

Fungi and Lichen



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Some of you might recognise this colourful mushroom and this coral-like lichen.

But have you ever stopped to look at them closely. Have you ever thought about what they are and what they do?

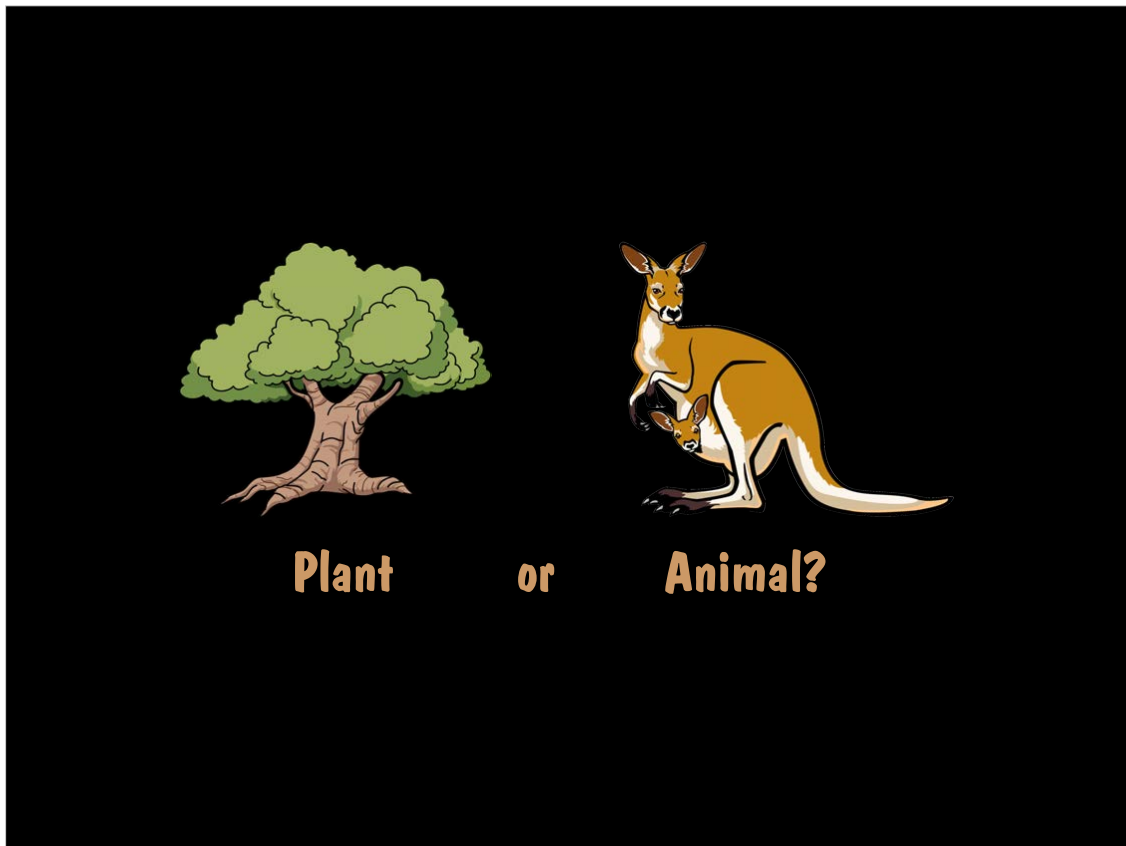
Most people don't, which is a shame as fungi and lichen really are amazing and, quite frankly, we can't live without them.

What are they?

Now I have to admit that is a pretty big statement to make about two things which are so often overlooked and poorly understood.

So what makes fungi and lichen so important?

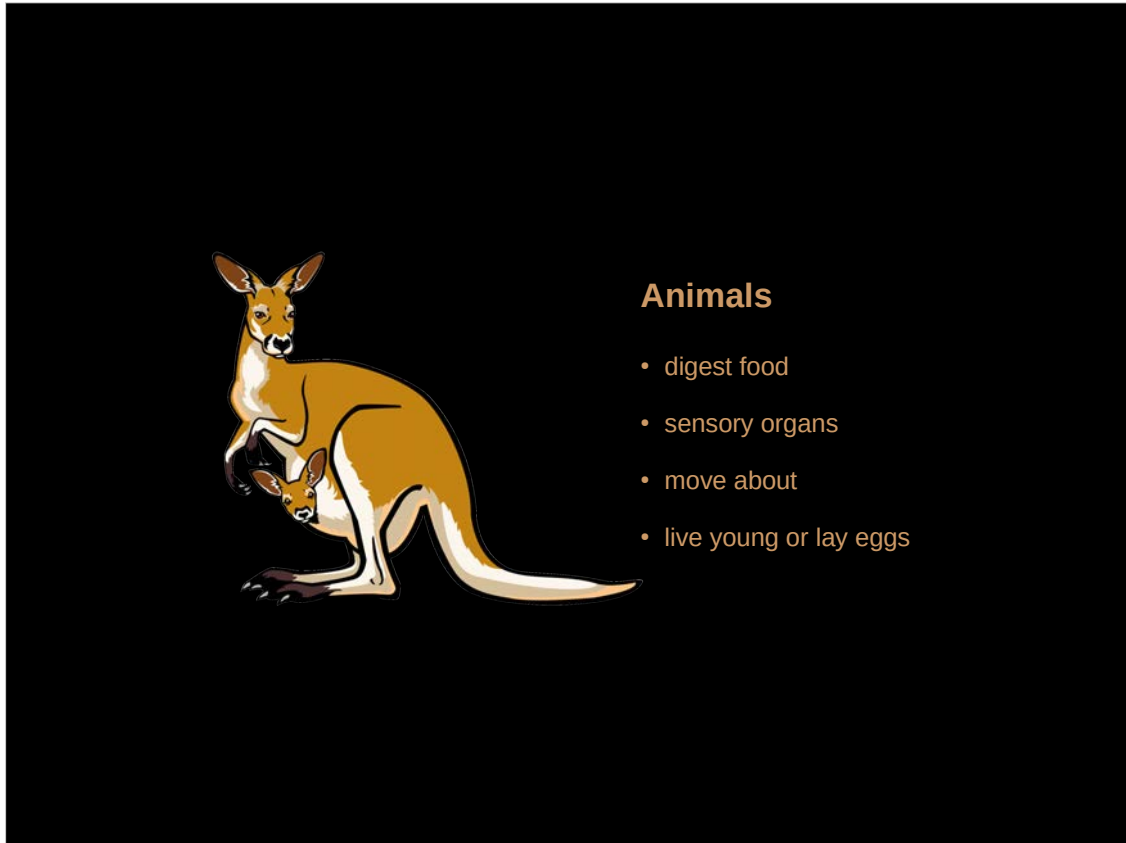
To understand that, we first need to understand what they are.



In the early days of science, all living things were classified into two groups or kingdoms.

This division goes back at least as far as Aristotle who lived around 350 BC – that's over 2,300 years ago.

He distinguished between plants, which generally do not move, and animals, which do move.

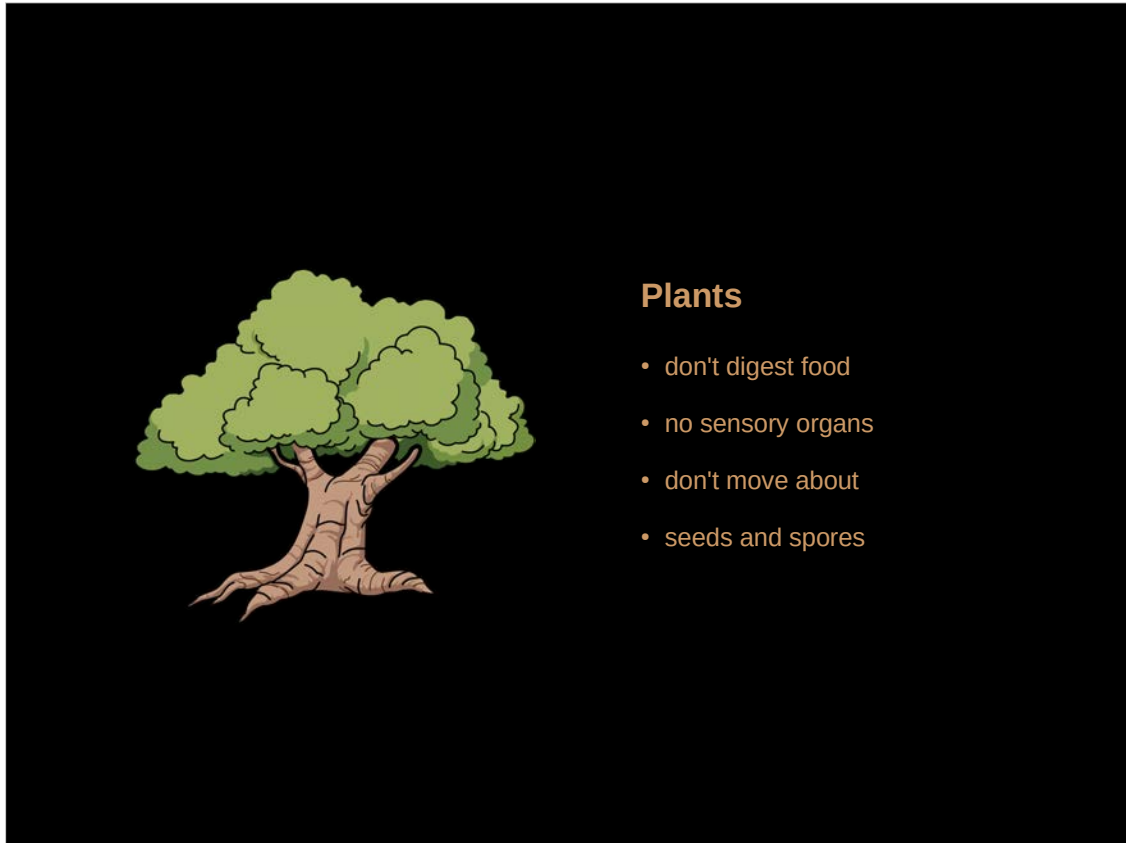


Over time, these observations were expanded upon by other scientists. It was generally agreed that animals:

- need to digest food such as plants and other animals to survive;
- have specialised sensory organs for recognising and responding to stimuli in the environment;
- they can move about voluntarily;
- they have live young or lay eggs.

There are always exceptions to the rules, but for our purposes, I'm keeping it simple.

So, following that description, it is obvious that fungi and lichen aren't animals and must be plants.



Let's look at the early scientists' observations about plants.

Plants:

- don't digest food;
- don't have specialised sensory organs;
- they have very limited movement, if any;
- and they reproduce via seeds or spores.

This broad description also seems to fit fungi and lichen.

