

- (i) **Pseudomycota** – having 3 divisions:
  - (a) **Oomycota** – one class – Peronosporomycetes
  - (b) **Hyphochytriomycota** – one class – Hyphochytriomycetes
  - (c) **Plasmodiophoromycota** – one class – Plasmodiophoromycetes.
- (ii) **Eumycota**: having 4 divisions:
  - (a) **Chytridiomycota** – one class – Chytridiomycetes
  - (b) **Zygomycota** – two class – Zygomycetes, Trichomycetes.
  - (c) **Ascomycota** – 4 classes – Sacchoromycetes, Plectomycetes, Hymenoascomycetes, Loculoascomycetes.
  - (d) **Basidiomycota** – 4 classes – Urediomycetes, Ustilaginomycetes, Heterobasidiomycetes, Homobasidiomycetes.

### 2.2.2. J. Webster and R.W.S. Weber (2007)

Webster and Weber (2007) in their book 'Introduction to Fungi' (3rd edition) have modified their previous classification. According to them, fungi in the widest sense, traditionally studied by Mycologists, currently fall into three kingdoms of Eukaryota, i.e. the Eumycota which contains only fungi. The Protozoa and Chromista (= Straminipila), both of which contain mainly organisms not studied by mycologists and were dumped together under the name Protoctista.

They have included the slimemoulds in the division Myxomycota under Protozoa kingdom. The outlines of their classification is given below:

According to their classification the fungi and fungus like organisms have been segregated in the three kingdom **Protozoa**, **Straminipila** and **Eumycota**.

**Under kingdom Protozoa:** There are two divisions which contain unicellular fungi like organisms. The two divisions are:

Division 1: **Myxomycota**: It has 4 classes: Acrasiomycetes, Dictyoteliomycetes, Protosteliomycetes, and Myxomycetes.

Division 2: **Plasmodiophoromycota**: It has two orders Plasmodiophorales and Haptoglossales.

**Kingdom Straminipila:** It is divided into three divisions.

Division 1: Hyphochytriomycota.

Division 2: Labyrinthomycota.

Division 3: Oomycota which has 8 orders.

**Kingdom Eumycota** has been divided into 4 divisions:

(a) Chytridiomycota- with one class Chytridiomycetes.

(b) Zygomycota- with 2 classes, Zygomycetes and Trichomycetes.

(c) Ascomycota- with 5 classes- Archiascomycetes, Hemiascomycetes, Plectomycetes, Hymenoascomycetes, and Loculoascomycetes.

(d) Basidiomycota- with 4 classes—Homobasidiomycetes, Heterobasidiomycetes, Urediniomycetes and Ustilaginomycetes.

These works are even getting outdated rapidly in terms of taxonomic concepts, though not of course, in their valuable information on general biological features of the fungi.

Due to fluidity in the above discussed classifications and schemes, a large consortium of fungal taxonomists joined forces through a communication platform 'Deep Hypa' and AFTOL (Assembling the fungal tree of life) (both the projects funded by United States National Science Foundation) to develop a classification scheme based on multi-gene phylogenies in the hope that this would provide a sound and permanent framework.

Kirk *et al.* (2001, 2008) have modified and edited Ainsworth's and Bisby's '*Dictionary of Fungi*' where they have dealt with the classification of fungi.

The following gives an account of the present classification of fungi adopted from the 9th and 10th edition of "The Dictionary of Fungi" (Kirk *et al.* 2001, 2008) with some inputs from the phylogenetic arrangements emerging from AFTOL as set out by Hibbett *et al.* (2007).

