Zygomycota -- Conjugating Fungi

Introduction

Fungi in this group include serious plant, animal and human pathogens, as well as industrially important species used for food and the fermentation of various agriculturally derived chemicals.

Efforts to develop a natural classification of these fungi have proven difficult because of their morphological simplicity. There has been much recent work on molecular phylogeny.

This division contains two classes:

1. Zygomycetes
2. Trichomycetes.

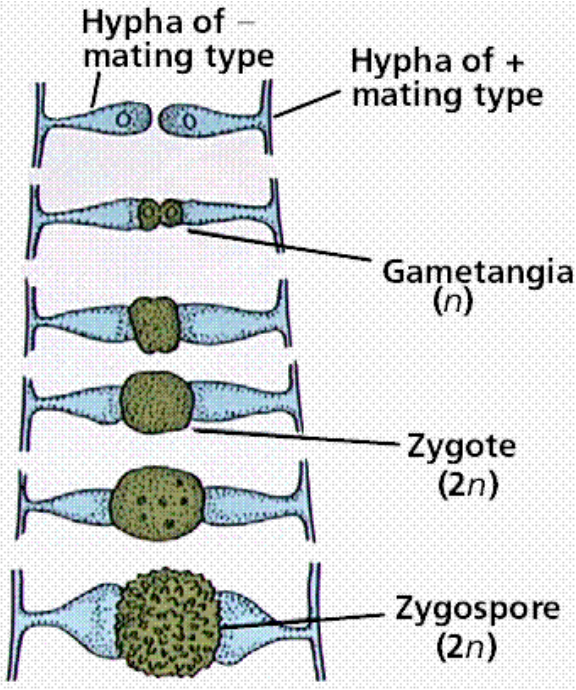
Since most Trichomycetes are parasites or commensals inside the guts of living arthropods, they are only a footnote, albeit a fascinating one, to this chapter.

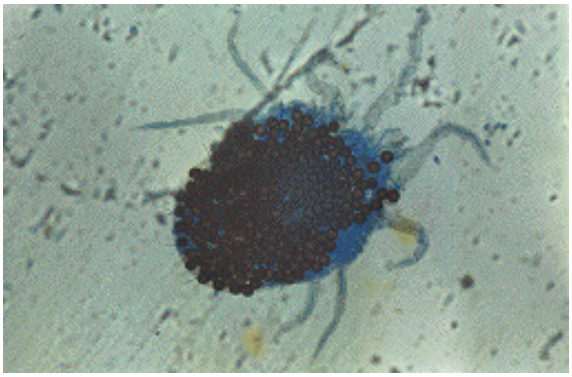
A. Class Zygomycetes (7 orders, 30 families, 125 genera, almost 900 species).

1. This class contains only about 1% of the known species of fungi,
2. Its members are distinctive, and some of them are common, successful, fast-growing, primary colonizers of substrates containing accessible carbon sources like sugar or starch.

3. `Zygos' is Greek for a yoke or joining. Their name is derived from the way in which they reproduce sexually by fusion or conjugation of morphologically similar gametangia to form a zygosporangium.

   a. The gametangia arise from hyphae of a single mycelium in homothallic species
   b. or from different but sexually compatible mycelia in heterothallic species.
   c. Zygosporangia usually develop thick walls, and act as resting spores.
   d. You won't often see zygosporangia in the field (except for an occasional homothallic species) but asexual or anamorphic phases of zygomycetes are easy to find.





4. The zygomycete hyphae do not have one nucleus per cell, but rather have long multinucleate, haploid hyphae that comprise their mycelia.
5. Asexual reproduction is by spores produced in stalked sporangia.