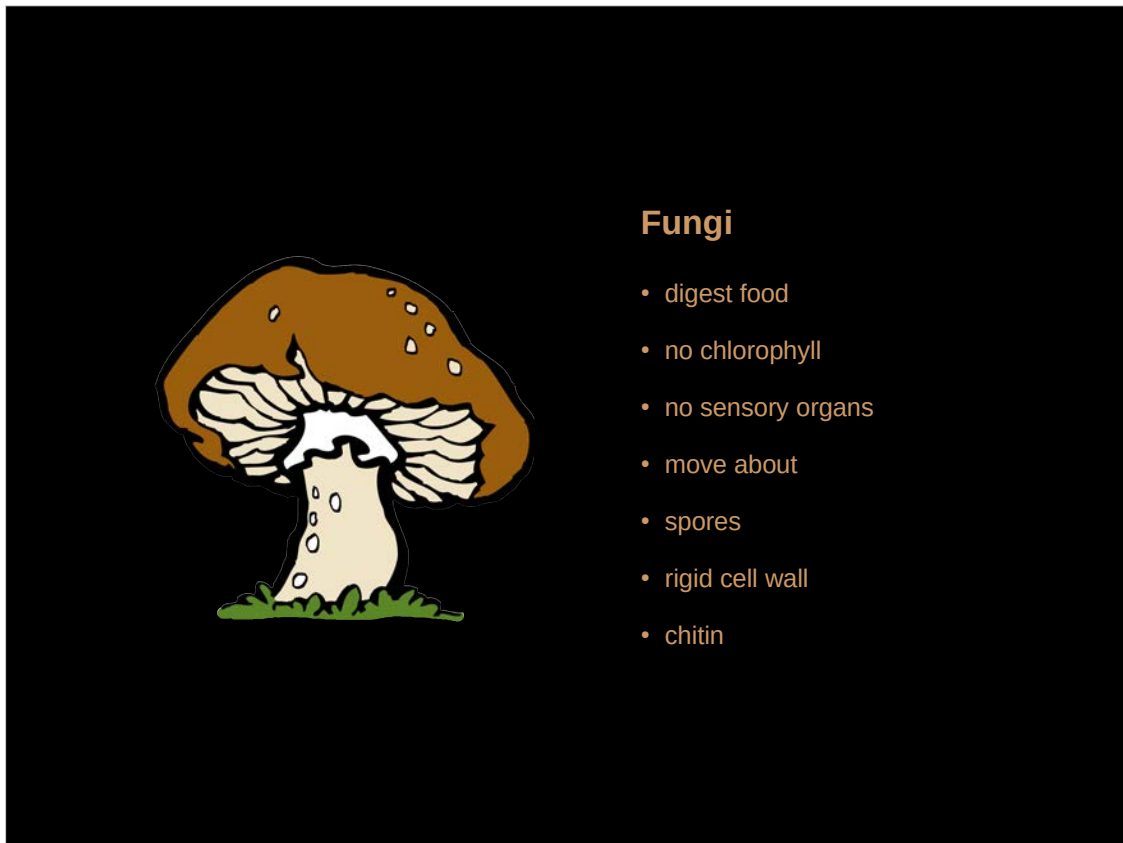
So, for many hundreds of years fungi and lichen were thought to be simple or lower plants like the mosses and liverworts.



This conclusion is quite understandable.

I mean, look at this lichen. It's green and looks like its got leaves and branches and maybe even tiny red flowers.

It wasn't until the early 1700s when scientists started using microscopes to look at cellular structures and processes that they realised that plants and fungi and lichen really are quite different to each other.



It was discovered that fungi actually do digest things. Unlike animals which engulf their food and digest it internally, fungi feed by external digestion and absorption.

Fungal cells, like animals cells, don't contain chlorophyll. Plant cells do. Plants use chlorophyll to make their own food.

The spores of some fungi are quite mobile. They have little tails and can swim – yes, just like animal sperm cells can swim.

Fungal cell walls are rigid like plant cell walls, but they contain chitin while plant cell walls contain cellulose and lignin.



Some colourful chitin.

By the way, chitin is the same stuff the exoskeletons and wings of insects are made of. It's also in the scales of fish and the beaks of octopuses.

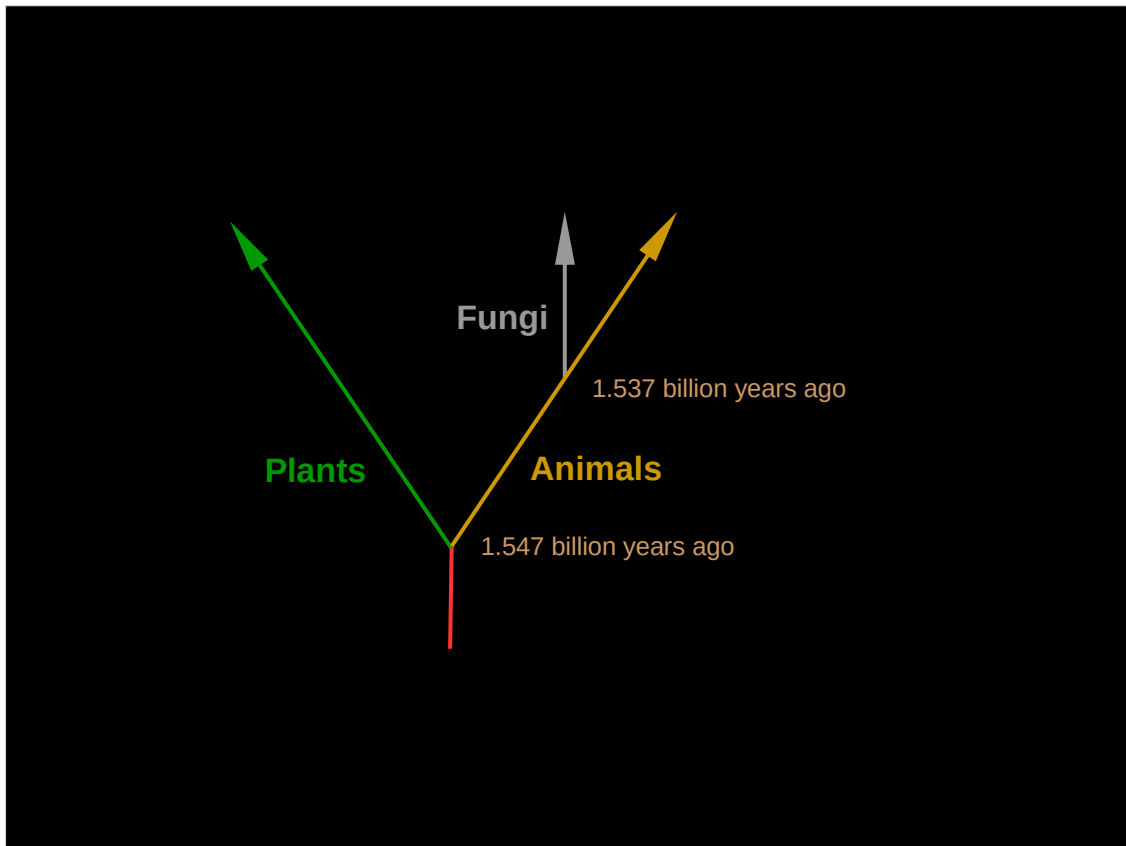
			
Digest food	✓	✗	✓
Chlorophyll	✗	✓	✗
Sensory organs	✓	✗	✗
Voluntary Movement	✓	✗	Some
Eggs or live young	✓	✗	✗
Seeds or spores	✗	✓	Spores
Rigid cell walls	✗	✓	✓
Chitin	Some	✗	✓

So fungi are organisms that:

- Feed by external digestion and absorption;
- Some can move voluntarily;
- Reproduce by spores;
- Have rigid cell walls that contain chitin.

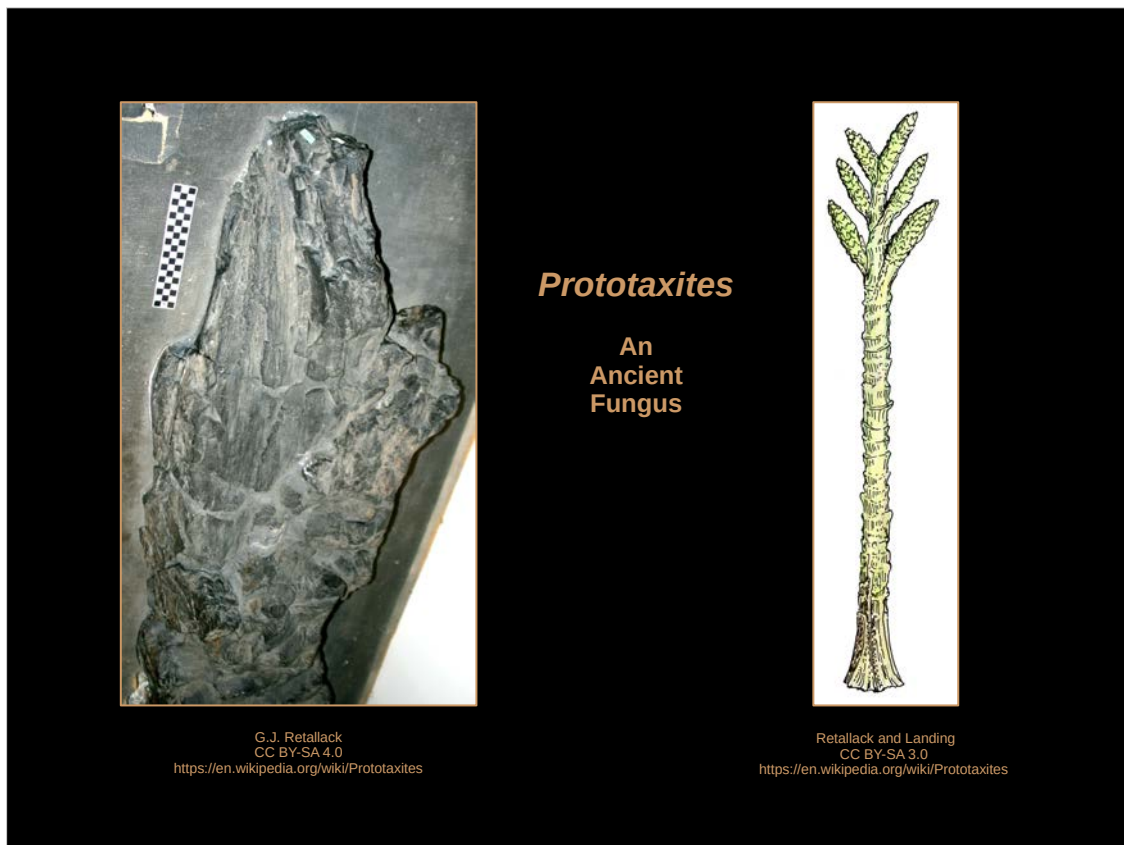
Fungi were duly reclassified and put into a kingdom of their own.

Recent DNA analyses have shown that fungi are actually more closely related to animals than plants.



Estimates vary, but it's thought that plants and animals diverged in their evolution around 1.5 billion years ago. At that point, fungi were still a part of the animal branch.

It wasn't until maybe about another 10 million years later that fungi separated from animals and began their own evolutionary path.



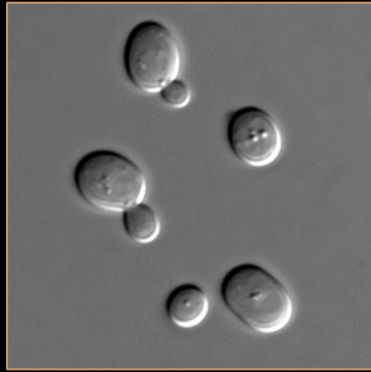
Fungi probably colonised the land over 500 million years ago.