### 2.2.3. Outline of modern classification of fungi: (Hibbett *et al.* 2007)

The following are the basic features of this classification:

1. Fungi and animals are considered as sister groups; they are each other's closest relatives and share a common ancestor known as the opisthokont clade (posterior flagellum).
2. The phylum Zygomycota is not accepted in the most recent classification because of doubts about the relationships between the groups that have been traditionally placed in this problem.
3. This is replaced by a term Glomeromycota phylum.
4. This is based on evolutionary consideration of groups. Chytridomycota or water moulds are considered to be primitive.
5. The evolution of higher fungi took place first by loss or withdrawal of chytrid flagellum and the development of branching, aseptate fungal filaments.
6. Septate filaments evolved by divergence from the Glomeromycota as a combined prebasidiomycota/preascomycota clade about 500 million years ago.
7. It considers Basidiomycota and Ascomycota as sister groups that have diverged about 300 million years ago and hence placed under sub kingdom Dikarya.
8. An aerobic chytrids have given rise to symbiotic fungi residing in the lumens of grazing mammals helping in their digestion recently perhaps 60-80 million years ago.
9. The members whose phylogenies have not been ascertained have been placed in *incertae sedis* of that class or phylum.
10. The system has covered 98000 species but estimates the existence of a total of 0.5 to 9.9 million species on the earth.

11. It has separated the pseudo fungi or fungi like organisms from the true fungi and classified them under sub kingdom Chromista and sub kingdom Protozoa.
12. The traditional class 'Phycomycetes' has been totally removed and similarly Myxomycetes of traditional classification is now considered under kingdom Protozoa.
13. True fungi which make up the monophyletic clade is called as kingdom fungi and has been classified in to 7 phyla.

Kingdom Fungi: Comprises 7 phyla:

### Phylum 1: Chytridiomycota

Watermoulds, aquatic saprotrophs/parasites produce motile zoospores, simple posterior flagellum, unicellular/filamentous, holocarpic/eucarpic, Zygotic meiosis, considered most ancestral).

Classes— Chytridiomycetes (3 orders) and Monoblepharidomycetes (1 order)

### Phylum 2. Neocallimastigomycota

Thallus mono/polycentric, anaerobic, found in digestive systems of large herbivores mammals, zoospores positively uniflagellate/polyflagellate one class—Neocallimastigomycetes (1 order).

### Phylum 3. Blastocladiomycota

Similar to chytrids, sporic meiosis, saprotrophs, parasites on algae/plants, invertebrates, all have zoospores, thallus monocentric / polycentric sometimes mycelial.

One class—Blastocladiomycetes (1 order)

### Phylum 4. Microsporidia

Unicellular parasites of animals, considered as sister group of rest of the fungi.

It is not further divided due to lack of well sample multigene phylogenies with the group.

### Phylum 5. Glomeromycota

It includes the glomalean fungi that form mutualistic symbiosis. Prior to this arbuscular mycorrhizal (AM) fungi were included in the zygomycota but they do not form zygospore. This Phylum has the name derived from the type genus *Glomeris* (instead of *Glomus*). It has one class- Glomeromycetes with 4 orders.

The other members whose Phylogeny has not been ascertained are kept in sub phyla incertae sedis.

*Incertae Sedis* (to assign to any phylum but represents the traditional Zygomycota which are saprotrophs/parasite that produce non motile asexual sporangiospores in sporangia and sexual spores as zygospores). The taxon includes the common moulds such as *Mucor*, *Rhizopus*, and *Phycomyces*. At one time, the Chytridiomycota, Oomycota and Zygomycota were classified together in the class 'Polycomycetes' which is no longer valid. The problem is

that zygomycota is polyphyletic and the name was published without a Latin diagnosis so invalid.

1. **Subphylum Mucoromycotina** (3 orders Mucorales, Endogonales and Mortierellales).
2. **Subphylum Entomophthoromycotina** (1 order Entomophthorales).
3. **Subphylum Zoopagomycotina** (1 order—Zoopagales).
4. **Subphylum Kickxellomycotina** (4 orders—Kickxellales, Demargaritales, Harpellales and Asellariales.)

**Subkingdom Dikarya:** The members are:

- (i) Unicellular or filamentous
- (ii) Lack flagella
- (iii) Often remains in dikaryotic state.

It include 2 phyla.