B. There are four orders:

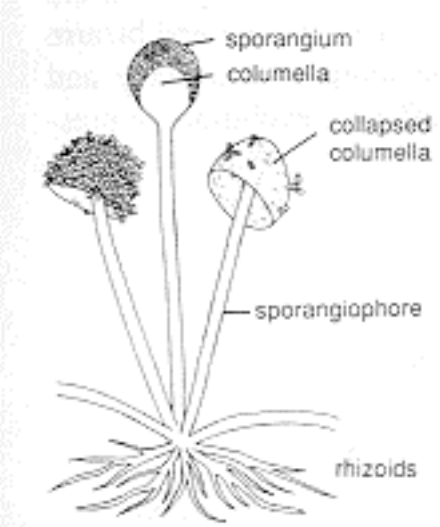
1. Mucorales
2. Entomophthorales
3. Kickxellales
4. Glomales.

The affinities of the Glomales are still uncertain, since they almost never reproduce sexually, but the mutualistic symbiotic relationships they establish inside the roots of most higher plants (perhaps as many as 300,000 plant species!).

1. Order Mucorales 13 families, 56 genera, 300 species.

a. This order includes all the common saprobic zygomycetes.

Ex. the ubiquitous bread mould, *Rhizopus stolonifer*



A: ***Rhizopus stolonifer***

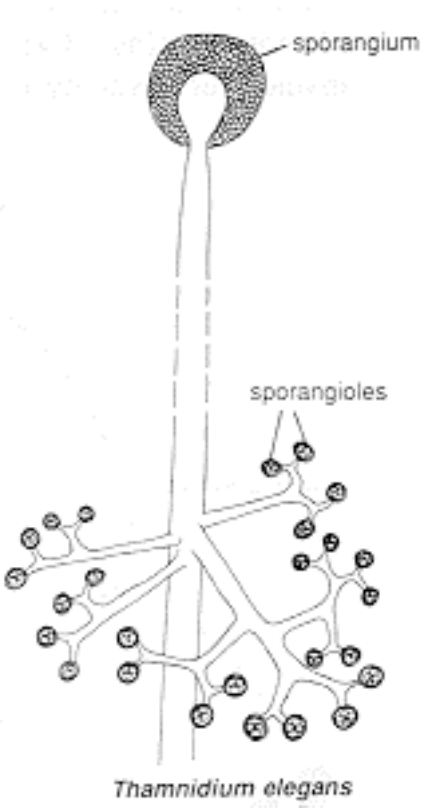
b. Each spherical mitosporangium of these fungi contains stout, simple or branched hyphae called sporangiophores.

c. The trade-mark of the family Mucoraceae is a swollen extension of the sporangiophore called a columella which protrudes into the sporangium, and often persists after the delicate outer skin or peridium of the sporangium has disappeared and the sporangiospores have been dispersed.

d. Each spherical mitosporangium of these fungi contains hundreds of non-motile, asexual spores, and these sporangia are produced at the ends of tall, stout, simple or branched hyphae called sporangiophores.

e. Other families often have fewer spores per sporangium, and their sporangia have no columella.

Ex. *Thamnidium elegans* (Thamnidiaceae) seems to compromise.

