FUNGI KNOWLEDGE

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Fungi are neither plants nor animals but belong to a kingdom of their own, remarkable for their incredible diversity and unique adaptations to various habitats. They range from microscopic moulds and insect-controlling fungi to those that form the single largest organisms on Earth. For most of us, though, our experience with fungi is limited to the delicious fruiting bodies that emerge from the ground. Yet fungi are found in nearly every habitat on Earth, playing essential roles in ecosystems as decomposers, parasites, and symbiotic partners with plants and bacteria.
Fungi also contribute to the production of textiles, partly through these symbioses and their natural pigment content.

Fungi exist in many different shapes.

Chantarelle.

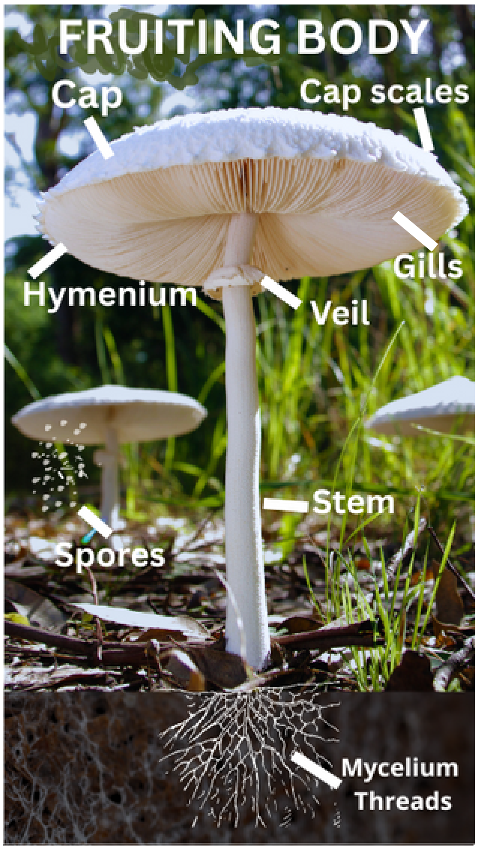
The fungal organism consists of a massive web network of hyphae called mycelium, which breaks down organic matter into nutrients and can create the symbiosis mycorrhiza, a nutrient exchange between fungus and plant. All these functions are crucial for a functioning ecosystem. When fungi reproduce, they form the spore-filled fruiting bodies we pick and enjoy eating. The study of the fungal world is known as mycology, and a mycologist is a biologist who works with fungi (1).

As with animals and plants, evolution has led to numerous adaptations in fungi. Some fungi are tree-dwelling saprophytes, parasites that kill their host organism, subterranean truffles and many more. For most of us, fungi live a hidden existence, yet they are found in almost every habitat and fascinatingly impact entire ecosystems (1).

THE FRUITING BODY

When we talk about mushrooms, we almost always think of the fruiting body—the spore-producing structure of the fungus that is usually visible above the surface where it grows. Fruiting bodies come in countless shapes and forms, with distinct characteristics that help us identify different species. Beneath the surface, fungi have a structure called hyphae, which are thread-like filaments forming a network known as the mycelium. The hyphae absorb nutrients from the soil and play a key role in reproduction by supporting the growth of the fruiting body.

On the underside of a mushroom cap is a surface called the **hymenium**, where the fungus produces its spores. These spores are formed in special organs, **spore** sacs (asci), or small club-shaped cells called **basidia**. On a immature muschroom, the hymenium is protected by a thin sheath called **veil**. In fungi such as mushrooms and fly agarics, remnants of this hymenium can be seen as a ring around the stem. This ring is formed when the mushroom cap opens and ruptures the hymenium.



Different parts of Fruiting Body.and Stem

Different fungi have different ways of spreading their spores. Some mushrooms and bracket fungi use small **tubes** on the underside of their caps. These tubes create large surfaces for the spores to spread into the air. Other fungi, such as champignons and gilled mushrooms, have **gills**, a thin, blade-like structure under the cap. These gills (lamellae) also provide an effective surface for spreading spores. In fact, the shape of the gills – which can be downward-pointing, urn-shaped or straight – is often used to characterise fungi.