### Phylum 6. Ascomycota

- (i) It is the largest group of fungi and the life styles adopted to cover the complete range from saprotrophs, to symbionts (Lichens) and to parasites.
- (ii) Sexual spores are known as ascospores formed endogenously within an ascus. Except for yeasts, asci are produced in complex fruiting bodies.
- (iii) It contains 64,000 species under 6355 genera.
- (iv) the basic type genus is *Peziza*.
- (v) It is further divided into 3 subphyla.

**Subphylum 1. Taphrinomycotina** (divided into 4 classes)

**Subphylum 2. Saccharomycotina** (has only 1 class with one order)

**Subphylum 3. Pezizomycotina** (has been divided into 10 classes)

**Subphylum 1. Taphrinomycotina** – is divided into 4 classes

Classes (a) Taphrinomycetes – one order Taphrinales

(b) Neoelectomycetes – one order Neoelectales

(c) Pneumocystidomycetes – one order Pneumocystidales

(d) Schizosaccharomycetes – one order Schizosaccharomycetales which includes *Schizosaccharomyces*.

**Subphylum 2. Saccharomycotina** (it has only one class)

Class (a) *Sachharomycetes*—One order Sachharomycetales

It includes gereers like *Saccharomyces*, *Candida* etc.

**Subphylum 3. Pezizomycotina**

It has been divided into 10 classes;

Class 1. **Arthoniomycetes** (1 order – Arthoniales Ex-*Rocella*)

**Class 2. Dothideomycetes**

Subclass = Dothideomycetidae (3 orders)

Subclass = Pleosporomycetidae (1 order) and Dothideomycetes incertae sedis (not placed in any subclass) has 4 orders (Botryosphaeriales, Hysteriales, Patellariales and Jahnules)

**Class 3. Eurotiomycetes** (It has 3 sub classes)

Subclass = Chaetothyriomycetidae (with 3 orders)

Subclass = Eurotiomycetidea (with 3 orders)

Subclass = Mycohaliciomycetidae (one order)

**Class 4. Laboulbeniomycetes** (It has two orders)**Class 5. Lecanoromycetes** (It has 3 sub class)

Subclass = Acarosporomycetidae (1 order)

Subclass = Lecanoromycetidae (3 orders)

Subclass = Ostropomycetidae (4 orders)

Lecanoromycetes incertae sedes – include genera not placed in the above subclasses. It was 2 orders.

**Class 6. Letiomycetes** (It has 5 orders)**Class 7. Lichinomycetes** (It has one order Lichinales)**Class 8. Orbiliomycetes** (1 order)**Class 9. Pezizomycetes** (1 order Pezizales)**Class 10. Sordariomycetes** (It has 3 subclass and 2 incertae sedis)

Subclass= Hypocreomycetidae (4 orders)

Subclass= Sordariomycetidae (7 orders)

Subclass= Xylariomycetidae (1 order)

*Soradiomycetes incertae sedis* (not placed in any subclass) has 4 orders and

*Pezizomcotina incertae sedis* (not placed in any class) has 3 orders.

**Phylum 7. Basidiomycota**

Saprotrophs, parasite on plants and insects, filamentous, hyphae septate, septa having central pore (dolipore), filaments two types—primary (homo karyotic) uninucleate cells, secondary (heterokaryotic) with dikaryotic cells, asexual reproduction by fragmentation, oidia, or conidia, sexual reproduction by somatogamy, basidiospores found. It contains 1600 genera and 32000 species.

It is divided into 3 subphyla :

Subphylum 1. **Puccieniomycotina** (equivalent to traditional Urediniomycetes)

Subphylum 2. **Ustilaginomycotina** (equivalent to traditional Ustilaginomycetes)

Subphylum 3. **Agarico mycotina** (equivalent to Hymnomycetes)

**Subphylum 1. Pucciniomycotina**

It is divided into 8 classes with 18 orders:

- Class 1. Pucciniomycetes (5 orders)
- Class 2. Cystobasidiomycetes (3 orders)
- Class 3. Agaricostilbomycetes (2 orders)
- Class 4. Microbotryomycetes (4 orders)
- Class 5. Atractiellomycetes (1 order)
- Class 6. Classiculomycetes (1 order)
- Class 7. Mixiomycetes (1 order)
- Class 8. Cryptomycocolacomycetes (1 orders).