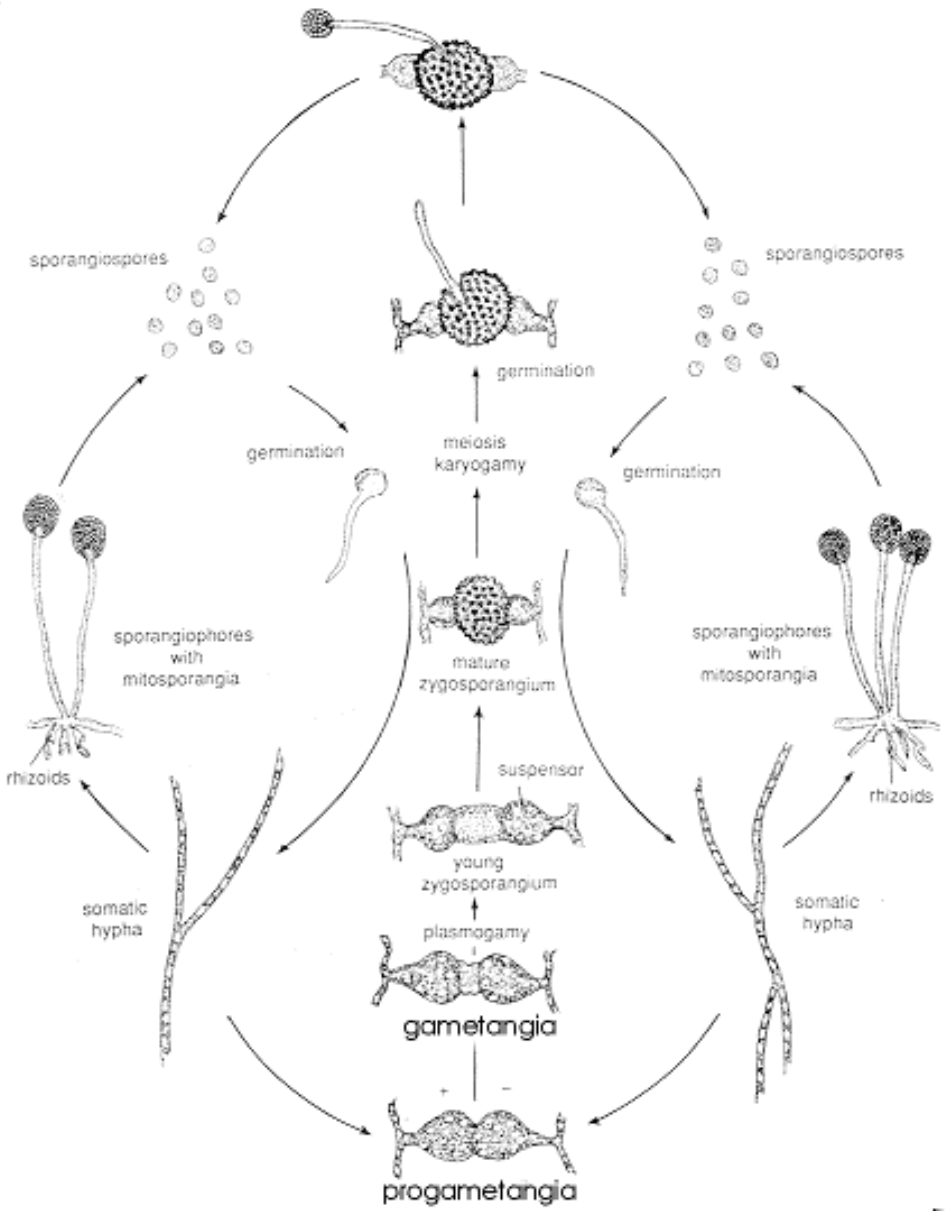


Thamnidium elegans

Its tall sporangiophores have one large, terminal, columellate sporangium, but lower on the stalk there are branches which fork repeatedly in a dichotomous manner, the final branchlets ending in tiny mitosporangia (sporangioles) which contain only a few spores.

Ex. Cunninghamella (Cunninghamellaceae) has only one spore per mitosporangium, and in which the walls of spore and sporangium appear to have fused. Now the whole mitosporangium becomes detached and acts as a dispersal unit.

f. Zygomycetes can go through cycle after cycle - spore, mycelium, sporangium, spore - producing only the anamorph, they sometimes form sexual zygosporangia, perhaps as a survival mechanism, perhaps for the benefits of genetic recombination, or perhaps just because compatible strains have met.



