium
6.–12. Development of binucleate mycelium
   a. Clamp connection
13. Mycelial mat, binucleate
14. Young basidiocarp
15. Mature basidiocarp
   a. Stalk (stipe)
   b. Ring (annulus)
   c. Spores
   d. Gills (lamellae)
   e. Cap (pileus)
16. Gill section
   a. Basidiospore
   b. Basidium
   c. Gill matrix
17. Hymenium
   a. Immature basidium (karyogamy)
   b. Developing basidium
   c. Sterigma
   d. Mature basidium

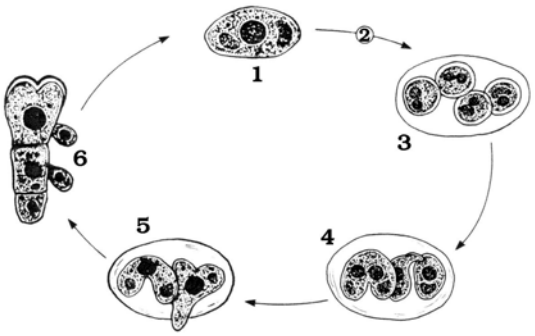
Yeasts are unicellular fungi that live in moist habitats, plant and animal tissues. Some yeasts reproduce sexually and are classified as ascomycetes or basidiomycetes. The balance reproduce asexually and are classified as fungi imperfecti. *Saccharomyces cerevisia*, an ascomycete, is used in baking and alcohol production.

YEAST LIFE CYCLES



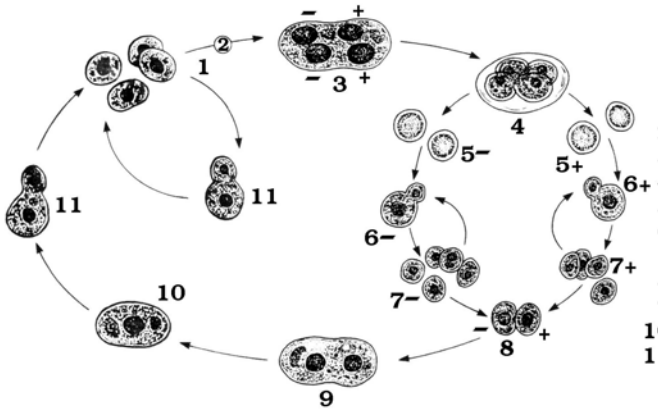
HAPLOBIONTIC
Short diploid and long haploid phases
Schizosaccharomyces octosporus

1. Somatic cells (n)
2. Cell division
3. Daughter cells
4. Copulation tube
5. Plasmogamy
6. Karyogamy (2n zygotic nucleus)
7. Meiosis
8. Young ascus with four nuclei
9. 8-nucleated stage
10. Mature ascus
11. Ascospores



DIPLOBIONTIC
Saccharomycodes ludwigii

1. Sprout cell
2. Meiosis
3. Ascus with four ascospores
4. Plasmogamy
5. Karyogamy (2n zygotic nucleus)
6. Sprout mycelium

