Zygomycota 2 – Kickxellales, Dimargaritales, Entomophthorales, Zoopagales, Mycoparasitism, & Trichomycetes

Kickxellales (8 genera, 21 spp.)– single-spored merosporangia from "**pseudophialides**" on " "**sporocladia**" – most are saprobes, some parasites.

Photos of *Coemansia*, *Kickxella, Linderia, Martensiomyces, Spirodacylon*

Dimargaritales – (4 genera, 14 spp.) all haustorial or intracellular parasites of other fungi (mostly Mucorales), **2-spored merosporangia**, zygospores thick-walled, hyaline on undifferentiated hyphae, can not use sugars in culture (but can use Krebs cycle intermediates)

Examples *Dimargaris*, *Thieghemiomyces*,

Trichomyetes (Class within Zygomycota) 180 spp. – all obligate biotrophs with insects (mostly aquatic larvae) and other invertebrates (isopods and millipeds). Impact of association for insects unclear; Asexual spores of various types. Attachment by non-cellular holdfast in hindgut.

Ameobidium – excommunicated from fungi

Harpellales - fit in Zygomycota somewhere, apparently near Kickxellales (septal plug similarity)

Other orders in group currently unsampled.

Harpellales: "trichospores" (really sporangium) with appendages released to environment. How does reinfection occur after molting? Example genera: *Smittium* and *Harpella*

pH change in insect gut (pH 10 in midgut) used to extrude spore from sporangium and align "spore bodies" (shift to pH 7, hindgut) causes release of "spore bodies" from end of spore to create holdfast
(Horn 1989. Spore development in *Smittium Mycologia* 81:742-753)

Zygospores odd in shape and formation

Entomophthorales – (180 spp.)mostly parasites of invertebrates (some opportunistic on vertebrates, parasites of fern gametophytes (*Completoria*) some saprobes, often host specific and deadly, mycelium not usually well development, sometimes fragmenting in the hyphal bodies, spores: "conidia", often actively discharged, or vectored via sticky spores (haptor). **Nuclear morphology** used for taxonomic distinctions.

Basidiobolus - based on 18S gene placed in the chytrids, but with new multigene data its back in the Entomophthorales. (you've heard about this alread)

Ancylistaceae – nuclei small with a prominent nucleolus; forcibly discharged conidia, zygospores, no hyphal bodies,

Conidiobolus coronatus – common in soil, also a parasite of insects – phototrophic development of 2ndary conidia, or microconidia

Entomophthoraceae – "hyphal bodies", large nuclei with condensed chromatin at interphase, no prominent nucleolus. Primary conidia forcibly discharged by "**papillar inversion**". Passive, secondary conidia in some.

E. muscae – fly parasite, infection, hyphal bodies, fly behavior, conidiophore formation,

Four kinds of active spore discharge in the Entomophthorales:
Cannon - *Entomophthora muscae*; Papillar inversion from condiophore *Entomophthora grylli*, Papillar inversion from Conidium - *Conidiobolus*, The rocket - *Basidiobolus;*

Zoopagales – (160 spp.) parasites of invertebrates and other fungi, not often seen, quick to sporulate and ephemeral

Zoopagaceae – fine external mycelium and haustoria,
Hosts include: rotifers, amoebae, nematodes, asexual spores single or in chains, zygospores (when present) hyaline (clear), roughened, formed on apposed hypoid suspensors.

Examples: *Zoophagus insidians* – fresh water, stick pegs ("lethal lollipops")
Stylopage anomola – attaches amoebae – capillary spore with **haptor** (sticky tip), used to hitch-hike (phoretic) on mites which are (phoretic on beetles!) between dung piles,

Piptocephalidaceae – ex *Piptocephalis* and *Syncephalis* - obligate "haustorial" parasites of Mucorales (and others). "merosporangia" and zygospores with intertwined apposed suspensors, sporangiophore dichotomolously branched in *Piptocephalis*,

Syncephalis – simple sporangiophores with merosporangia borne on terminal vesicles

Mycoparasitism (Jeffries and Young 1994)– widespread in fungi, types of mycoparasites: contact necrotrophs, invasive necrotrophs, **haustorial biotrophs**, **intracellular biotrophs**, fusion biotrophs.
Common components:
Directional growth toward host (Photo)– indicated chemical sensing, shown in *Dimargaris*
Thin hyphae – relative to host

Coiled hyphae – common in many mycoparasites (not necessary in zygos)
Appressoria – swollen end of parasitic hyphae that ultimately penetrates host
Haustoria – with neck thickening "neckband", extrahaustorial membrane

Papillae - - local thickening of host cell wall in area of penetration, may be absent in compatible interaction and accentuated in resistant host

Sequence in Dimargaritales & Mycoparasitic Zoopagales parasites – directional growth toward young hyphae, appressoria, lobed haustoria in most (intracellular hyphal growth in *Syncephalis*), breakdown of host parasite interface (6-36hrs), senescence of host hypha, but host mycelium not usually killed (in culture), but reduces growth rate and affects growth form.

	Dimargaritales	Mycoparasitic Zoopagales
Haustoria	With nuclei, neck septa, simple extrahaustorial matrix, haustorial lobes lack a wall	No nuclei, no septa, complex extrahaustorial matrix, haustorial lobes with a wall

Broad host range in most (e.g. *Piptocephalis unispora*, 20 known in Mucorales, + several Ascomycetes.

References"
Chapters 5 & 6 in Alexopoulos et al.

Mycoparasitism part from

Jeffries, P., T. W. K. Young and C.A.B. International. Mycological Institute. 1994. Interfungal parasitic relationships. CAB International, Wallingford, Oxon.

Most EM photos from

O'Donnell, K. L. 1979. The Zygomycetes in Culture. Department of Botany, University of Georgia, Athens, Georgia.