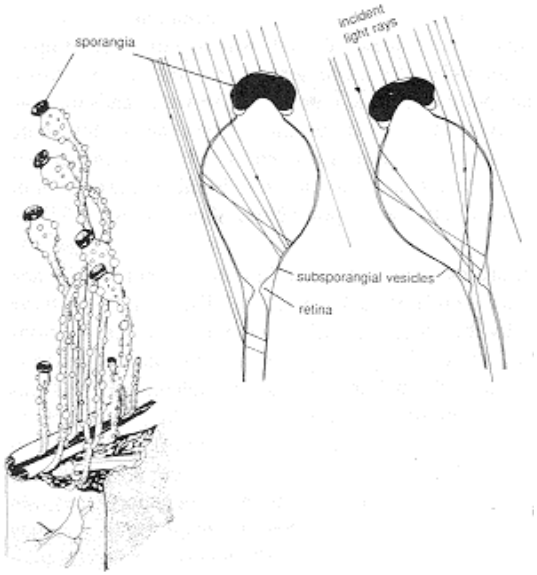
Mucorales, *Rhizopus stolonifer*. Note that when the zygosporangium germinates, it produces a mitosporangium.

g. The anamorphs of zygomycetes -- mitosporangia and the structures on which they are borne -- have evolved some amazing and bizarre adaptations. This contrast between teleomorphic constancy and anamorphic diversity is presumably the result of differing evolutionary pressures.

- Long-term survival, one of the main objectives of the teleomorph, is presumably best ensured by structures with minimal surface area and thick, protective walls.
- Dispersal, the main purpose of anamorphs, can be achieved in many ways.

Ex. *Pilobolus crystallinus* is an atypical but fascinating coprophilous (dung-inhabiting) member of the order Mucorales.

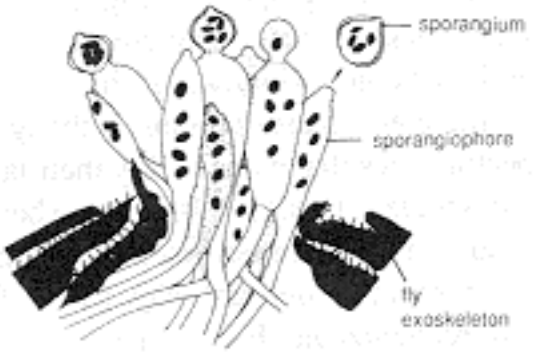
- •It grows very rapidly, and is one of the first fungi to fruit in the extended succession that occurs on dung.
- •Its unbranched sporangiophores are 2-4 cm tall, and have a unique explosive dispersal mechanism.
- •Beneath the black apical mitosporangium is a lens-like subsporangial vesicle, with a light-sensitive `retina' at its base that controls the growth of the sporangiophore very precisely, aiming it accurately toward any light source. It is phototropic.
- •Osmotically active compounds cause pressure in the sporangiophore and the subsporangial vesicle to build up until it is more than 100 pounds per square inch (7 kilograms per square centimeter).
- •This eventually causes the vesicle to explode, hurling the black sporangium away to a distance of up to 2 meters, directly toward the light.



2) Order Entomophthorales.

a. As the name implies, these fungi often attack insects.

Ex. *Entomophthora muscae* infects, and eventually kills, houseflies. Dying flies, their bodies riddled by the fungus, usually crawl into exposed situations where the fungal infection bursts through the insects' exoskeleton and produces tightly-packed masses of sporangiophores.



Each sporangiophore bears one unicellular, sticky mitosporangium that is shot away at maturity. When the fly dies on a window, this barrage produces a whitish halo of mitosporangia on the glass. These sporangia can infect other unsuspecting flies

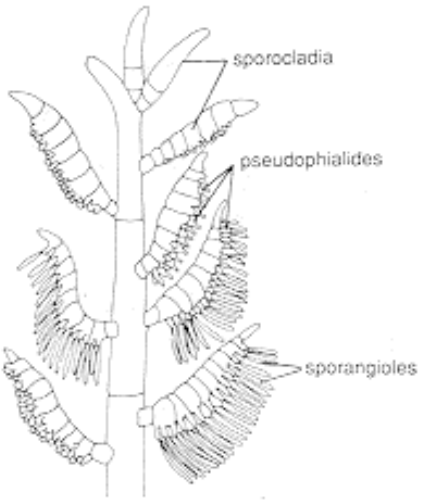
Species of *Entomophthora* are being investigated for their potential in biological control of insect pests

3) Order Kickxellales (Named after a mycologist called Kickx).

a. Members of this order are atypical of the Zygomycetes in that they often have regularly septate hyphae.

b. Their teleomorphs are unremarkable, but they develop some of the most complex anamorphs known.

