

# FUNGI

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# FUNGI

## Introduction

Mycetes are diffused practically in all environments: approximately 70,000 species, that include the fungi we commonly find in the woods, plant rusts and mildews. They do not have roots, a stem nor leaves, they do not even have chlorophyll to produce nutritive substances; mycetes are prevalently pluricellular organisms consisting of masses of filamentous cells known as hypha.

A group of mycetes, commonly known as yeasts, includes unicellular organisms, such as for example *Saccharomyces cerevisiae*. Some fungi are parasites of animals, plants and protista and even of other fungi, others instead are saprobe fungi...

## Fungi knowledge

The fungal kingdom includes all the organisms that are commonly known as fungi (a large group of multi-cellular organisms that also includes edible mushrooms), yeast (unicellular organisms responsible for fermentation) and mildews (organisms of microscopic size, such as the green-coloured *Penicillium*). This kingdom is composed of heterotrophic organisms, because they feed themselves by absorbing organic matter from the environment. Fungi produce molecules, the so-called digestive enzymes, which are used to degrade the organic matter so that it can be absorbed. Fungi are mainly multi-cellular organisms composed of masses of threads and living virtually anywhere. A group of fungi, commonly known as yeast, includes unicellular organisms, such as, for instance, *Saccaromyces cerevisiae*. Some fungi are parasites of animals, plants, protista and even of other fungi, while others are saprobic (they live by decomposing dead organic matter) and are essential for the degradation of the matter. Some species have developed complex symbioses with photosynthetic organisms, as in mycorrhizas or lichens.

## The reproduction

Fungi consist of one division only, the Eumycota, which is divided into four classes: zygomycetes, ascomycetes, basidiomycetes (which includes most edible mushrooms) and deuteromycetes. They are divided by their cellular features and sexual reproduction methods, which occur through the recombination of genetic material. Most fungi reproduce alternately through asexual and sexed methods.

Asexual reproduction occurs in two ways:

- by fragmentation of the hyphae (the filaments that compose the fungus). Every fragment becomes a new individual;
- by structures known as sporangia. When a sporangium disintegrates, asexual spores are released and carried away by the air.

In suitable environmental conditions, they originate new masses of hyphae. Sexed reproduction begins when two hyphae from different individuals unite into specialised reproductive structures, called **gametangia**. A cell called **zygote** from which the new fungus will develop is formed inside



these structures. The **genetic inheritance** from the different hyphae **recombines** in the zygote to form a completely new one.

## Classification

At present, fungi are classed into four groups, including:

- **Zygomycetes:** fungi living in the soil or on decomposing animal or vegetal organic material. Their reproduction is asexual and occurs by scattering spores, which are produced in special structures (black bulb-type sporangia). If the spores are formed in a different type of sporangium (zygosporangium), a sexed cycle occurs. This group includes the “black mildew” which develops on fruits, vegetables and many baked products. Many species in the class Zygomycetes form mycorrhizas.
- **Ascomycetes:** they include a wide variety of species, which are very different in size and living conditions. They are equipped with asci, sac-like structures that produce sexed spores (ascospores), which form at the end of the hyphae and are called conidia. This group includes yeast, edible mushrooms (*Morchella esculenta* and truffles) and some marine species.
- **Basidiomycetes:** this group includes edible mushrooms and plant parasites such as smuts and rusts. They usually consist of a fruit-bearing body composed of a stipe and cap, which forms when the fungus reproduces through sexed reproduction. The lower part of the cap is provided with a series of parallel or entwined lamellae, which host the basidia, tiny sporangia where sexed spores are formed. Nevertheless, the most frequent form of reproduction is the asexual one, which occurs through the spores produced by the conidia.
- **Deuteromycetes:** this group includes the species in which no sexual reproduction cycle has ever been observed and that cannot be grouped under any one of the other three classes.

