

Welcome
to the
Museum

ADMIT ALL

Fungarium

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Royal Botanic Gardens
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The Tree of Life



All species on Earth are related and connect together in a 'tree of life'. But what does the fungal tree of life look like?

This is a difficult question to answer. Sometimes similar-looking fungi are not at all closely related. Also, because a large proportion of species are still awaiting discovery, it is difficult to build an understanding of historical relationships of the kingdom Fungi.

DNA is helping us to understand how the branches of the fungal tree fit together, including the discovery of new branches such as the Cryptomycota and Microsporidia. These two early groups were originally thought not to contain chitin, a key feature of fungi (see page 10), but DNA later proved this wrong. Other groups, including downy mildews (Oomycota) and slime moulds (Myxomycota) have been proved to not belong to fungi.

The earliest fungi are thought to have evolved around one billion years ago and to have been simple, single-celled organisms that lived in water. Around 700 million years ago the evolutionary transition from aquatic to land-dwelling fungi is estimated to have taken place. Ascomycota and Basidiomycota are the two fungal groups that are able to form highly complex spore-bearing structures. These groups formed around 600-700 million years ago and together contain the vast majority of known fungal species – around 140,000 in total.

Research on the fungal tree continues and a whole new 'invisible dimension of fungal diversity' in our soils, bodies and waterways is being explored – the so-called dark taxa.

What is a Fungus?

Historically, fungi were treated as plants and studied by botanists. They were included in *Species Plantarum* by the famous naturalist Linnaeus in 1753. But fungi aren't plants: they don't make food by photosynthesis, they don't have roots and they reproduce with spores. Lichens are not plants either; they are a collaboration between a fungal element and a photosynthesising algae (known as a photobiont).

Fungi are in fact more closely related to animals than plants. Just like the outer skeletons of insects and crustaceans, fungal cell walls are made largely of chitin. While animals ingest their food by engulfing or swallowing, fungi secrete enzymes that dissolve food outside their bodies and absorb the nutrients through their cell walls. Another difference is that animals move around to search for food, while fungi grow towards it.

Key to plate

1: Bird's nest fungus

Cyathus striatus;

2: Red marasmius

Marasmius haematocephalus

3: Pixie-cup lichen

Cladonia chlorophaea

4: Leathery goblet

Cymatoderma elegans

5: Veiled lady

Phallus indusiatus

6: Enokitake mushroom

Flammulina velutipes (cultivated form)

7: Turkeytail fungus

Trametes versicolor

8: Golden shield lichen

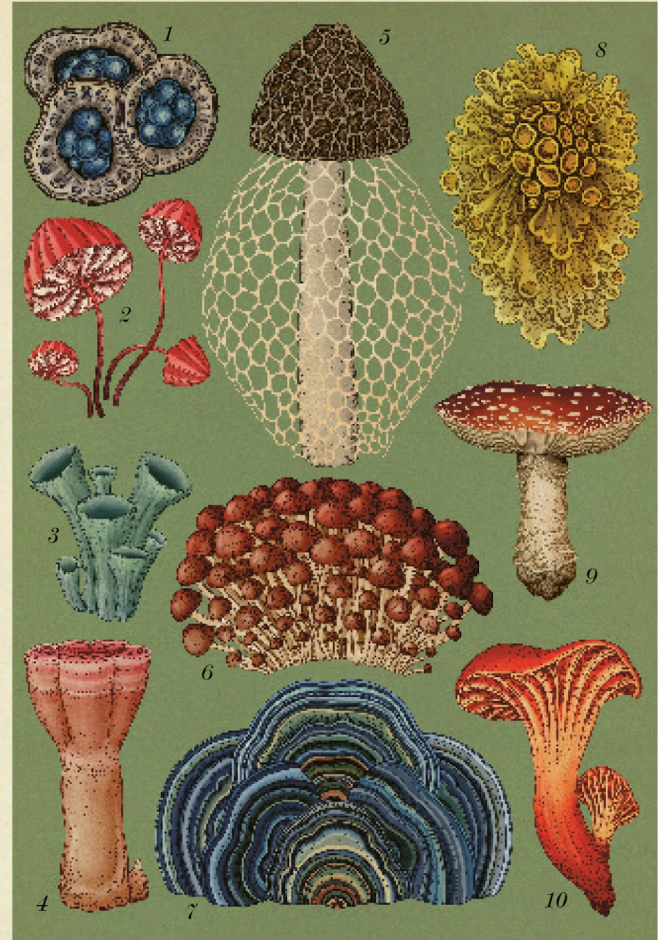
Xanthoria parietina

9: Fly agaric

Amanita muscaria

10: Lane Cove waxcap

Hygrocybe lanecovensis



Types of Fungi

Just like animals and plants, fungi have their own lesser-known kingdom. New species are constantly being discovered and scientists think of the estimated 2.2 to 3.8 million species on Earth, fewer than 5 per cent have been identified.