Ex. Coemansia on bat dung from a cave. Its tall sporangiophore bears many fertile side branches called sporocladia. Each of these produces a row of lateral cells called pseudophialides. Finally, from the apex of each pseudophialide arises an elongate, one-spored mitosporangium (a sporangiole).



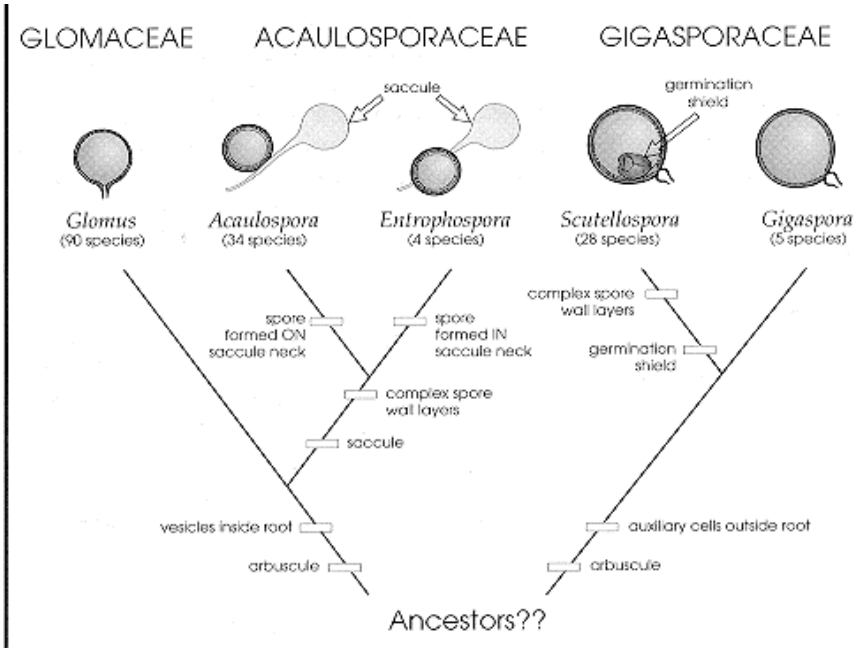
E: *Coemansia*

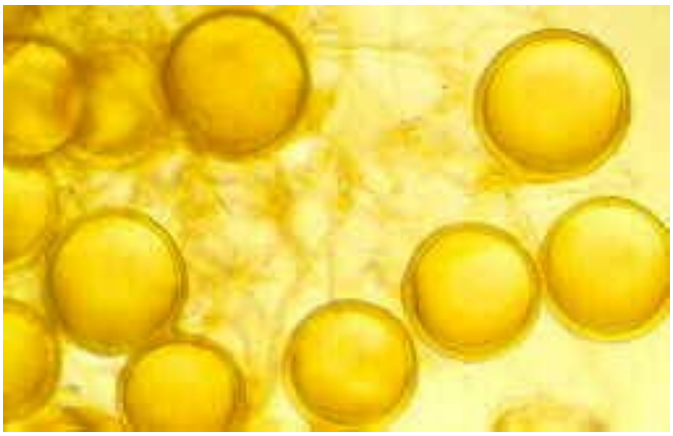
4) Order Glomales.

a. These soil-inhabiting fungi were placed in the Zygomycota only tentatively, since almost none of them form zygosporangia.

b They are extremely important, because their hyphae enter the living root cells of perhaps 90% of all higher plants and establish with them obligate mutualistic symbioses called arbuscular mycorrhizae(AM) or endomycorrhizae.

c. They typically have large, thick-walled spores.





