

References: Beard CE. 2008 Trichomycetes. In: Capinera J.L. (eds) Encyclopedia of Entomology. Springer, Dordrecht.
Chinn RY, Diamond RD. 1982. "Generation of chemotactic factors by *Rhizopus oryzae* in the presence and absence of serum: relationship to hyphal damage mediated by human neutrophils and effects of hyperglycemia and ketoacidosis". *Infection and Immunity*. 38 (3): 1123–29.
Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008. *Dictionary of the Fungi* (10th ed.). Wallingford, UK: CABI.
Zheng RY, Chen GQ, Huang H, Liu XY. 2007. A monograph of *Rhizopus*". *Sydowia*. 59 (2): 273–372.
Webster, J., & Weber, R. (2007). *Introduction to fungi*. Cambridge, UK: Cambridge University Press.

GENERAL FEATURES OF ZYGOMYCOTA

The phylum Zygomycota comprises the first group of fungi which lacks any motile stage. Asexual reproduction is by spores which are called aplanospores because they are non-motile, and sporangiospores because they are typically contained within sporangia. They are dispersed passively by wind, insects and rain splash, although violent liberation of entire sporangia (e.g. *Pilobolus*) or individual spores (e.g. *Basidiobolus*, *Entomophthora*) can also occur. Sexual reproduction is by gametangial copulation which is typically isogamous and results in the formation of a zygospore. The mycelial organization is coenocytic, and the cell wall contains chitin and its deacetylated derivative, chitosan. As in the Chytridiomycota, Ascomycota and Basidiomycota, the mitochondria possess lamellate cristae, and the Golgi system is reduced to single cisternae (Webster & Weber, 2007).

Spores

The term "spore" is used to describe a structure related to propagation and dispersal. Zygomycete spores can be formed through both sexual and asexual means. Before germination the spore is in a dormant state. During this period, the metabolic rate is very low and it may last from a few hours to many years. There are two types of dormancy. The exogenous dormancy is controlled by environmental factors such as temperature or nutrient availability. The endogenous or constitutive dormancy depends on characteristics of the spore itself; for example, metabolic features. In this type of dormancy, germination may be prevented even if the environmental conditions favor growth (Url 1).

Mitospores

In zygomycetes, mitospores (sporangiospores) are formed asexually. They are formed in specialized structures, the mitosporangia (sporangia) that contain few to several thousand of

spores, depending on the species. Mitosporangia are carried by specialized hyphae, the mitosporangiophores (sporangiohores). These specialized hyphae usually show negative gravitropism and positive phototropism allowing good spore dispersal. The sporangia wall is thin and is easily destroyed by mechanical stimuli (e.g. falling raindrops, passing animals), leading to the dispersal of the ripe mitospores. The walls of these spores contain sporopollenin in some species (Url 1).

Chlamydo spores

Chlamydo spores are asexual spores different from sporangio spores. The primary function of chlamydo spores is the persistence of the mycelium and they are released when the mycelium degrades. Chlamydo spores have no mechanism for dispersal. In zygomycetes the formation of chlamydo spores is usually intercalary. However, it may also be terminal. In accordance with their function chlamydo spores have a thick cell wall and are pigmented (Url 1).

Zygo spores

Zygo spores are chemotropic aerial hyphae that are the sex organs of Zygomycota, except for Phycomyces in which they are not aerial but found in the substratum. They have two different mating types (+) and (-). The opposite mating types grow towards each other due to volatile pheromones given off by the opposite strand, mainly trisporic acid and its precursors. Once two opposite mating types have made initial contact, they give rise to a zygo spore through multiple steps (Url 1).

Division: *Zygomycota*

Two classes, *Zygomycetes* and *Trichomycetes*, are included in the division *Zygomycota*.

Class: *Zygomycetes*

Characteristics of the class are the same as those of the division. The class contains 6 orders, 29 families, 120 genera, approximately 800 species.

Order: *Endogonales*

The order includes only one family, four genera and 27 species. Its members are distinguished by their production of small sporocarps that are eaten by rodents and distributed by their feces. Order: Entomophthorales Most members of the order are pathogens of insects. A few attack nematodes, mites, and tardigrades, and some are saprotrophs.

Family: *Basidiobolaceae*

It is a monotypic family and *Basidiobolus* is the only genus in the Basidiobolaceae. The best-known species is *B. ranarum*, which has a worldwide distribution. It fruits on the dung of frogs, toads, lizards, some insectivorous fish and mammals such as bats. It has also been found on the dung of kangaroos and wallabies (Webster & Weber, 2007).

Family: *Entomophthoraceae*

The family includes 12 entomopathogenic genera.

Genus: *Erynia*

There are about 12 species of *Erynia* parasitic on terrestrial insects such as aphids and Lepidoptera, but some attack the aquatic larval stages of Diptera, stone flies and caddis flies. Characteristic features of the genus are branched conidiophores bearing uninucleate, bitunicate primary conidia which are discharged by septal eversion (Webster & Weber, 2007).

Genus: *Entomophthora*

Members of the genus are parasitic on flies and other two-winged insects.

Order: Kickxellales

The order contains single family and eight genera.

Order: *Mucorales*

Mucorales, also known as pin molds, is the largest order of the class Zygomycetes. The order includes 13 families, 56 genera, 300 species. Most of its members are saprotrophic and grow on organic substrates. Some species are parasites or pathogens of animals, plants, and fungi. A few species cause human and animal disease zygomycosis, as well as allergic reactions.