Until then, bacteria were pretty much the only things living on land. Plants still lived in the sea and only a few molluscs represented the animals on land.

Fossil fungi up to 420 million years old have been found all over the world. These fungi were giants, standing over six metres tall and they were about 1 metre wide at the base. At that time, the tallest plants were only about a metre high, so these fungi would have dominated the landscape.

The only land animals at that time were creatures without a backbone - things like millipedes, insects, snails and worms.

So fungi were around long before there were any dinosaurs.



Masur
Public Domain
<https://en.wikipedia.org/wiki/Yeast>

Yeast



Rust

Most fungi these days are a lot more modest in size.

The kingdom includes microfungi such as yeasts, moulds, mildews, smuts and rusts...



and macrofungi, which are the more familiar mushrooms, puffballs, crusts and brackets.

Little is known about the true biodiversity of fungi.

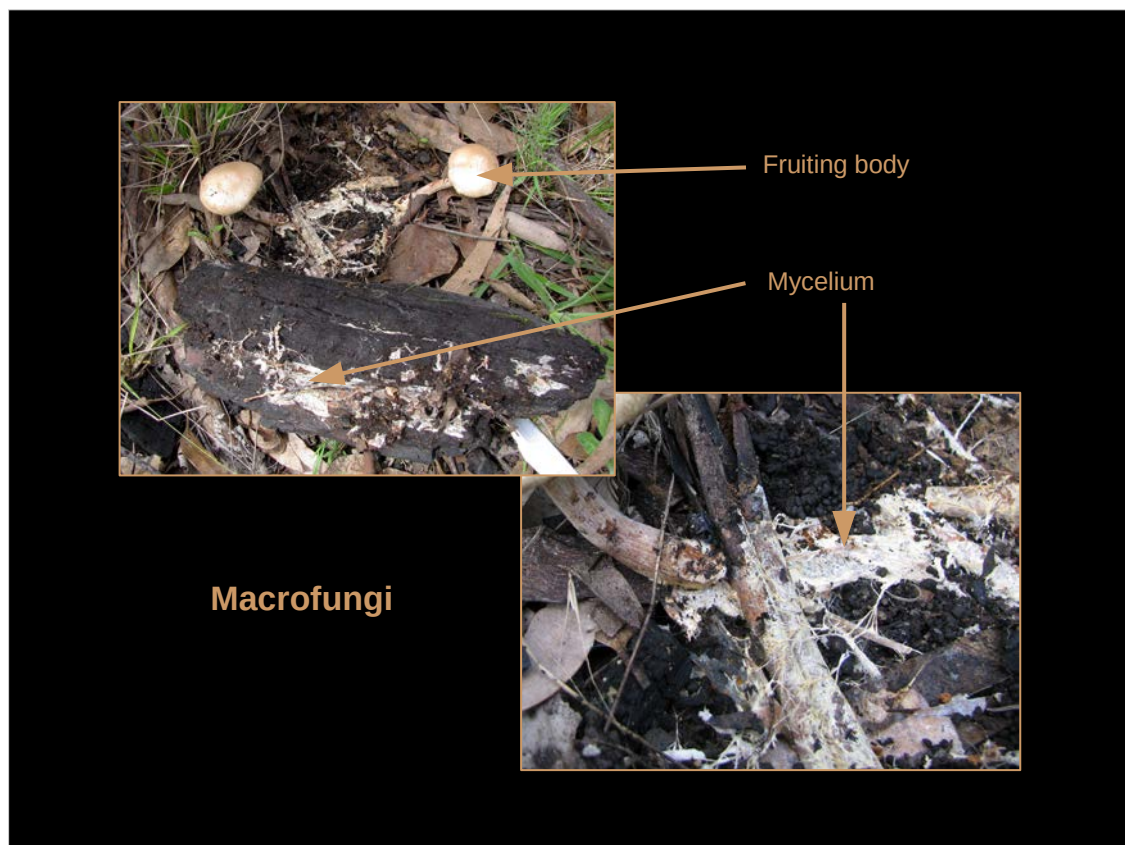
They seem to have endless ways to interact with the environment, have hugely varying life cycles, and come in so very many different shapes, sizes and colours.



Let's look at your typical little brown mushroom that you might find out in the bush.

It has a cap, gills and a stipe.

But it doesn't end there.



Like other macrofungi, the actual fungus organism is hidden away beneath the mushroom. It is made up of a network of tiny threads called hyphae that live on or within the food source. This network is called the mycelium. What it grows on or in is called the substrate.

Usually, the mycelium isn't visible but sometimes, such as pictured here, the threads grow together to form thicker cords or cobweb-like structures. In this case, the fungus was growing on and feeding on some burned wood.

The mushrooms, puffballs, crusts and brackets we see are only the fungus's fruiting bodies, like apples on a tree.

Our example above had put out two fruiting bodies, one on each side of the piece of wood.

Mycelium Mosaic



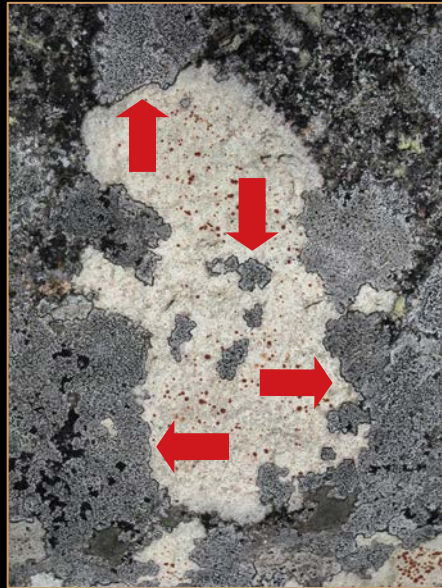
© Mark Newbound

Fungi aren't distinct organisms. Their mycelium are an open network of hyphae that can grow through each other. It is quite possible for more than one fungus to share the same area of substrate.

If we could see the fungi beneath the surface of the soil, it would be something like this - a patchwork of overlapping mycelium.

What's not shown here would be a similar mosaic of fungi on and within the trees.

Fungi at War

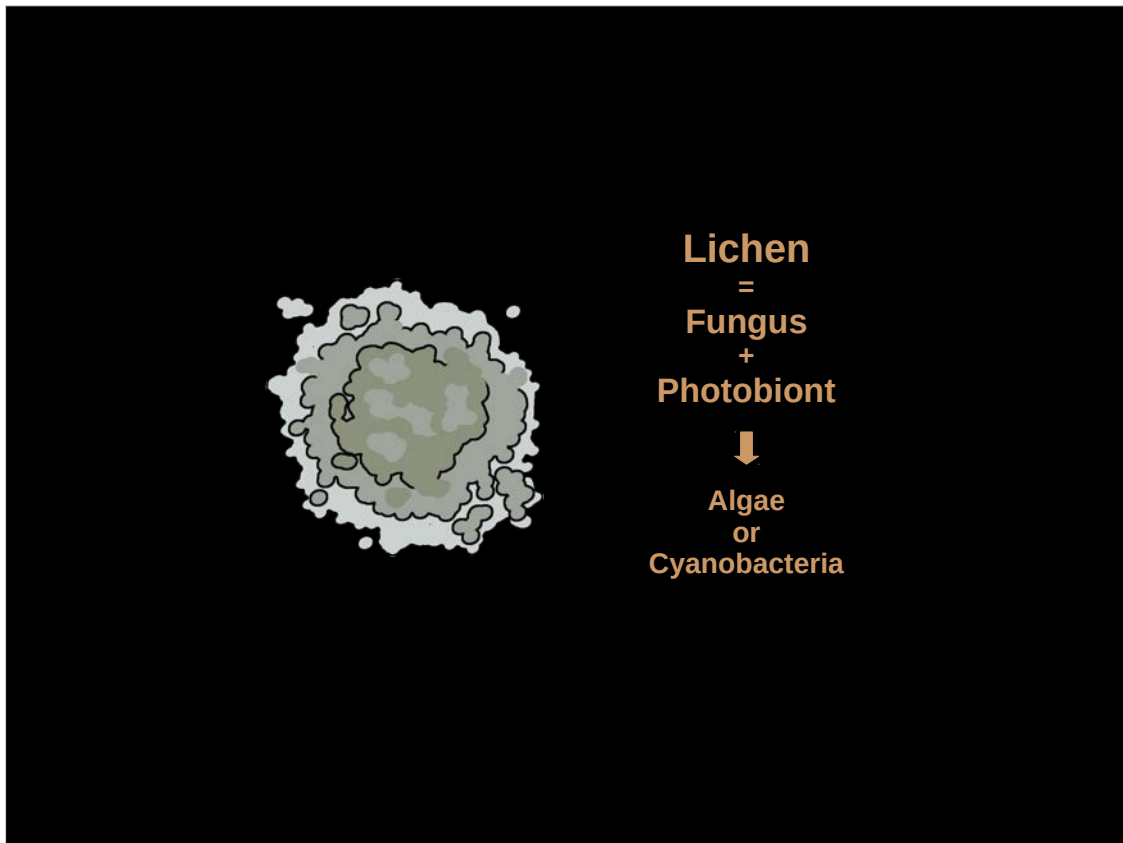


It's not all peace and harmony. These lichen illustrate what also goes on within the mycelium network.

Like all organisms, lichen and fungi compete with each other for food.

Some fungi and lichen fight for their territory by producing chemicals that attack foreign invaders.

These lichen on a rock reflect what is also going on under our feet. The black lines show the areas where a chemical combat is fiercely raging.



So that brings us to lichen. What are they?

Lichens are complicated things. They are actually composite organisms made up of a fungus and green alga and/or cyanobacteria living together.

Green algae are tiny plants and cyanobacteria are as their name suggests a kind of bacteria – which are another whole story. All we need to know for now is that cyanobacteria can, like plants, use sunlight to make their own food.

In lichen, the alga and cyanobacteria are called the photobionts. Photo – meaning relating to light and biont, meaning an organism.

About 90% of lichen have a green alga as their photobiont.

Cladia retipora



Fungus = *Cladia retipora*

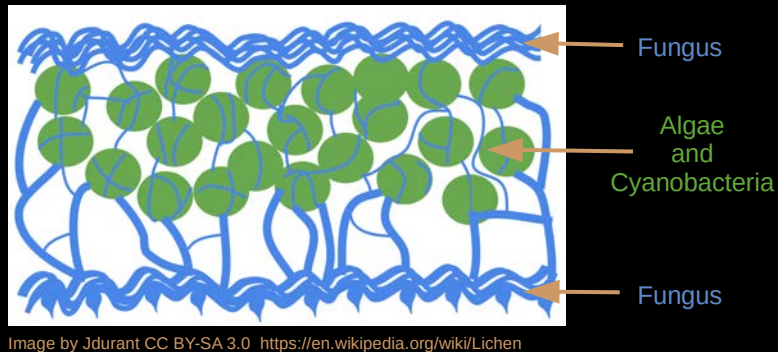
Alga = *Trebouxia* species

The fungus part is called the mycobiont. Myco means “relating to fungi”. Mycology is the study of fungi and a mycologist is someone who studies fungi. A lichenologist studies lichen.

The fungi, algae and cyanobacteria have been all been given their own scientific names, but the lichen is given the same name as its fungus component.