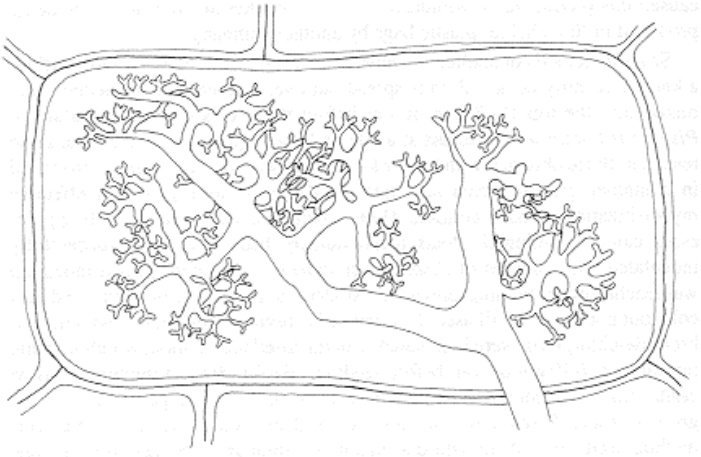
d. Some mycologists prefer to merge the sixth genus, *Sclerocystis*, (which makes many-spored fruiting structures) with *Glomus*. Here are some thick-walled, lipid-filled spores of Glomus that have been extracted from the soil by repeated sieving.

e. AM fungi won't grow in axenic culture: they must be associated with a plant root.

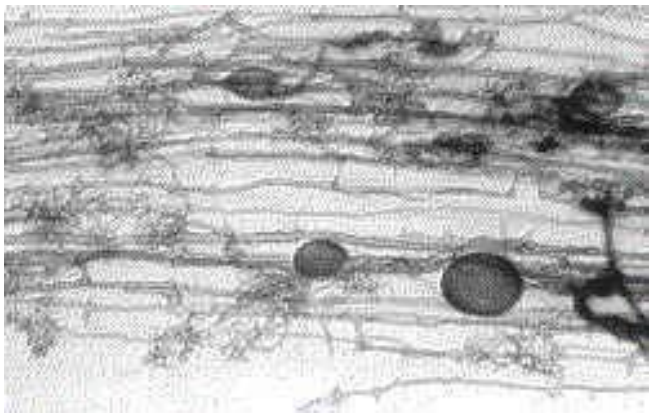
f. Their generally very large and thick-walled resting spores are common in most soils, and are stimulated to germinate by the proximity of plant roots (almost any plant will do, because these fungi have such wide host-ranges).

g. Their usually non-septate hyphae spread through the soil and enter living roots, where they develop structures that are diagnostic of the order:

•intracellular, finely branched, tree-like arbuscules which are the interface across which the fungus exchanges mineral nutrients, especially phosphorus, for photosynthates (sugars, etc.) provided by the plant.



•Many of the Glomales produce both arbuscules and lipid-filled structures called vesicles or intramatrical spores inside plant roots



- The soil-inhabiting mycelium is very efficient at mobilizing insoluble phosphorus and translocating (moving) it to the plant.
- Since phosphorus is often the limiting nutrient for plant growth, AM fungi help plants to thrive in poor soils. These fungi are therefore vital in many natural habitats, and of great potential value in agriculture.

C. Class Trichomycetes. 4 orders, 7 families, 48 genera, almost 200 species.

This eccentric group of fungi live almost exclusively attached to the lining of the guts of living arthropods. But they are good examples of the opportunism displayed by fungi.

- ecologically and morphologically distinct from all other fungi
- all members are obligately associated with living arthropods including insects, millipedes and crustaceans
- the thalli of certain larger species may be so densely aggregated as to give the inside of the gut a fuzzy or hairy appearance (hence the name Trichomycetes or "hair fungi")
- the nature of the relationships between these fungi and their hosts is not fully understood
- if mosquito larvae are deprived of sterols and B vitamins, larvae containing the trichomycete *Smittium culisetae* survived through more instars than did larvae that did not have the fungus
- on the other hand, *S. morbosum* kills mosquito larvae