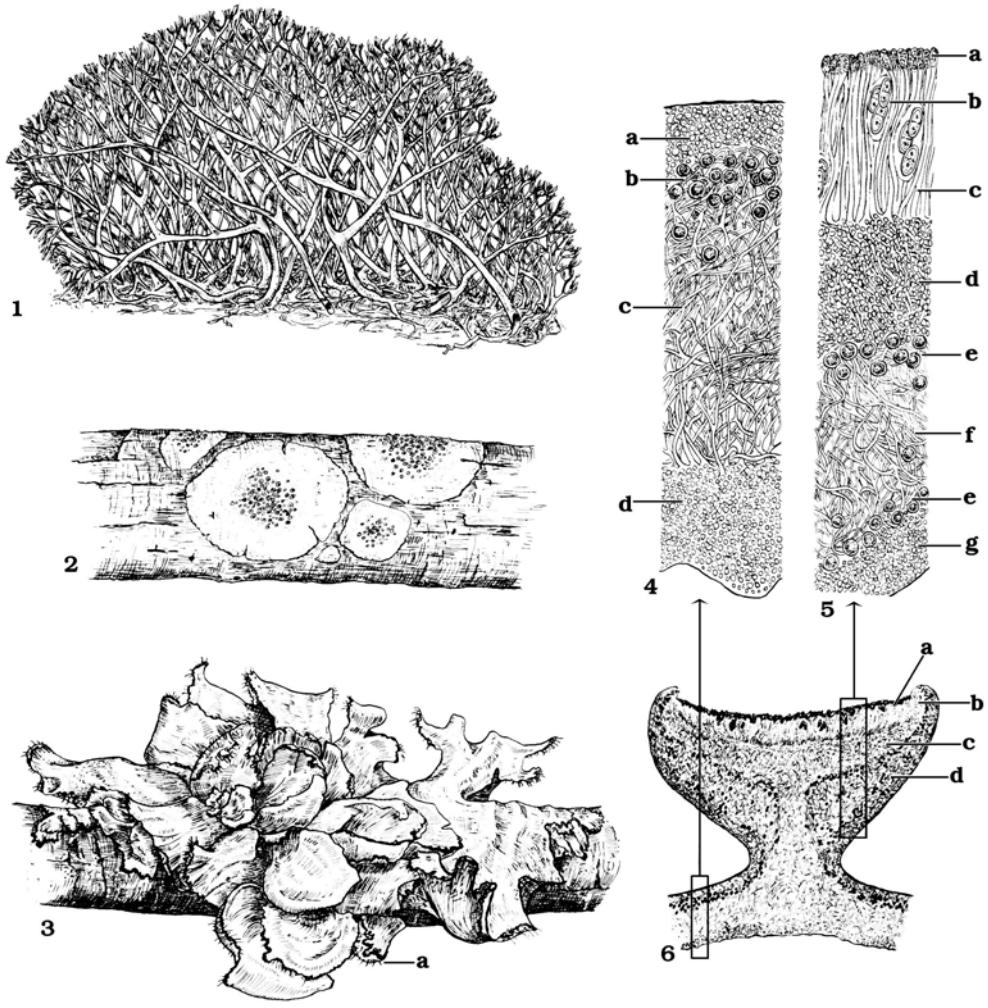


HAPLODIPLOBIONTIC
Long haploid & diploid
Saccharomyces cerevisiae

1. Somatic cells (2n)
2. Meiosis
3. Young ascus
4. Mature ascus
5. Ascospores
6. Budding
7. Somatic cells (n)
8. Copulation
9. Plasmogamy
10. Karyogamy
11. Budding

Lichens are symbiotic associations of photosynthetic microorganisms (cyanobacteria and chlorophyta) tangled in a mesh of fungal hyphae. Algae provide food to fungi while the fungi provide support and minerals.

LICHEN TYPES



1. Fruticose lichen
2. Crustose lichen
3. Foliose lichen
   a. Rhizines
4. Foliose lichen, c.s.
   a. Upper cortex
   b. Algal layer
   c. Medulla
   d. Lower cortex
5. Apothecium, vertical c.s.
   a. Epithecium
   b. Ascus
   c. Hymenium
   d. Hypothecium
   e. Algal layer
   f. Medullary hyphae
   g. Upper cortical hyphae
6. Stalked apothecium, l.s.
   a. Hymenium
   b. Proper exciple
   c. Hypothecium
   d. Thalloid exciple

Lichens reproduce by soredia (small clusters containing fungal hyphae and algal cells.) Lichens are often the pioneers in an environment and are very intolerant of pollution and used to predict pollution.