So why do these organisms live together?

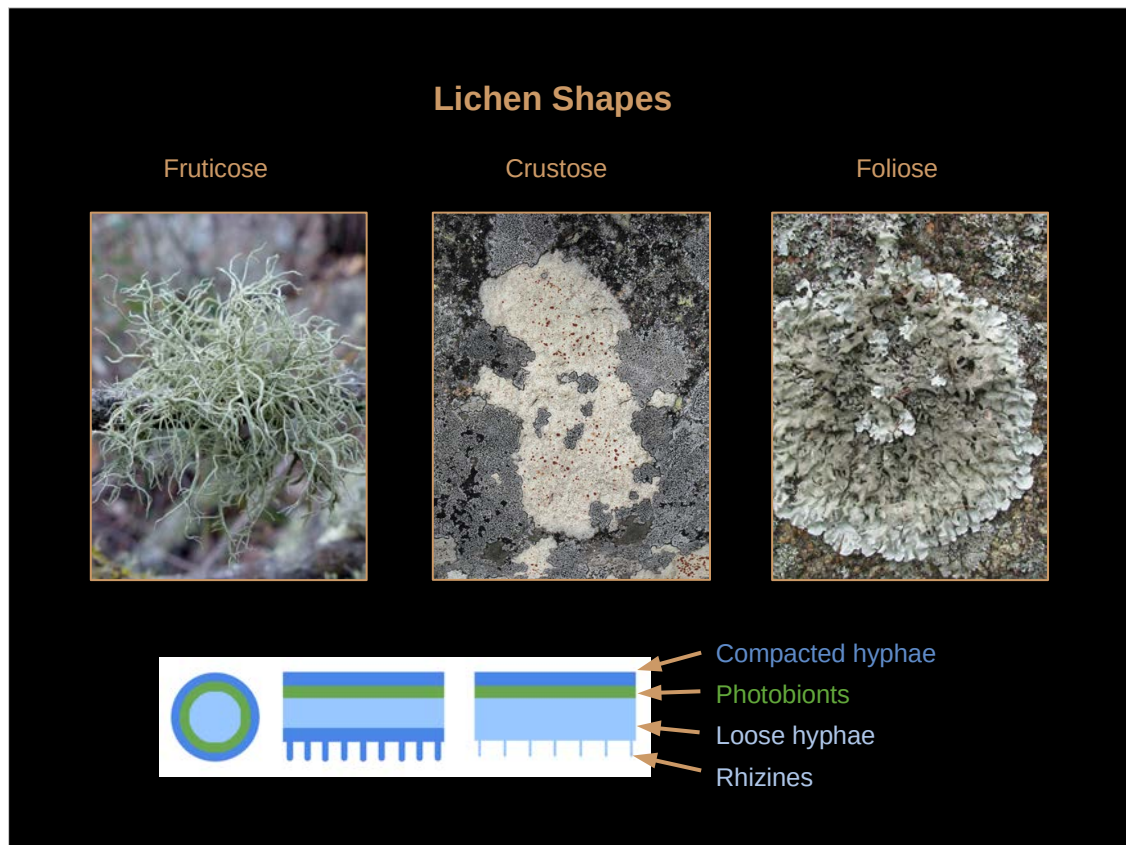
Thallus Structure



Think of lichens as tiny farms. The fungus is the infrastructure holding together and protecting the “crops” - the photobionts – with its network of hyphae.

With its relatively much larger surface area, the fungus also provides its crops with water and nutrients that it gathers from the air – much more than the photobionts would get if they were living alone.

This mixture of fungal hyphae, algae and/or cyanobacteria is called the thallus of the lichen.



The way the components of the lichen are organised affects the shape of the resulting lichen.

Some lichens are hair-like or shrubby and are often found hanging from trees. They dangle or sit upright with no distinguishable upper and lower surfaces. These are called fruticose lichens.

Some are flat and are attached firmly to the surfaces of rocks, soil, tree trunks and roof tiles, forming crusts. These are called crustose lichens.

Some are almost flat with leaf-like lobes. They grow in layers with distinct upper and lower surfaces. These are called foliose lichens.

There are other shapes as well, but these are the main ones.



Now, like us, fungi can't make their own carbohydrates - that's why they need to eat.

Algae and cyanobacterium through photosynthesis can make their own carbohydrates in the form of sugars.

In a lichen, the fungus “harvests” the sugars the algae and cyanobacterium make. In fact they can take up to 80% of the sugar produced.

Some lichen contain more than one kind of alga and cyanobacterium. This can be very useful if changing conditions favour one over the other.

Also, cyanobacteria can “fix” or gather nitrogen from the atmosphere. The alga components benefit from this, and in turn, so does the fungus.



Lichens have been described as being more than the sum of their parts. They possess structures and produce chemicals that none of the partners would if they were living by themselves.

Living together in this symbiotic relationship, these totally different kinds of organisms help each other to survive and prosper.

Only quite recently, another lichen component organism has been discovered. Many, if not most lichens contain single-celled yeasts. The function of these yeasts is not yet known, but there appear to be hundreds if not thousands of yeast species associated with lichens.

So we are still discovering things about them.



Let's get back to this leafy, green lichen.

We now know that the leafy parts, here down on the rock, are the lichen's thallus.

The green colour is produced by the lichen's photobionts, busily making sugars to share with their fungus partner.

The tall stalks with the tiny red bits on top are the fungus component's fruiting bodies. They aren't flowers at all, but more like tiny mushrooms.

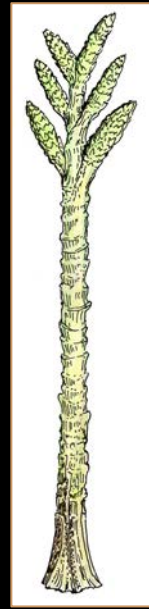


G.J. Retallack
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<https://en.wikipedia.org/wiki/Prototaxites>

Prototaxites

An
Ancient
Fungus

or
Lichen



Retallack and Landing
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<https://en.wikipedia.org/wiki/Prototaxites>

And remember this?

There is some debate as to whether or not it was a fungus
or if it was actually a six metre tall lichen.



Fossils show that lichens have been around on land for more than 400 million years, back to the time when plants were evolving from green algae in the sea.

Lichens are well known to be the first colonisers of bare surfaces. They can survive on rocks in full sun and in the harshest of environments.

Their thalli put pressure on the rock surface, slowly pulling it apart as they grow. The chemicals lichens produce also slowly eat away at the rock, dissolving it into fine particles. When lichens die they contribute organic matter to the soil.

It's thought that lichens perhaps provided a key stepping stone for life on land by helping other natural weathering processes create the first soils.



Fuligo septica, the "dog vomit" slime mould

Now we get to the slime moulds. Slime moulds are not fungi and they're not lichens, even though they might look like them. They are very different organisms again. Even so, mycologists include them in their studies and they are worth a mention.

Slime moulds are a very ancient group, their origin predating the split between animals and plants.

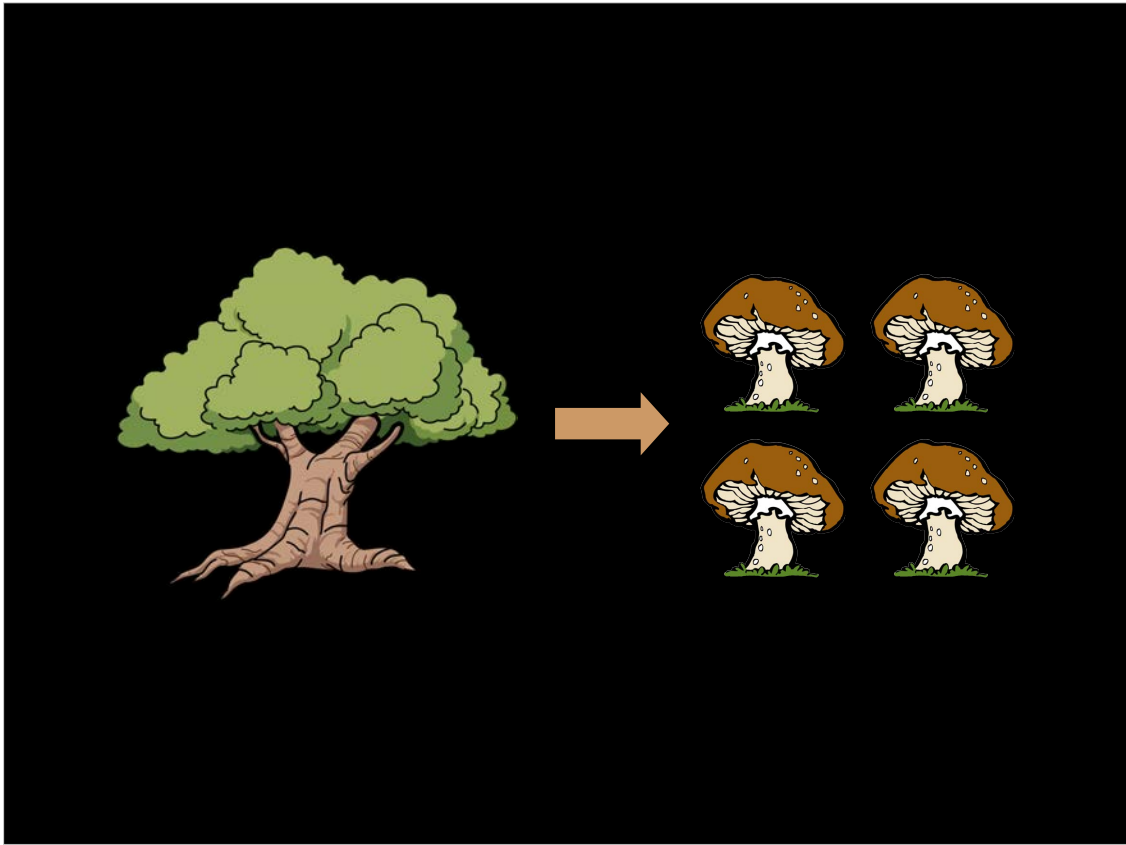
They usually live as single-celled creatures in the soil, quietly going about their business of hunting down and eating bacteria and fungi. When food gets scarce, a chemical signal is given and the individual cells clump together into a gelatinous slime. Acting as a single organism, this slime can move about looking for more food. When the food supply runs out, it will change again, turning into rigid fruiting bodies that produce spores.

Slime moulds don't have anything remotely resembling a brain, but they have shown an ability to learn and predict periodic unfavourable conditions in laboratory experiments.

**How many species of
fungi and lichen
are there?**

How many fungi and lichen are there?

That's a very good question and one that is hard to answer.