Both tubes and gills have basidia for spore production and release. Once the spores are ready, they spread to new locations. They are very resilient and can survive long under challenging conditions. Spores can spread in several ways, but most often by wind. However, some fungi cooperate with animals that assist in transporting the spores further.

DECPMPOSERS

Fungi are important to nature because they, along with other organisms, break down dead plants and animals into a nutrient-rich soil we call humus. Microorganisms of fungi and bacteria allow plant waste to be transformed into nutrients that plants can take up, such as different forms of nitrogen (2). The fungal mycelium releases enzymes that break down the nutrients outside the fungus. This process makes the nutrients available to trees and other plants (3). Some fungi live on trees and break them down by decomposing them. A healthy forest with high conservation value supports a significant variation of fungi species. They help break down old trees left on the ground, and such fungi are usually called indicator species. They signify that the forest is natural and has a rich biodiversity (1).

MYKORRHIZA

Mycorrhiza refers to the symbiotic relationship between fungi and plants in which the hyphae of the fungus grow together with the plant's roots, resulting in a favourable nutrient exchange for both organisms. Fungi that form mycorrhizas are usually attached to one or a few specific plant species, and the fruiting bodies are, therefore, only found in their vicinity. So which species form mycorrhizas? Most of the mushrooms in the forest are mycorrhizal, including the prized yellow chanterelle. This symbiotic relationship with trees is so complex that humans cannot replicate it, which explains why cultivating chanterelles remains impossible (1).

Mycorrhizal root with mycelium of Fly Agaric.
Photo: Ellen Larsson via Wikimedia Commons

Thin threads of mycelium.

Symbiotic Nutrient Exchange

The thin, thread-like hyphae of fungi form a dense web through the soil as they spread. Over hundreds of years, a single fungus can extend across several square kilometres, creating a network that helps support an entire forest ecosystem. A teaspoon of forest soil can contain several kilometres of hyphae (4). Remarkably, for every step you take in a forest, there are approximately 48 kilometres (30 miles) of fungal hyphae with their countless extensions. This incredible underground network exists all over Earth, even in the desert (3).

Fungi act as an extension of tree roots, forming a network of hyphae extending far beyond the trees' roots. Through this network, the fungi can collect water and nutrients, especially phosphorus and nitrogen, which are otherwise difficult for trees to reach. In exchange, the trees supply the fungi with carbohydrates through photosynthesis. The mycorrhizal fungi also help improve the trees' water availability, strengthening their ability to cope with drought. This symbiosis is crucial for both parties and has a significant ecological impact.

Communication & Defence

Mycelium communicates with electrical impulses and electrolytes similarly to our brains (3). Trees use these signals to feed, talk to each other, and exchange information about hazards such as drought and insects (4). Plants also use this method to recognise their offspring, allowing the mother tree and the baby plant to communicate with each other. For example, suppose the mother tree knows there are pests nearby, and her life is in danger. In that case, she increases her competitiveness for her offspring, using mycelium so that they reproduce further away (3).

The network of hyphae in the soil.

Fungi also act as a defence for trees against harmful organisms in the soil. By spreading their hyphae, fungi take up space and resources, making it harder for harmful microorganisms, such as bacteria and other potential pathogens, to take hold. In this way, they help keep pests away and protect trees from damage (7).

They can also protect themselves, more specifically, by providing plants with antibiotics to defend against parasitic intruders. This cooperation is so widespread that up to 85 per cent of all plants on Earth today need a fungal buddy to thrive (2). In turn, the fungi benefit from the underground protective environment of the trees, which prevents external interference (7). Fungal spores can also spread more efficiently through the root system of trees, which also favours fungi in their reproduction (8).