**Subphylum 2. Ustilaginomycotina**

It is divided into 2 classes with 8 orders :

- Class 1. Ustilaginomycetes (2 orders)
- Class 2. Exobasidiomycetes (6 orders)

*Ustilaginomycotina incertae sedis* (which are not placed any class) with 1 order.

**Subphylum 3. Agaricomycotina**

It is divided into 3 classes with – 21 orders

- Class 1. Tremellomycetes (3 orders)
- Class 2. Dacrymycetes (1 order)
- Class 3. Agaricomycetes
  - Subclass (a) Agaricomycetidae (3 orders)
  - Subclass (b) Phyllomycetidae (4 orders)

*Agaricomycetes incertae sedis* (not included in any subclass) has 10 orders.

Basidiomycota incertae Sedis — (not placed any sub phylum)

- Class 1. Wallemiomycetes (1 order)
- Class 2. Entorrhizomycetes (1 order)

The above classification is that of true fungi. However, there are many organisms which are not fungi in true nature but studied by mycologists as fungi and this includes such organisms from two other kingdoms – **Chromista** and **protozoa**. So the following is the classification of such group of organisms.

**Kingdom Chromista (126 genera, 1040 species)**

This includes common microorganisms and important plant pathogens like *Phytophthora* causing late blight of potato. They have motile spores, two flagella, and grow as hyphae with cellulose containing walls. The majority are in the Oomycota.

This is divided into 3 phyla:

**Phylum 1. Hyphotriomycota** ( 1 order Hyphochytriales)

**Phylum 2. Labyrinthulomycota** ( 2 orders)

**Phylum 3. Oomycota** ( 1000 species in 110 genera)

Economically important pathogens like *Saprolegnia*, *Phythium* and *Phytophthora* belong to this group. It has 13 orders from Leptomitales to Haptoglossales.

*Phythium*, *Phytophthora* belong to order Pythiales; *Saprolegnia* and *Achlya* belong to Saprolegniales; *Albugo*, *Peronospora*, *Plasmopora* belong to order Peronosporales.

### Kingdom Protozoa

Protozoa is vast group of unicellular organisms which are thought to have descended from different unicellular ancestors. Slimemoulds belong to this kingdom. They donot form hyphae lack cell wall, phagocytic nutrition but produce fruiting bodies that superficially resemble to those of fungi and for this reason they are called as moulds and studied under fungi by many mycologists.

This is divided into 4 phyla:

**Phylum 1. Plasmodiophoromycota** (15 genera, 50 species)

Class 1. Plasmodiophoromycetes ( 1 order)

**Phylum 2. Myxomycota** ( 82 genera, 888 species)

Class 1. Dictyosteliomycetes ( 1 order )

Class 2. Myxomycetes (5 orders)

Class 3. Protosteliomycetes (1 order)

**Phylum 3. Acrasiomycota** (Amoeboid Slimemould, 6 genera, 14 species)

Class 1. Acrasiomycetes (1 order)

**Phylum 4. Choanazoa**

Class 1. Mesomycetozoa (2 orders)

### 2.2.4. Critical Appraisal

Fungi are now thought to be the sister group of animals sharing a common ancestor known as the Opisthokont clade. They have a single posterior flagellum which applies to chytrid zoospores and animal sperms. In other eukaryotes that have motile cells propel them with one or more anterior flagella (called heterokonts). It is often viewed that the first terrestrial eukaryotes might have been fungal (Blackwell, 2000).

Evolution of fungi is associated with mutualism or coevolution. Lichens have been found in some of the oldest fossils. Fully formed mycorrhizas can also be found in the most ancient plant fossils and today 95% of all terrestrial plants depend on this fungal infections of their roots to provide the plants with phosphorous and other nutrients. The ability of fungi to recycle the dead remains of other organisms is thought to be the key point of their success