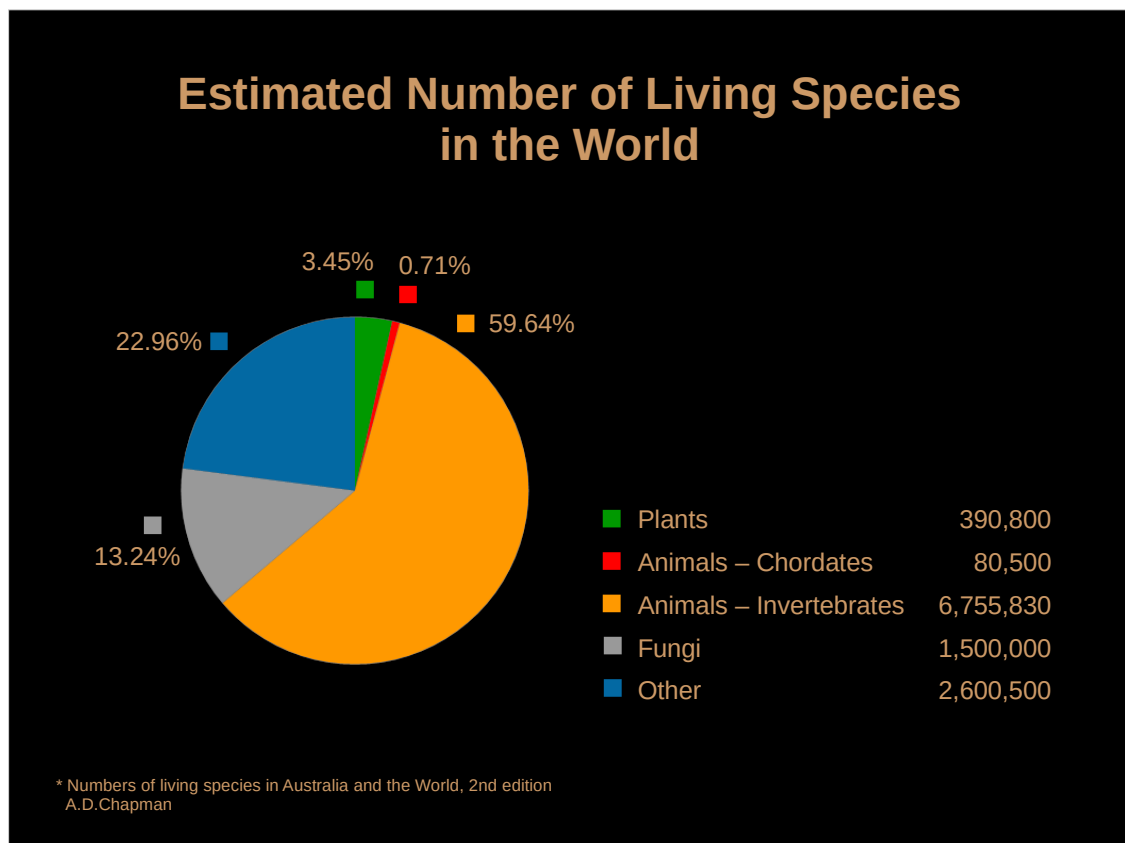


It's been estimated that fungi outnumber plants by 10 to one. That is, for every plant, there are 10 fungi.

For Australia with our often harsh, dry climate that number has been reduced to about four fungi for every plant.

In 2009, 11,846 species of Australian fungi had been described, of which 3,495 were lichens.

Estimates for Australian fungi as a whole range from 50,000 to 250,000 species.



This graph is a bit out of date as the information is also from 2009, but it gives you an idea of the relative numbers of the different kinds of living species world wide.

You can see that there are roughly four times as many fungal species (shown in grey) than there are plants (green).

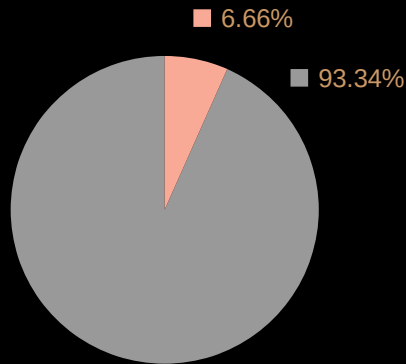
The fungi far outnumber creatures that have some sort of a backbone (red).

The invertebrates (yellow), which includes insects, molluscs and worms, outnumber everything.

The category “other” (blue) includes things like bacteria, viruses and slime moulds.

Here they estimate that there 1.5 million different species of fungi, but others have estimated that there may be as many as 5 million.

**Less than 7% of the world's
estimated 1.5 million fungi
are currently known.**



So far, only about 100,000 have been described and named. If we go with the more conservative 1.5 million species, that's less than seven percent.

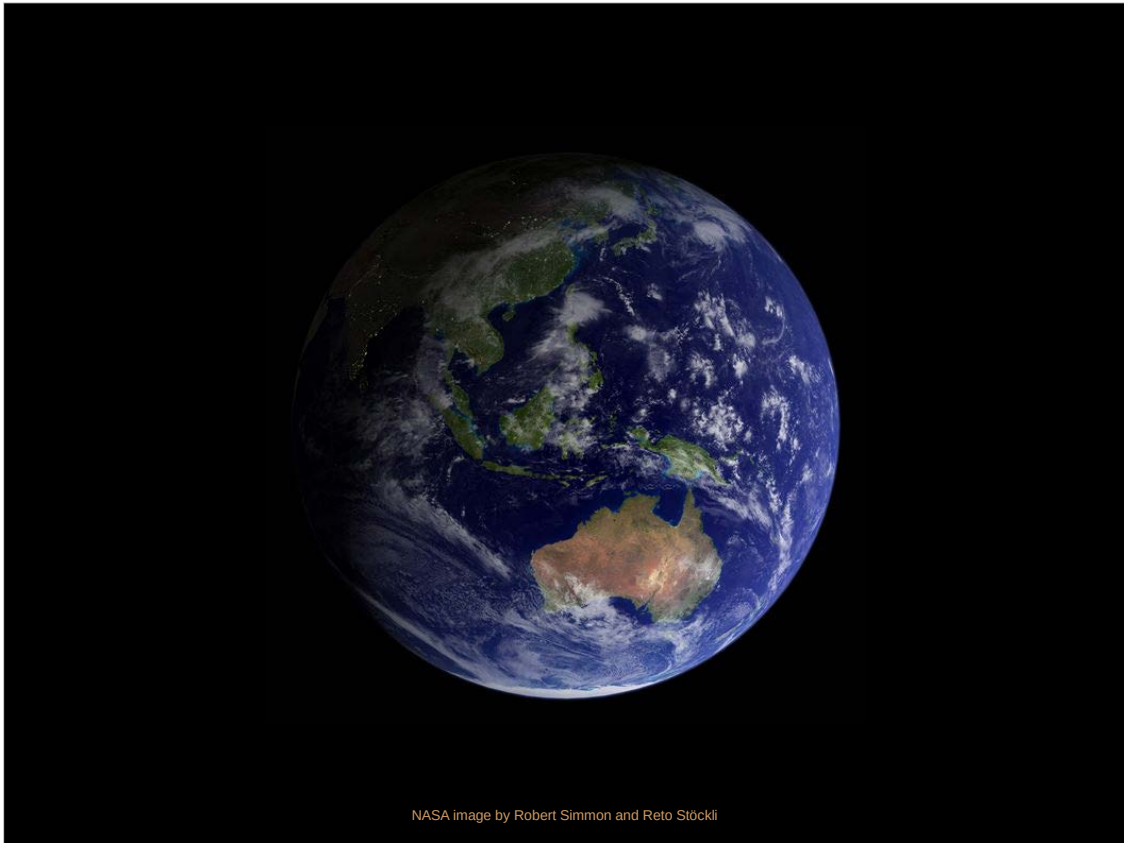
That number includes the 18,000+ lichen species.

By the way, all those lichens are associated with only about 300-400 different photobiont species.

Where do we find them?

So now you know what fungi and lichen are and how many different species there might be.

The next question is, where do they live?



The simple answer to that is... Everywhere.

The obvious places are where we can see them, on the ground, on rocks and on plants.

Fungi also live in the soil, in both fresh and salt water and their spores fill the air.

They live on our skin and hair and even inside us in our blood, guts and bones.

Fungi and lichen have been found on every continent, from jungles to deserts, and in both polar regions to the equator.

It has been estimated that 6% of Earth's land surface is covered by lichen.

Fungi have also been found living kilometres deep underground, inside the rock that makes up our planet's crust.

And finally, experiments have shown that fungal spores and lichen can even survive in space.

Where we don't find them is important too.



Alfred T. Palmer
Public Domain
https://en.wikipedia.org/wiki/Air_pollution

Where we don't find them is important too.

Lichens pretty much get all their nutrients from the air and rain, so atmospheric pollution is a big problem for them.

Some lichen can tolerate pollutants better than others.
Those that can't won't grow in polluted areas.

The interaction between lichens and air pollution has been used as a means of monitoring air quality since as far back as 1859.

Lichens also respond to environmental changes in forests, including changes in forest structure. So if a forest becomes more open after a fire, the lichen population will change to suit the changed environment.

Fungal Weeds



Anemone stinkhorn



Death cap



Fly agaric



Orange ping-pong bats



Myrtle
rust

John Tann CC BY 2.0
<https://www.flickr.com/photos/31031835@N08/8593947727/>

Humans are responsible for the transportation of many species around the world and fungi are no exception.

The anemone stinkhorn was introduced to English and North American gardens from Australia.

The death cap was introduced to Australia from Europe and the fly agaric also originates from the Northern Hemisphere. Both species are poisonous.

A recent arrival in Australia is orange ping-pong bats. It is thought to come from Madagascar. We don't yet know what its impact will be on our native species.

Another recent arrival is Myrtle rust. This disease is spreading very quickly and over 350 Australian native plants have proved susceptible. Myrtle rust comes originally from South America.

What do they do?

Fungi and lichen are a lot like us in some ways.

- They eat things.
- They grow.
- They reproduce.
- They can have friends...
- ...and enemies.
- They can get sick.
- They get old.
- They die.

Let's start with what they eat...

Mycorrhizal Fungi

Mycelium and Roots



André-Ph. D. Picard
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https://en.wikipedia.org/wiki/Ectomycorrhizal_extramatrix_mycelium

I've already touched a bit on what the fungal component of lichens eat, but what about other kinds of fungi?

A lot of fungi that live in the soil actually get their food in a similar way to lichen. Instead of partnering up with tiny algae and cyanobacteria, these fungi attach themselves to the roots of more complex plants such as grasses, herbs, shrubs and even large trees.

Again, it's a symbiotic relationship. The fungus's mycelium is able to gather more water and nutrients from the soil than the plant's roots could alone. Fungi can also draw minerals such as nitrogen and phosphorus from the soil, something that plants aren't very good at. In return, the plant gives the fungus sugars that the fungus can't make. It's been estimated that plants give their fungal partners 15-30 percent of their sugars.

This relationship is called a mycorrhizal association.



It's a very ancient relationship. Evidence of mycorrhizas have been observed in 400 million year old fossil plants.

It's been estimated that up to 95% of existing plant species need fungal partners to be healthy or to even stay alive. Such a relationship is essential in areas where there are poor soils.

Orchids especially need their fungi. The seeds of many species won't even germinate unless they have the right mycorrhizal partner.

Here's a thought. Does that mean that most of the plants around us are really lichens?

Some Australian plants which don't have mycorrhizal partners belong to the Protea family – that includes the Banksias, Grevilleas, Hakeas, and Geebung.

The Underground Network



Kirill Ignatyev
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Many mycorrhizal fungi can partner with different species of plants and many plants have more than one mycorrhizal partner. Thus, plants and fungi are interconnected by a complex underground network.

