Fungi – Phylum Chytridiomycota

Phylum Chytridiomycota includes a number of different orders, Chytridiales, Rhizophydiales, etc. that occur in aquatic habitats or moist soil.

Both saprotrophic and parasitic species (algae, plants, invertebrates and vertebrates) are known; mainly aerobic with a few anaerobic species in ruminants.

1000-1200 species.

Their vegetative thallus is single cells, single cells with rhizoids or hyphae with or without rhizoids. Hyphae have septa associated with reproductive structures. Chitin in cell walls.

All produce motile cells (zoospores, and some species have motile male gametes). Zoospores may form a resistant cyst or a cyst that develops into a vegetative thallus.

Sexual reproduction is known in some but not all species, examples include, oogamous (motile gamete and non-motile gamete) or involve a receptive and a contributing thallus/cyst.

One of the earliest fungus lineages dating back to at least 550 million years.
Evidence Fungi and Evolutionary timeline – 1) fossil record – ancient organism remains, 2) age of substrates, rock, etc., fossil layers, 3) similarities among organisms alive today, 4) molecular clock - similarities in DNA, proteins, etc.
FIG. 2. ASTRAL consensus cladogram of Kingdom Fungi based on analyses of individual bootstrap trees for each of 192 conserved orthologous proteins. All branches received 100% ASTRAL branch support except where noted by number above or below respective branches. 

https://www.researchgate.net/publication/309126296_A_phylum-level_phylogenetic_classification_of_zygomycete_fungi_based_on_genome-scale_data
Chytridiomycota

Largest group of chytrids, monocentric; with an epibiotic, inoperculate and operculate, uniporous or multiporous zoosporangium; with rhizoids originating from a single site on the thallus/sporangium.

Thallus hyphae narrow, no septa, with foamy contents (vacuoles), attached by rhizoids. Sexual reproduction is oogamous. Asexual reproduction by zoospores in cylindrical or flask-shaped sporangia. Members are typically aquatic saprotrophs or parasites.
Chytridiomycota, Rhizophydiales

1. The vegetative thallus is composed of one or more single cells, often with rhizoids, nuclei are often haploid but also can be diploid in some genera.

2. Asexual reproduction (mitosis) is by zoospores with a posterior, single, whiplash flagellum, produced in a single celled called a zoosporangium. Main means of dispersal! Under unfavorable conditions zoospores my encyst!

3. Sexual reproduction – method of fertilization varies among genera (we’ll look at a couple of examples), typically results in the production of a thick-walled, resistant zygote (2n) (meiosporangium), meiosis is followed by the production of zoospores inside a zoosporangium.

4. Some species are saprotrophic; others are parasites of plants, animals, algae and other fungi. We’ll discuss examples.

5. Chytrids require at least a water film for zoospores to disperse, and primarily occur in aquatic habitats or moist soil.
Vegetative Thallus and Asexual Reproductive

- **epibiotic**
- **endobiotic**
- **rhizoids**
- **monocentric**
- **polycentric**

**Encystment** – zoospore retracts or loses flagellum and forms chitinous wall.

Resistant or infection stage.

**zoosporangia**

- **operculate**
- **inoperculate**

**papilla**

**apophysis**

**rhizoids**
Motile asexual spores = Zoospores

No cell wall, one posterior whiplash flagellum

Flagellum – long slender structures extending from cell and surrounded by cell membrane

9+2 microtubular structure characteristic of eukaryotes

https://www.youtube.com/watch?v=ZgpwSoXeFM8
Zoospore Ultrastructure

JEL 281 *Rhizphydium* clade with spur, vesiculated area, and two lipid globules, one with fenestrated cisterna, one with simple cisterna