Shrubs, grasses and possibly all plant species have similar communication benefits to trees. However, the crops cultivated today have largely lost the ability to communicate above and below ground due to plant breeding. In a sense, they have become deaf and lost their protective barriers, making them easy prey for pests and increasing the need for pesticides (4).

STORAGE OF CARBON

According to scientific research, trees store about 70% of their carbon from photosynthesis underground. In exchange for nutrients, the root system releases carbon, which ends up in the cell membranes of fungi and serves as fuel for soil microorganisms.

The fungal cell walls made up of chitin - a hard, natural material also found in the shells of insects—decompose slowly and help the carbon remain in the soil for a long time.

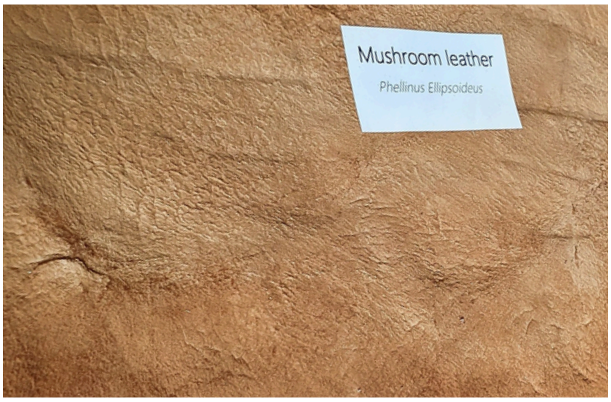
The Yellow Foot Mushroom Cratellus Lutescens with its mycelium in the ground.

Fungi are, therefore, vital in balancing the carbon in the system and stabilising it in the soil. We have a natural mechanism for storing carbon underground if we maintain plants, forests and natural fungal communities (3).

RELEVANCE TO TEXTILES

Fungi play a crucial role in ecosystems and contribute to the development of textiles in many ways. Through the formation of mycorrhizas by trees such as beech, pine, and spruce, fungi improve tree growth and health, favouring the production of textiles such as modal and viscose. Flax, used to make linen fabrics, also benefits from this cooperation. Cotton benefits from the symbiosis with mycorrhizal fungi, which help the plant absorb nutrients and protect the roots from pests, strengthening its resilience and growth.

Dyer's Mazegill are rich in yellow colourants.



Vegan leather made from mushrooms.
Photo: Thamara Groenleer, Wikimedia Commons

Additionally, fungi contribute to the development of entirely new textile materials. Mycelium, the underground network of fungi, is used to create sustainable and biodegradable alternatives to leather and other textiles. These materials have become increasingly popular in sustainable design and production. In addition, some fungi contain natural pigments that can be used for more environmentally friendly dyeing of textiles, where, for example, leather fungi can produce shades of brown, yellow or orange.

Fungi also play an important role in the life cycle of textiles through biodegradation. Natural fabrics such as cotton and wool can be decomposed by fungi, which is valuable in circular systems where textile waste is recycled and returned to nature. In addition, researchers are exploring how fungal enzymes can be used to treat textiles and give them properties such as increased durability or water repellency without using chemicals.

Wool can be broken down by fungi and become new nutrients.

OTHER TYPES OF FUNGI

A **parasitic fungus** is a fungus that benefits from another organism to obtain nutrients while harming or weakening its host. A saprophyte is something in between parasitism and symbiosis. The saprophyte benefits, but the interaction neither benefits nor harms the host. Many types of bracket fungi are saprophytes, as are many oyster mushrooms (1).

'Stump fungi' is a general term for saprophytes that grow on dead or dying stumps and wood in nature. Mustard Yellow Polipore and velvet shank are two examples (1). Without these digestive activities, forests would disappear under a mountain of logs and leaves!
Some fungi influence the behaviour of various animals to guide them to specific locations, making them targeted spreaders of the fungi's spores. Crayfish plague is an example of such a fungus, where the crayfish are unwillingly driven onto land, die, and become covered with the fungus's fruiting bodies, which then spread the spores through the wind (1)


The saprophyte and stump fungus Velvet Shank.