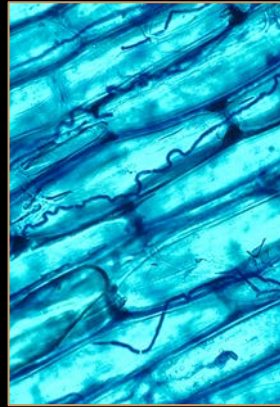
Nutrients can flow through this network, enabling, for an example, an adult tree to provide sugars to its seedlings.

Other chemical signals can also be transmitted. Recent research has shown that plants can warn other plants on the same mycorrhizal network of insect or herbivore attack.

Fungal mycelium help plants in another way by binding the soil particles together. This helps to prevent erosion and also creates spaces in the soil that increases water retention and drainage.

In one square meter of healthy soil there may be up to 20,000 kilometres of fungal hyphae.

Endophytic Fungi



Fungal hyphae inside the cells of a grass leaf.

Nick Hill
Public Domain
https://en.wikipedia.org/wiki/List_of_endophytes

Some fungi have another kind of close symbiotic relationship with plants.

These fungi live completely inside plants - in their leaves and stems - for at least part of their life cycle. They are called endophytes.

It's thought that they help plants grow better in poor soils and to better tolerate stresses such as heat and drought, diseases and being eaten by insects and larger animals. In return, the fungus is given the sugars it needs.

A lot of research is going in to how endophytes can help us by improving the health and strength of the crops we grow.

Parasitic Fungi



Downy mildew, a common parasite on plants.

Amara Dunn, NYS IPM
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<https://www.flickr.com/photos/99758165@N06/35505132301/>

Now, fungi also have a darker side. Some are greedy. They take from their partner or host and don't give anything back in return.

These are the fungal parasites and they infest plants, animals and even other fungi.

Most are microfungi. Some live on the surface of their host while others live deep inside them.

A great many actually don't harm their host as they need them to survive so they can survive, but others can make their host sick or even kill them.

8,000 species of fungi are known to be detrimental to plants and together they cause 80% of plant diseases in agriculture. Some have caused crop failures that have led to famines – such as the Irish Potato Famine of 1845-49 when over 1 million people died.

300 species of parasitic fungi are known to cause diseases in humans. Common fungal infections are ringworm, thrush and Athlete's foot. It's been estimated that 1.6 million people die each year of fungal infections.



Zombie Ants

David P. Hughes, Maj-Britt Pontoppidan
CC BY 2.5
https://en.wikipedia.org/wiki/Ophiocordyceps_unilateralis

One notorious parasitic fungi is *Ophiocordyceps unilateralis*. You might know it as the Zombie Ant fungus. It's found in the rainforests of Thailand and Brazil and it is associated with only a few ant species.

The spores of the fungus attach to an ant, germinate and force their way through the ant's exoskeleton into its body. As the fungus grows, it affects the ant's behaviour. It makes the ant climb up a stem and bite very hard into the vein of a leaf that's positioned just at the right height and position for the fungus' optimum growth. After a couple of days, the ant eventually dies with its jaws still locked in place on the leaf. The fungus continues to grow and eventually produces a fruiting body.

The ants bite so hard into the leaf vein that they leave a unique dumbbell-shaped mark on it. This distinct pattern has been found on a 48 million year old fossil leaf.

Humongous Fungus



Armillaria ostoyae
Honey fungus

Alan Rockefeller
CC BY-SA 3.0
https://en.wikipedia.org/wiki/Armillaria_ostoyae

Some parasitic fungi spread their mycelium through the soil to move from plant to plant.

One very aggressive parasitic species, the Honey Fungus, can spread at the rate of up to 1 metre per year.

The largest single living organism in the world is a Honey Fungus. It lives in Oregon, USA and covers an area of about 8.8 square km. It weighs somewhere between 6,865 - 31,751 tonnes and is thought to be anywhere between 2,000 to 8,000 years old.

They're not all that bad.



Bidgee
CC BY-SA 3.0 AU
<https://commons.wikimedia.org/wiki/Platycercus>

Some parasitic fungi take advantage of damaged trees.

They enter through the wound in the bark and proceed to eat away at the wood underneath, causing cavities to form. The external, living part of the tree may remain quite healthy despite having some quite large holes in it.

These holes become homes for many animals.

Parasitic Plants



Erythrorchis cassythoides



Dipodium variegatum

Here's a twist. About 400 kinds of flowering plants and one conifer parasitize fungi.

The plants may get only some of their food from their fungal host, or they might take all of their food.

The plants that are totally reliant on their fungal hosts often don't have well developed leaves and they have lost the ability to photosynthesis.

Some of these plant species are orchids and we have a number of them here in Australia.

Carnivorous Fungi



Sticky net used to trap nematodes.

Bob Blaylock
CC BY-SA 3.0
https://en.wikipedia.org/wiki/Carnivorous_fungus

Some fungi take their search for food even a step further. They actively hunt and eat tiny animals. More than 200 carnivorous species have been described so far.

Carnivorous fungi live in nutrient poor soils or dead wood poor in nitrogen. They get some or most of their nutrients from trapping and eating microscopic creatures such as nematodes – which are tiny worms, springtails - which are microscopic insect-like creatures, and amoebae.

They have three basic trap types:

- constricting rings that squeeze shut when tripped;
- toxic structures which lure and paralyse;
- sticky structures that act like fly paper.

This is an example of a sticky net one species uses to trap nematodes.

Saprotrophic Fungi

The Decomposers



© Megan Prance



Dung

Wood



© Lee Davies

Bone

The great majority of fungi obtain their food from dead organic matter. I read somewhere that 80% of all fungi are decomposers.

Some endophytic and parasitic fungi are opportunistic and can change their feeding habits to saprotrophic after their host dies.



I mentioned earlier that plant cells contain cellulose and lignin in their walls. These organic compounds are very tough and resist degradation.

Fungi are just about the only things that can break these compounds down.

Some fungi species prefer feeding on cellulose and others prefer lignin. This causes two easily identifiable kinds decay.

Brown, or cubical rot, is caused by the breakdown of cellulose in the wood. As a result, the wood shrinks, turns brown and cracks into roughly cubical pieces. You can see the cubical cracks forming here in this stump.

White rot fungi break down the lignin in wood, leaving the lighter-coloured cellulose behind. The wood becomes soft, spongy, or stringy and its colour changes to white or yellow. Some white roters also break down cellulose.



Mrs skippy
Public Domain
https://en.wikipedia.org/wiki/Fairy_ring

Fairy rings are made by decomposer fungi.

The fungus mycelium starts in the centre and grows outwards as it searches for food. In places like this where there is an even distribution of nutrients, the mycelium grows into a circular shape. It can take a number of years for it to get this big.

The fungus, depending on the species, can either kill the grass by starving it of nutrients or make it grow more lushly by providing it with nutrients. Some rings are visible even when they aren't fruiting by the colour of the grass.

Some fairy rings are huge – over 35 metres across.

Fungi in our Guts



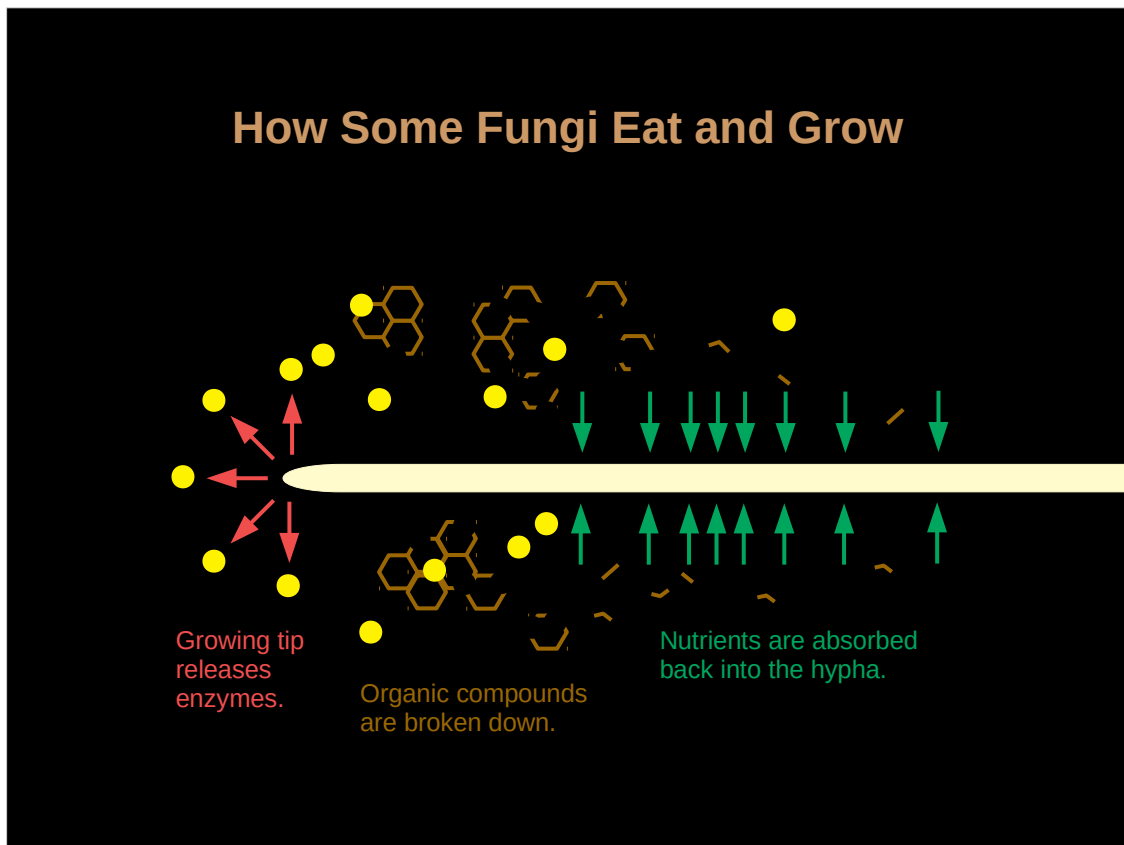
CC0
<https://www.pexels.com/>

Ok, we don't eat wood, but fruit and veges can still be hard to digest. We need fungi to help us get the most from them.

More than 100 different kinds of fungi live in the human gut. That might sound a lot, but it's really only just 0.1 percent of our gut microbe population – the rest are bacteria, viruses and other single celled organisms. Without these decomposer fungi, a lot of plant nutrients would be inaccessible to us.

Needless to say, if we find gut fungi important, then herbivores are totally dependent upon them.

Animals have been consuming plants with the help of their fungal symbionts for a very long time. Fossils have shown that plants were being eaten by arthropods about 410 million years ago. Four-legged animals probably started eating plants about 300 million years ago.



So that's *what* fungi eat. *How* they eat is also related to how some fungi grow. This diagram illustrates the process used by a typical decomposer fungus.

As I mentioned earlier, the fungus organism is made up of a mass of tiny threads called hyphae. These hyphae grow through the fungus's food source, the substrate.

Initially, the nutrients in the substrate are locked away in large and complex organic molecules. The fungus has to break these molecules down into smaller parts before it can absorb them.

The growing tip of each hypha releases enzymes into the substrate around it. The enzymes break down the complex organic compounds. As the tip grows forward, the part of the hypha behind it absorbs the nutrients from the now broken down or "digested" compounds.