There are at least eight phyla (major groups) of true Fungi: Cryptomycota, Microsporidia, Blastocladiomycota, Chytridiomycota, Zoopagomycota, Mucoromycota, Ascomycota, and Basidiomycota. Some of the most ancient are single-celled and don't look at all like typical fungi. Most familiar fungi belong to Ascomycota and Basidiomycota, which produce septate hyphae (typical fungal filaments) and can include mushrooms, yeasts and those fungi that associate with algae to form lichens.

Key to plate

1: *Rozella* sp.
(Cryptomycota)
Motile zoospore

2: *Rhizophyidium planktonicum*
(Chytridiomycota)

3: *Piromyces communis*
(Chytridiomycota)

4: *Berwaldia schaefernai*
(Microsporidia)
Spore (sporoblast)

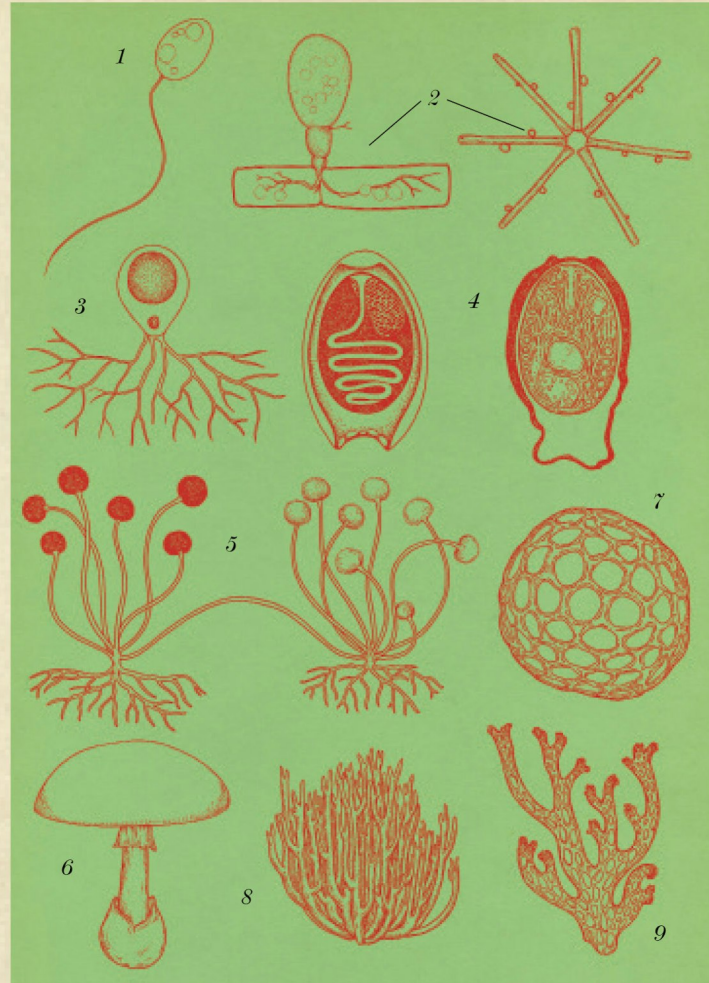
5: *Black bread mould*
(Mucoromycota)
Rhizopus stolonifer

6: *Caesar's mushroom*
(Basidiomycota)
Amanita caesarea

7: *Darwin's fungus*
(Ascomycota)
Cyttaria darwinii

8: *Upright coral*
(Basidiomycota)
Ramaria stricta

9: *Cladia aggregata* lichen
(Ascomycota)



Sexual Reproduction

Fungi can reproduce both sexually and asexually. This is rare and caused great confusion in the past because each reproductive form would often be classed as a distinct species. Even today, scientists sometimes use DNA to identify reproductive 'pairs' of the same fungus.

Sexual reproduction in fungi can only be seen with a microscope. Two nuclei (the membrane-bound structures that contain the cell's genetic material), each with a single set of chromosomes (thread-like structures in which the DNA is packaged in the nucleus), must fuse together. It is a complex process that involves cell division and the exchange and rearrangement of genes. Living organisms including fungi do this because it ensures genetic diversity, fundamental to evolution and ultimately survival. The fusing nuclei can be from the same individual, or different ones of the same species. Once nuclei are fused, they remain in special cells from which new spore-producing structures arise. The new spores will form new fungal colonies.

Key to plate

1: Common field mushroom

Agaricus campestris

- a) Development of a mushroom
- b) Part of a gill showing basidia and basidiospores.

2: Common jellyspot fungus

Dacrymyces stillatus

Fork-shaped, branched basidia.

3: Common rust fungus

Phragmidium violaceum

The stalked spore includes a row of four cells with two nuclei each.

4: *Zygorhynchus* sp.

- a) The process of hyphae forming a zygosporangium
- b) Zygosporangium and zygospore formed

5: Candlestick or candle snuff fungus

Xylaria hypoxylon

As in most ascomycetes, the asci contains eight spores.

6: Dog lichen

Peltigera canina

Produces asci with a special form