Of the approximately 100,000 known species of fungi, about one-third of these are mutualists, as either lichens or mycorrhizae. About another third are decomposers living in the soil and rotting organic matter. The rest are parasitic, mostly in or on plants. Sometimes a fungus can cause major changes to the landscape. An example of this is the fungus that causes Dutch Elm disease that continues to destroy American elms in the landscape following accidental release from logs imported from Europe after World War I.

Agriculturally, fungi are a serious pest. Species called smuts and rusts cause tremendous crop losses every year. One group of fungi, known as ergots, can cause serious medical problems including gangrene, nervous spasms, burning sensations, hallucinations, temporary insanity, and death. Ergots infect poorly stored cereal grains (mainly rye, wheat and oats) and produce several kinds of toxins, including lysergic acid which is the precursor for LSD. In 944 an ergot outbreak killed 40,000 people in Europe and an ergot infestation in barley is now thought to have triggered the events that led to the Salem witch trials. Some of the ergot compounds, however, have medicinal value in small doses, one such compound being used for treating blood pressure. Two species of *Aspergillus* (*Aspergillus flavus* and *Aspergillus parasiticus*) produce toxins (known as aflatoxins) that have been found in milk, cheese, corn, peanuts, cottonseed, nuts, almonds, figs, spices, and a variety of other foods and feeds, with corn, peanuts, and cottonseed being the most common source (milk, eggs and meat probably become contaminated through animal consumption). These toxins are some of the most toxic naturally occurring substances and are tightly regulated in foods. They cannot be present at levels above 20 ng/g (0.5 ng/g for milk) and produce symptoms which include vomiting, abdominal pain, pulmonary edema, convulsions, coma, and death.

Animals are less susceptible to parasitic fungal infections. About 50 species of fungus parasitize humans and other animals. Human fungal infections include yeast infections of the lungs (*Aspergillus* species), and vagina and bucal cavity (*Candida*), and *Tinea* infections of the scalp, skin and feet (ringworm and athlete’s foot). In recent times, two toxic molds have been the focus of considerable attention. *Stachybotrys chartarum* and *S. atra* have

made homes, schools and commercial buildings uninhabitable – the so-called sick building syndrome. Laws have recently been passed to protect consumers from poor home construction and/or repair that results in moisture problems in cellulose-containing areas of the structure (which promotes mold growth).

Economically, fungi are extremely important as we depend on them as decomposers and recyclers of organic matter. Fungi also have a number of practical uses for humans. Mushrooms are widely eaten as food but fungi also provide the distinctive flavors of a number of cheeses, including Roquefort and blue cheese, which are ripened by fungi. Truffles, the fruiting bodies of mycorrhizal fungi of oak trees in Western Europe are highly prized. A species of *Aspergillus* is used in the production of soy sauce. Yeasts, which are unicellular fungi, are used for baking, brewing, and winemaking. Some fungi are important because they produce antibiotics. The first antibiotic discovered, penicillin, is the product of the *Penicillium* mold. *Tolypocladium inflatum* yields cyclosporine, a drug that prevents rejection following organ transplant.

Important fungi: *Rhodotorula* (appears as a pink scum on shower curtains), *Candida* (a common cause of vaginitis), *Clavicipes purpurea* (source of the precursor for LSD), *Pilobolus, Amanita bisporigera* (the death angel fungus which produces a powerful hallucinogenic toxin), *Penicillium notatum* (antibiotic discovered by Alexander Fleming in 1927), *Aspergillus* (aflatoxin), *Agaricus* (edible mushroom.)

Significance includes roles as decomposers, spoilers, pathogens, edible good and producers of antibiotics.

Laboratory Questions:

1. Name the 4 main taxa and give characteristics of each.

2. Describe the life cycles characteristic of the taxa.

3. Discuss distinguishing characteristics of fungi.

4. Discuss both positive and negative impacts of fungi.

5. Research an economically significant fungus and printout at least one report from a reliable journal about this fungus. Write a one paragraph synopsis of the report and be prepared to present this to the class in lab.

6. Draw representatives of each type of lichen.