Fungal Sex



Bernard Spragg
Public Domain
https://en.wikipedia.org/wiki/Schizophyllum_commune

As they grow through the substrate, fungal hyphae are not only looking for food, they are also looking for a suitable partner to mate with.

More than one individual of the same species of fungus may be growing in the same area. Should their hyphae meet, and if they are compatible mating types, they fuse together and share their cell nuclei.

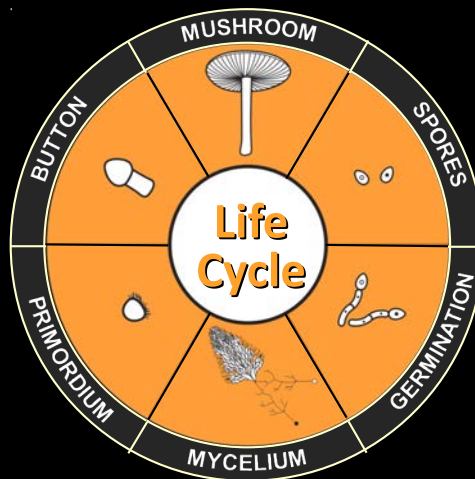
Meeting isn't totally by chance. Hyphae secrete chemical attractants – pheromones – into the substrate.

Fungal mating types are akin to sexes, although there's no way to tell them apart by looking at them.

Some fungi such as yeasts have only two mating types. Some have a lot more, such as this pretty fungus. It has 23, 328 mating types.

Individuals of any type are compatible for mating with all but their own type.

Life Cycle of a Mushroom



Fungimap
Adapted from: www.namycology.org/images/fungus_files/The_Fungus_Files.pdf
Images by Ian Bell.

So, here we have the life cycle of your typical mushroom.

I've just spoken about fungal mating, so let's start there.

Compatible hyphae mate and form a new mycelium that contains two sets of chromosomes.

The mycelium grows and spreads.

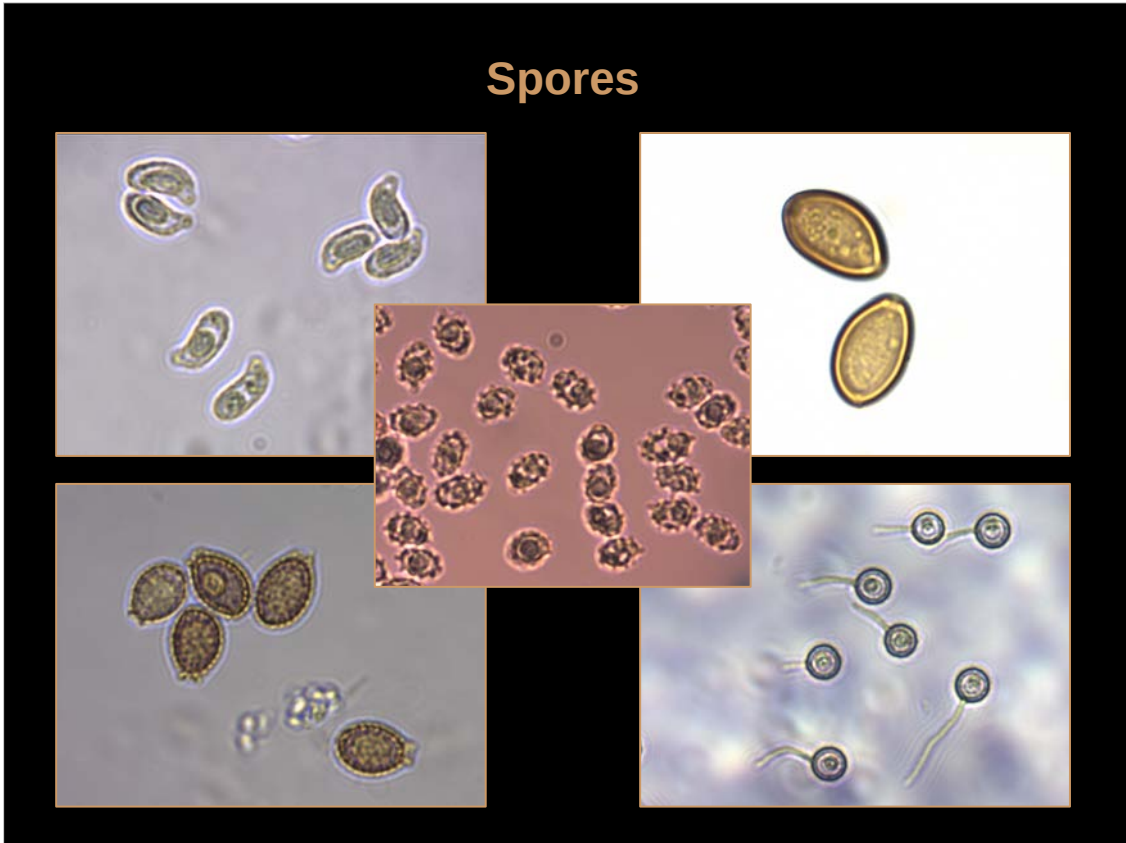
When the mycelium is big enough and the weather is right, the fungus produces on or near the surface of its substrate a tiny nodule called a primordium.

The primordium grows larger and becomes a button, which in turn expands into a mushroom. The fruiting body is more than 90% water, so it can grow very quickly.

The fruiting body produces spores which are dispersed by air, water and animals. These spores only contain one set of chromosomes.

If the spores land on a suitable site, they germinate and grow hyphae which search for food and a mate... and the cycle begins again.

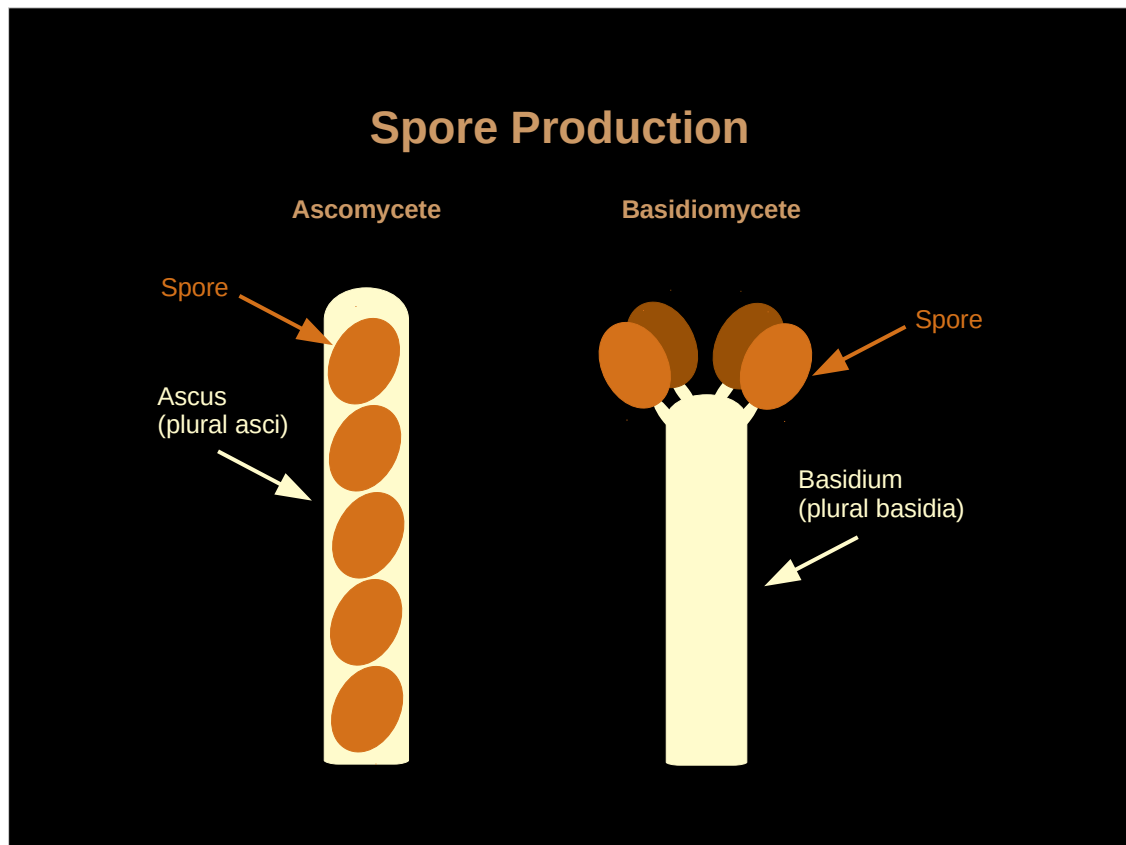
Spores



Fungal spores are tiny and can't be seen with the naked eye.

Each species of fungus and lichen produces spores that are unique in size, shape and colour.

To help make sense of the fungal kingdom, mycologists and lichenologists look at spores as part of the identification process.



Mycologists and lichenologists also look at how the fungus produces its spores.

Some fungi produce their spores inside a special cell called an ascus. These fungi are known as ascomycetes. Most lichen fungi are ascomycetes.

Other fungi produce their spores on the ends of special cells called basidia. These fungi are called basidiomycetes. Most of the larger fungi we see in the bush are basidiomycetes.

Gills = Agaric



The fruiting bodies of mushrooms also come in many different sizes, shapes and colours.

Again, to help identify the different species, mycologists have grouped some fungi by the kinds of structures their fruiting bodies produce their spores on.

Fungi with gills are called agarics.

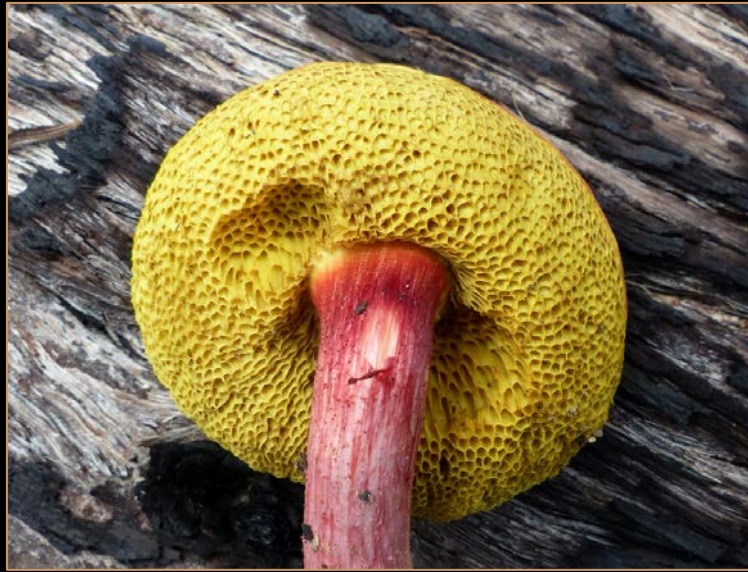
Folds = Chanterelles



Fungi with folds are called chanterelles.

The folds might look a bit like gills, but they are much thicker and more uneven.

Soft tubes and pores = Bolete



Fungi with soft tubes and pores are called boletes.

Tough tubes and pores = Polypore



Fungi with very tough tubes and pores are called polypores.

Pegs and spines = Toothed



Those with pegs or spines on them are called toothed.