Lichens are a complex symbiosis between different algae, fungi and bacteria. The fungus hyphae provide structure, the photosynthesis of the algae provides nutrients, and bacteria help transport substances between the fungus and algae (10). Lichens do not have roots but are attached to the surface of rocks, cliffs, trees, or the ground. Lichens grow slowly, can be several metres (yards) long, and become very old. Many species are sensitive to air pollution and are, therefore, indicators of changes in air quality (9).

Lichens are sometimes mistaken for mosses. A classic example is reindeer lichen, or window lichen, which is also commonly known in the trade as white moss. However, we use lichen, not moss, to decorate candle holders and Christmas decorations. The actual white moss is green or reddish and grows in moist woodland. Window lichen grows on dry ground in conifer forests and is essential to the reindeer diet (9).

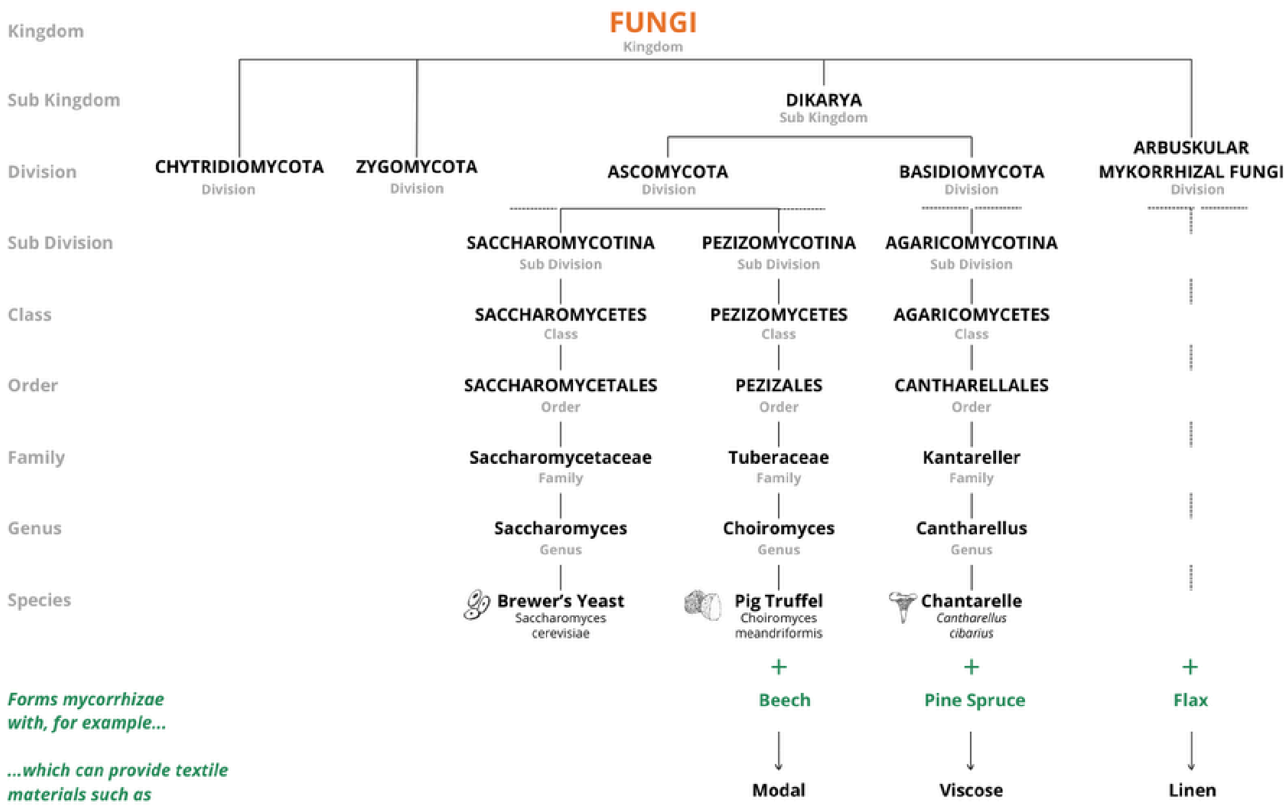

Lichens come in many different colours and shapes.