Family: *Mucoraceae*

The Mucoraceae are a family of fungi of the order Mucorales, characterized by having the thallus not segmented or ramified. Pathogenic genera include *Absidia*, *Apophysomyces*, *Mucor*, *Rhizomucor*, and *Rhizopus*. The family contains 25 genera and 129 species.

Genus: *Mucor*

Approximately 40 species of *Mucor* are currently known. The genus is cosmopolitan, with many species being widespread in soil or on substrates in contact with soil. Most species are mesophilic, but some are thermophilic (Webster & Weber, 2007).

Genus: *Zygorhynchus*

There are about 6 species, mostly reported from soil, often from considerable depth. All species are homothallic and, unusually, form heterogametangic zygospores. The sporangiophores are commonly branched and the columella is often broader than high (Webster & Weber, 2007).

Genus: *Rhizopus*

There are about 10 species in the genus *Rhizopus* (Webster & Weber, 2007). Members of the genus are multicellular and they are common saprophytic fungi on plants and specialized parasites on animals. They are found on a wide variety of organic substrates such as fruits and vegetables, syrups, leather, bread, peanuts, and tobacco. Some *Rhizopus* members are commonly used in industrial processes. *R. oryzae* is useful for the production of lactic acid and cortisone, for alcoholic fermentation, *R. stolonifer* is used to produce fumaric acid, lactic

acid, and cortisone, and *R. delemar* produces fumaric acid and biotin. Some *Rhizopus* species such as *R. oligosporus* and *R. oryzae* are important in some foods and traditional alcoholic beverages.

Genus: *Absidia*

There are some 20 species growing in soil. Characteristic features are pear-shaped sporangia arising in partial whorls along stolon-like branches which produce rhizoids at intervals but not opposite the sporangiophores. The zygospores are surrounded by curved unbranched suspensor appendages which may arise from either or both suspensors. Most species are heterothallic but

A. spinosa is homothallic. *Absidia glauca* and *A. spinosa* are amongst the most commonly isolated species. *Absidia corymbifera* is a human pathogen (Webster & Weber, 2007).

Genus: *Phycomyces*

The two best-known species are *P. blakesleeanus* and *P. nitens*. The sporangiospores of *P. nitens* are larger than those of *P. blakesleeanus*, but it is likely (Webster & Weber, 2007).

Genus: *Syzygites*

Syzygites is a monotypic genus in *Mucoraceae*. The sole described species is *Syzygites megalocarpus*, which was the first fungus for which sex was reported and the main homothallic representative in the research that allowed for the classification of fungi as homothallic or heterothallic. *Syzygites megalocarpus* is found on the decaying basidiocarps of various toadstools, especially *Boletus*, *Lactarius* and *Russula* (Webster & Weber, 2007).

Family: *Pilobolaceae*

There are two common genera, *Pilobolus* and *Pilaira*, which grow on the dung of herbivores. Both genera have evolved mechanisms to ensure that their sporangia escape from the vicinity of the dung patch on which they were produced (Webster & Weber, 2007).

Genus: *Pilobolus*

The generic name means literally the 'hat thrower', referring to the sporangial discharge mechanism. Common species are *P. crystallinus*, *P. kleinii* and *P. umbonatus* (Webster & Weber, 2007).

Genus: *Pilaira*

Pilaira also appears early in the succession of coprophilous fungi, i.e. the order in which their fruit bodies appear on herbivore dung incubated under moist conditions. It has not been found in the tropics. The structure of the melanized sporangium closely resembles that of *Pilobolus* in that the spores are separated from the columella by a mucilaginous ring which extrudes from the base of the sporangium (Webster & Weber, 2007).

Order: *Zoopagales*

The order includes 5 families, 22 genera, and 190 species. Most members are parasites or predators of microscopic animals such as amoebae. They also prey on rotifers.

Family: *Piptocephalidaceae*

This family includes *Piptocephalis* and *Syncephalis*, both mycoparasites. *Piptocephalis* is a biotrophic haustorial parasite which needs the presence of a susceptible host for good growth and reproduction, although on certain agar media *Piptocephalis* spores will germinate and give rise to a limited mycelium producing dwarf sporangiophores.

Class: *Trichomycetes*

The class contains 4 orders, 7 families, 52 genera, about 210 species. Its members grow in the guts of arthropods living in aquatic habitats. They are generally viewed as commensals, having little effect on the host, but in stressful environments, they might confer an advantage to colonized hosts; in some cases, they act as pathogens. Most *Trichomycetes* colonize freshwater and marine arthropods, but some colonize terrestrial arthropods.

Order: Harpellales Members of the order are obligate, symbiotic fungi that colonize the digestive tracts of ods, including black flies. Thalli of the order are either unbranched or branched, producing basipetal series of trichospores. Zygosporangia are biconical.

Genus: Herpella

The genus includes five species which grow in Diptera.

REFERENCES

Beard CE. 2008 Trichomycetes. In: Capinera J.L. (eds) Encyclopedia of Entomology. Springer, Dordrecht.

Chinn RY, Diamond RD.1982. "Generation of chemotactic factors by *Rhizopus oryzae* in the presence and absence of serum: relationship to hyphal damage mediated by human neutrophils and effects of hyperglycemia and ketoacidosis". *Infection and Immunity*. 38 (3): 1123–29.

Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008. *Dictionary of the Fungi* (10th ed.). Wallingford, UK: CABI.

Zheng RY, Chen GQ, Huang H, Liu XY. 2007. A monograph of *Rhizopus*". *Sydowia*. 59 (2): 273–372.

Webster, J., & Weber, R. (2007). *Introduction to fungi*. Cambridge, UK: Cambridge University Press.

Url 1. <https://en.wikipedia.org/wiki/Zygomycota>.