## Why are not plants?

Fungi come in a wide variety of forms and life cycles. As a consequence, it is very hard to classify them. In the past, fungi were classed as plants and only after in-depth studies the features that distinguished them from both vegetal organisms and all the other eukaryote organisms were discovered, so that they could be considered as belonging to a completely different kingdom. One of the first essential differences from plants is that fungi are heterotrophic; secondly, their cellular walls are composed of chitin, a carbohydrate that lacks in plants but can be found in the external skeleton of insects and crustaceans. In addition, fungi can store glycogen as a reserve material just like animals do.

## How many species?

Little is known about the first fungi to have appeared on Earth; these organisms must have derived from protista. These originated the first fungi, whose fossil finds date back to approximately 400 million years ago. At present, about 100,000 species of fungi are known, and it is estimated that at least 200,000 are still to be identified. The evolutionary links between the main classes of



zygomycetes, ascomycetes and basidiomycetes are not clear yet, while the class deuteromycetes includes all the species in which no sexed reproduction cycle has ever been observed.

### The mycelium

Yeast and some fungi are unicellular organisms, but most species are multi-cellular organisms, composed of masses of filaments known as hyphae, which altogether compose the mycelium or body of the fungus. This structure differs according to the function that the organism has to serve. Saprobic fungi have special hyphae, called rhizoids, which anchor the mycelium to the substrate, while some parasitic fungi develop hyphae, called haustoria, which invade the cells of the host organism.

The hyphae in a mycelium grow very quickly, even more than one kilometre a day. The mycelium can be found in different forms: in single and scattered hyphae or as a fluffy mass, sometimes in very complex forms as in the case of edible mushrooms (boletus edulis, field mushroom, honey mushroom). They have a structure composed of a stipe and a cap which surfaces above ground level, while the part accommodating the reproductive structure of the fungus is underground.

### Distribution in the environment

Fungi are spread anywhere and can live on their own or as parasites of other **eukaryote** organisms. Some species can tolerate adverse conditions, such as, for instance, extreme temperatures: some live even at 5-6 degrees below zero, others at temperatures above 50 degrees. Mildews are microscopic fungi that look like a white, grey, green or black dusty coating. They are usually visible on such foods as bread, jam and fruits in the form of a blue or green coating.

### Saprobic fungi

Fungi and bacteria are the main decomposers of organic matter; the activity of these organisms is as essential for the endless functioning of the earth's ecosystems as that of the producers of nutrients. As they feed on dead organic matter, saprophytic fungi decompose it into simple molecules that go back into the soil and can be reused by plants and all other organisms. Their ability to demolish organic matter has been used by man, in particular to destroy foods and clothes (cotton and leather items).

### Symbiont fungi

Many fungi are involved in close and long associations known as symbiotic associations, which are mutually beneficial to both organisms. Two of these associations, lichens and mycorrhizas, have enabled some photosynthetic organisms to colonise deserted environments.

**Lichens** are the combination of a fungus with a green alga or cyanobacteria; they are the first colonisers of bare rocky areas, they survive even when dry, they need light, air and mineral salts. The fungus makes it easier to absorb mineral salts and water as well as to maintain suitable conditions for the photosynthetic process, while the alga or bacterium supplies food in the form of by-products of the photosynthetic process. Lichens are not only economically important, but they

are also used as bio-indicators or to date geological events (such as landslides or the withdrawal of glaciers). They are winter food for reindeers in the Arctic regions, are used in perfumery and to produce some colours.

**Mycorrhizas** are associations between fungi and plant roots. The fungus uses the organic substances produced by the plant, supplies the plant with the minerals contained in the soil and makes it easier for the roots to absorb water. Sometimes, these associations become vital for both organisms, as is the case for some orchids, whose seeds do not sprout without a specific symbiont fungus. In its turn, the fungus cannot grow without a plant. A surprising association is the one that occurs between some species of fungi and some species of ants, such as, for instance, the *Atta cephalotes*. The ants collect and break up leaves and petals of flowers, on which grow special fungi that can only be found in ant nests, where they find the perfect conditions to spread.