Star-tipped raindeer lichen.

TAXONOMY OF FUNGI

Historically, fungal relationships have yet to be as well studied as those of plants and animals. Modern DNA technology is paving the way for a better understanding of the fungi kingdom. Research into how fungi are related to each other, known as taxonomy, is constantly evolving as we learn more. All fungi are categorised by their Latin species name, but in everyday speech, the more simplified names found in different languages are often used (1).

In biology, kingdoms are one of the highest levels of organizing organisms. Fungi belong to the fungi kingdom, which is divided into smaller groups of divisions. A kingdom corresponds to phyla in the animal kingdom. Divisions are subdivided into classes, orders, families, genera and species. A family includes one or more closely related genera, and each genus consists of species that share common characteristics. Species are the most basic level and are usually defined as organisms that can produce fertile offspring with each other.



Penny bun belong to the basidiomycetes.

Basidiomycetes is one of two divisions of the fungi kingdom that includes most of our edible fungi, such as mushrooms, bracket fungi, puffballs and others. Basidia are the microstructures most commonly found under the cap and responsible for spore spreading.

Spore Fungi. Also known as Ascomycetes, the spore fungi are the second of the two divisions that include our edible fungi. These include genera such as morels and truffles. They are characterised by the spores being stored in so-called spore sacs, asci, instead of basidia (1).

Black Morels belong to the spore-forming fungi.

USE OF MUSHROOMS

Mushrooms are extremely useful. In addition to being used as food, there are a multitude of species that have additional uses. You can use dyeing fungi to dye yarns or fabrics, such as the loofah sponge, which produces shades of blue, or the blood-red webcap, which makes a bright red colour (1).

Medicinal fungi can contribute to positive health effects or cure diseases. Penicillin is one of the best known (1), but also Chaga, i.e. blast fungus, has been used for a long time in folk medicine and is considered good for the immune system (11). Mould fungi can also be used to process foods such as cheese.

Yeasts, which include around 600 different species, can extract energy from sugar without using oxygen—a process known as fermentation. Sourdough bakers almost always rely on wild yeast, meaning yeast cells are naturally present in the air around us. These yeast fungi produce at least 600 different chemical compounds that significantly contribute to the characteristic flavour of the bread (2).

Yeasts play an essential role in the energy sector by producing ethanol as they process sugar, enabling bioethanol production from crops like sugar beet and sugar cane (2).

Stinking Earthfan turn fabric & yarn blue when dyed.

Blood Red Webcap can give textiles a red colour.

DID YOU KNOW

Approximately 148,000 species of fungi have been identified, while the actual number is estimated to be around 3.8 million. Around 2,000 new fungal species are discovered yearly, yet more than 90 per cent of fungi are likely to remain unknown (2).

Like bacteria, fungi are found more or less everywhere on Earth. They can survive in extreme conditions, such as deserts, high-salt environments, super-hot deep-sea volcanic wells and even the intense UV radiation and vacuum of space (2). Scientists have also discovered fungi living several kilometres below the Earth's surface, where they survive on small amounts of nutrients and produce spores to reproduce.

Fungi are more closely related to animals than plants, meaning that the genetic makeup of fungi is more similar to human and other animal DNA. Fungi, like humans and other animals, can also produce vitamin D when exposed to sunlight (2).

In Oregon, there is a colony of the dark honey fungus (Armillaria ostoyae), consisting of tiny fungi that form a large organism with common DNA. The fungal organism is called Humongous fungi, and its root system covers an area of up to 965 hectares. This enormous root system makes it the largest living organism in the world. It is also very old, estimated to be between 2,000 and 8,500 years (2).

Detail of Dark Honey Fungus

Dark Honey Fungus

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