Monoblepharidales
Rhizophydium pollonis on Pine pollen

The zoospore of the fungus encysts on the wall of the pollen grain and penetrates into the interior. Inside the pollen the fungus produces a branching system of very fine hyphae (rhizoids) for absorbing nutrients. Outside the pollen grain the fungus produces a spherical thallus that, at maturity, becomes a zoosporangium and gives rise to a new population of zoospores that escape through a small perforation in the zoosporangial wall (red arrow) and swim off to attack new prey. The empty zoosporangia appear as blister-like outgrowths over the surface of the pollen grains.
Asexual reproduction, using *Rhizophidium* as a model

(Fig. 1) Thallus consisting of a spherical sporangium and branched rhizoids

(Fig. 2) Mature sporangium with two discharge pores appearing as domes, each plugged with gelatinous material

(Fig. 3) Sporangium releasing a cloud of numerous zoospores through one of several discharge pores
How do zoospores locate a suitable host or substrate during asexual reproduction?

Zoospores of parasitic chytrids use light and chemical cues to locate hosts. Zoospores of *Rhizophydiurn littoreum*, a parasite of marine green algae, are positively phototactic toward blue light, a mechanism that might assure that zoospores swim to the photic zone where its host resides. Zoospores of both *R. littoreum* and *B. dendrobatidis* exhibit chemotaxis to specific sugars, proteins and amino acids, also a mechanism by which zoospores might detect signals to potential hosts.
Sexual reproduction, using *Rhizophidium* as a model

A. Zoospores swim to a host cell.
B. On the host cell, zoospores produce a wall around themselves and may penetrate the host with a germ tube. The receptive cell (right) produces a rhizoidal system. The contributing thallus (left) only has a germ tube.
C. Contents from an adjacent contributing thallus (left) are transferred through a fertilization tube into the receptive thallus (right).
D. The receptive thallus enlarges into a thick-walled resting spore, with attached rhizoids (right). Sometimes the expanding resting spore lifts up the attached contributing cell (left), which persists as an appendage.

Fertilization – plasmogamy plus karyogamy = zygote

The end product of sexual reproduction is a thick-walled resting spore which contains copious amounts of lipids and glycogen stored food for energy. It will eventually go through meiosis and germinate to produce a zoosporangium with numerous zoospores.
Batrachochytrium dendrobatidis

- chytrid that causes the amphibian disease chytridiomycosis. In the first decade after it was discovered in amphibians in 1998, the disease devastated amphibian populations around the world.

The fungus grows on amphibian skin and produces aquatic zoospores. It is widespread and ranges from deserts and lowland forests to cold mountain tops. It is sometimes a non-lethal parasite and possibly saprobic. The fungus is associated with host mortality in highlands, or during winter, and, becomes more pathogenic at lower temperatures.

http://www.amphibiaweb.org/chytrid/chytridiomycosis.html#whatis
Batrachochytrium dendrobatidis

Asexual reproduction

Diploid nuclei!

**Batrachochytrium salamandrivorans (Bsal):** Deadly fungal threat to salamanders

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**What do we know?**

* 2010: 96% wild mortality in Netherlands
* 2013 & 2014: wild mortality in Belgium
* 2015: UK (trade) and Germany (captivity)
* Present in:
  * wild salamanders in Asia (Vietnam, Thailand, Japan)
  * museum records in Asia >150 yrs
  * possible Asia origin

*Unknown to occur in North America*

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**Effects on salamanders**

Multifocal superficial erosions and deep ulcerations all over the body

Death generally occurs in under 2 weeks after a short episode of anorexia, apathy, and ataxia

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Phylogeny and classification of the genus *Batrachochytrium*. Cladogram showing the taxonomic position of *Batrachochytrium dendrobatidis* and *Batrachochytrium salamandrivorans* within the fungal kingdom (a), the phylum Chytridiomycota (b) and order of the Rhizophydiales (c). The position of the Microsporidia remains uncertain. Branch lengths are not proportional to genetic distances.

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Monoblepharidales, *Monoblepharis*

Oospore (meiospore) germinates by a germ tube.