## Man and fungi

The parasitic species transmit diseases and form relations with other organisms, in which the fungus benefits from the association and damages the host organism (human beings and plants). Such fungi as *Endothia parasitica*, *Ceratocystis ulmi*, *Puccinia sparganioides*, *Puccinia graminis* are parasites of plants, while fungi of the genus *Aspergillus* or *Candida albicans* carry infections to the human organisms.

**Plant parasites.** Devastating effects have been observed in the forests due to the spread of two different diseases: the “powdery mildew”, that affects chestnut trees (*Endothia parasitica*), and the “dry disease”, that affects elms (*Ceratocystis ulmi*). Not to mention the damages caused by such fungi as rusts and smuts to the harvests of the whole world. Some rusts, such as *Puccinia sparganioides*, need several host plants to complete their life cycle: in temperate climates, they spend the winter on the spartina, while in spring they produce small spores that the wind carries away to make them sprout on the new leaves of the nearby ashes. The “boil smut” damages the crops, even if Mexicans consider it a delicacy.

**Human parasites.** About one hundred of the thousands of known species of fungi are pathogenic to man, causing infections that are called mycoses. A large part of mycoses is transmitted through inhalation, ingestion or the infection of skin wounds and attack the skin, hairs, nails and mucosa. When inhaled, the spores of the genus *Aspergillus* transmit a serious lung infection, Aspergillosis, while the mycoses of the skin, hairs and nails are called tineas. The mouth, the digestive and the reproductive systems can be infected by the genus *Candida albicans*; in new-born children, this infection is called thrush and causes white patches on the mouth mucosa.

## Pharmaceutical uses

From a pharmaceutical point of view, mushrooms are extremely interesting. Fungi have recently helped to produce other innovative and important drugs, such as cyclosporin, an anti-rejection substance that has aided the development of organ-transplant surgery over the last few years. Penicillin, the first antibiotic ever, is made from a fungus of the genus *Penicillium*, a green mildew,



belonging to deuteromycetes. Fungi produce a wide variety of substances that are not only important for the human organism. An ascomycete, *Giberella Fujikuroi*, can secrete a plant-growth hormone known as gibberellin.

### Let's discover Penicillin

In the early 20th century, the micro-organisms that cause the most important infectious diseases in man had already been discovered. Up to that time, the control of the spread of such diseases relied on prevention, in the form of vaccines (against smallpox, rabies and anthrax) and disinfectants. Chemicals, such as antibiotics, that could kill the micro-organisms without damaging the infected individual, began to be discovered and used. In 1926, Alexander Fleming found a mildew (*Penicillium notatum*) in a culture of Staphylococci. He noticed that the area of the culture medium near the fungal colony was completely free of staphylococci. Through some tests, he found out that mildew was an excellent bacterial inhibitor and at the same time it was not toxic on the test animals. Penicillin was then purified before it could be used on man. This substance is still one of the best and widespread antibiotics for the treatment of many infectious diseases of bacterial origin.

### Lichens

Lichens are ecologically important because they are sensitive to the atmospheric pollutants, and this is why they are called **bio-indicators**. The presence of some substances, such as sulphur dioxide, in the air produces changes in the growth of the lichen. The quality of the environment can be assessed by studying the growth of these organisms. Lichens are organisms that colonise an environment that has just settled. They are therefore the first organisms that we can find, for instance, on the rocks of a landslide or, on the mountains, on the rocks left behind by a withdrawing glacier. With time, lichens grow steadily and by studying their size one can determine the year in which the landslide fell or the rocks were left behind by the glacier. These dates are useful to the geologists to reconstruct historical events, to study and gain an insight of the surrounding environment. Many study projects on the movements of Alpine glaciers also rely on this dating system.

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