Smooth = Leather



And tough, leathery fungi with smooth reproductive surfaces are called leathers.

Gelatinous = Jelly



Jelly fungi also have a smooth reproductive surface, but they are easily identifiable by their soft texture and gelatinous appearance.

Cups



Discs



Pins



These fungi also have smooth reproductive surfaces, but instead of noting their texture, mycologists group them by their shape.

Clubs, Corals and Icicles



© Ian Bell

Clubs are simple upright spikes, while corals have a few or many branches.

Icicles look like tiny icicles, hanging from their substrate.

Cup and Eggs = Birds Nest



Birds nest fungi look like tiny cups with eggs in them.

The fungus's spores are inside the eggs which are flicked out of the cups when they're splashed by raindrops.

Round and full of spores



Puffball



Earthball



Earthstar

Puffballs and earthstars also use raindrops to spread their spores.

The round balls act like tiny bellows when raindrops hit them, puffing out their spores.

Earthballs crumble away, exposing their mass of spores to the open air.

Weird and Wonderful Stinkhorns



© Images: Top right – Michael Jefferies, remainder John Van de Geyn

Stinkhorns have been grouped together because they all, well, stink.

Stinkhorns produce their spores in a smelly slime that attracts insects. The slime sticks to the insect and is carried away to a new location, sort of how flowers use insects to spread their pollen.

As you can see, their fruiting bodies can have some very strange shapes.

Underground = Truffle-like Fungi



A lot of fungi that fruit underground also use insects and other larger animals to spread their spores.

True truffles are the edible species from Europe that are highly prized delicacies. Other underground fruiting fungi are called “truffle-like” to distinguish between them.

Australia is very rich in truffle-like fungi.

Brackets



Polypore



Gilled



Leather



Toothed jelly

Brackets look a bit like shelves.

They can be quite large or small and they may be only a single shelf or many of rows of shelves growing in tiers along the substrate – usually on tree trunks and logs.

Brackets can be agarics, polypores, leathers and even toothed jellies!

Crusts



Crusts are fungi with flat fruiting bodies that lie close to the surface of their substrate. They are also called paint or patch fungi.

These fungi are usually leathers or polypores.

Another Humongous Fungus



A polypore that is also a crust.

Dr. Bao-Kai Cui
CC BY-SA 3.0
https://en.wikipedia.org/wiki/Phellinus_ellipsoideus

By the way, the largest single fruiting body in the world is a crust. It's also a polypore and a decomposer species.

It's located on Hainan Island, China.

When it was found in 2010, it was over 10 metres long and its estimated weight was between 400 and 500 kilograms. It was thought to be about 20 years old at the time.

What's this?



So, now knowing what you know, what is this?

Yes, it is an agaric, but it's also a lichen.

See this fuzzy green stuff here? That's the lichen's thallus.

The fungus component of the lichen is an agaric, which is quite unusual for lichens.



The fungal component of most lichens are different types of cup fungi.

Their cup-shaped reproductive structures are called apothecia.

Sometimes, the cup-shape is bulged outwards to form blobs.

The fungus's spores are released from the apothecia and dispersed into the air.

Should the spore land and germinate near a free-living alga or some other mycobiont, its mycelium will grow around it and start a new lichen.

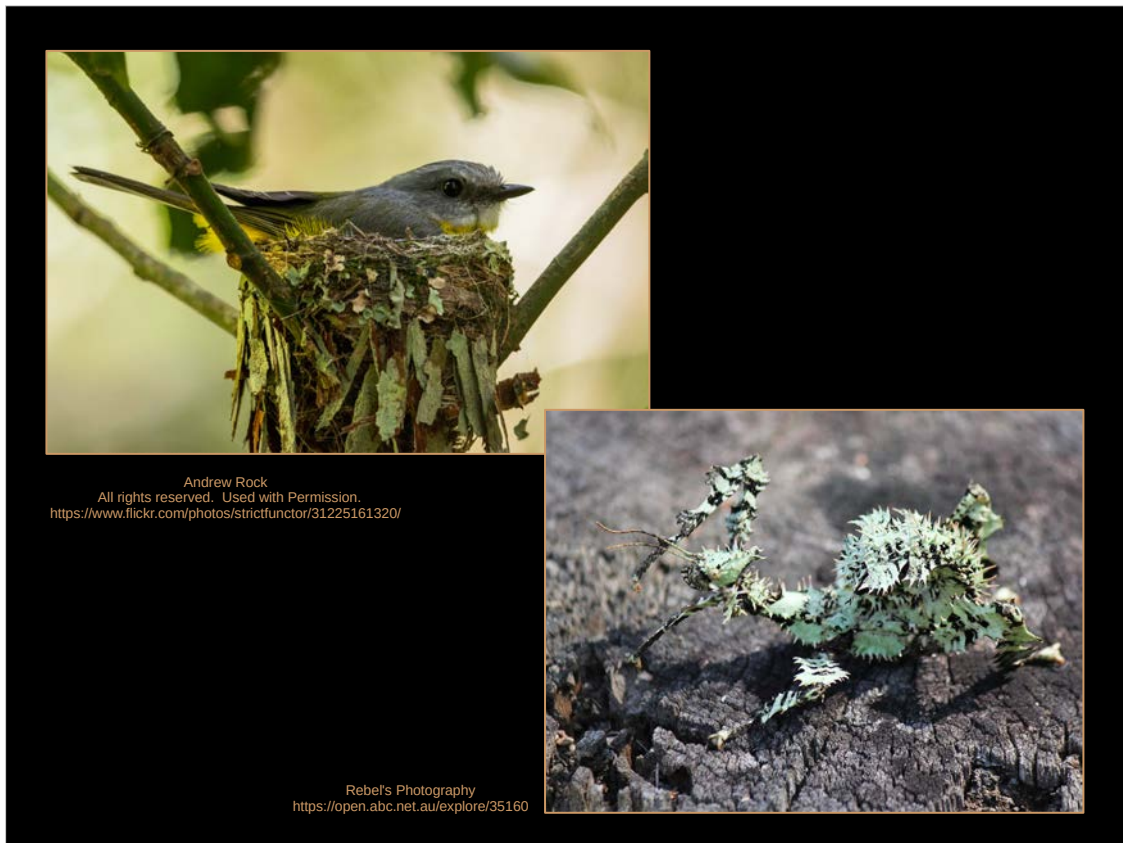
If it doesn't find a partner, the fungus will eventually die.



Many lichens also reproduce from fragments that break off their thallus.

Each piece contains both the fungus and mycobiont and can grow into a new lichen.

Some lichens grow special structures that break off easily, just for this purpose.



Some birds break off bits of lichen to camouflage their nests.

On the topic of camouflage, some creatures have lived among lichens for so long that they've evolved to look like them so they can hide better.

How old?



Lichen on a rocky ridge of the Pennine Alps, Switzerland.

Lichens grow very slowly. Some species grow less than a millimetre per year.

By measuring rates of growth, lichenologists have been able to estimate the ages of some lichens living high in the European Alps to be over 10,000 years old.

Considering the fact that these lichens might not grow at all some years due to the harsh conditions, they might be quite a lot older. Some estimates have been as much as 50,000 years.

Fungi get sick, too.



A fungus parasitizing another fungus.



Rosecomb gill, a disease caused by environmental pollution.

Fungi and lichen, just like plants and animals, are susceptible to a large range of diseases.

Mycoviruses make an infected fungus grow more slowly, be malformed, fruit less, produce fewer spores and those spores have less a chance of germinating.

Bacteria can also infect fungi and are responsible for deformities and rot.

There are also fungi which infect other fungi. Some of these fungi start out as parasites that don't harm their host, but in a later stage of the relationship, they turn nasty and become mycopathogens.

Finally, an unhealthy environment can cause diseases. Rosecomb gill is a deformity that can be caused by diesel fumes.

Fungi in Defence



Lichen warfare



Death cap

Remember this photo where the lichens are fighting for their territory?

When you think about it, fungi and lichen are very vulnerable. They can't run away from danger. The only thing they can do is stand and fight. They use chemicals to get their food, so it's only a natural step for them to use a chemical arsenal to protect themselves against pathogens and parasites.

Several of these chemical compounds are even toxic to plants and large animals. They are called mycotoxins.

I've already mentioned the death cap. It's deadly to humans and is responsible for the majority of fatal mushroom poisonings worldwide. However, other creatures, such as slugs and many insects and their larvae, find them quite harmless.



Some fungi produce chemicals that do other things, like glow in the dark.

We don't know why they do this. It might be to attract grazing animals such as insects to help spread their spores. Or it might be to scare fungi-eating creatures away. Or it might simply just be a beautiful side-effect of the chemical processes these fungi use to feed on wood.

What we do know is that over 75 species have this ability, all are white rotters and all but one are mushroom forming agarics.

The light is greenish in colour and may be produced in the cap or the mycelium. It only occurs in living cells and it is continuous – so they still glow in the daytime, we just can't see it.

Bioluminescent fungi live in temperate to tropical parts of the world. We are lucky that we have a couple of different species here in Southeast Queensland.

Death



Craig Strachan
CC BY-NC-SA 4.0
<https://www.notesfromthecape.com/2011/07/dripping-mushroom.html>

Like all living things, fungi and lichen also die.

Cause of death may be malnutrition or starvation, dehydration, disease, poisoning, predation, terminal injury and simply old age.

We don't know how long most fungi live for.

The lifespans of fruiting bodies are most likely to be much shorter than those of the organism that produced them. Remember, they are like the apples on a tree, not the tree itself.

A fruiting body being eaten can be a good thing for the fungus. Its spores will most likely distributed away from the fungus, possibly with a generous dose of fertiliser.



John Gould
Public Domain
<https://en.wikipedia.org/wiki/Potoroo>



Bjørn Christian Tørrissen
CC BY-SA 3.0
<https://en.wikipedia.org/wiki/Cassowary>



Many different kinds of creatures eat fungi and lichen. These include mammals, birds, reptiles, fish, insects, slugs and snails, bacteria and, as I mentioned earlier, even other fungi.

Some are occasional mycophages, while others are specialists.

Reindeer are well known for surviving on lichen during the harsh northern hemisphere winters. They also like to eat mushrooms in late summer.

In Australia, about 90% of a potoroo and bettong's diet is truffle-like fungi. Fungi are also an important part of the diet of cassowaries.

And of course, many smaller creatures eat fungi too. How many times have you turned over a wild mushroom to find it riddled with all sorts slugs, grubs and bugs?



Leaf cutter ants

Bandwagonman
CC BY-SA 3.0
https://en.wikipedia.org/wiki/Leafcutter_ant

Some insects such as beetles, termites and ants have learned to farm fungi.

Over 200 species of ants farm fungi and the most well-known would be the leaf cutter ants of South America.

These ants carefully cultivate fungi in their underground colony. They feed the fungi with freshly cut plant material, remove any waste and try to keep it free of dangers such as pests and infection.

These ants and the fungi they farm are totally dependent upon each other. It is a very old relationship thought to go back as far as 45 million years or more.



Marsh periwinkle

Mary Hollinger
CC BY 2.0
https://en.wikipedia.org/wiki/Littoraria_irrorata

Did you know that a snail also farms fungi?

The snail lives in the marshes of southeast of the USA where it deliberately damages grass blades to encourage fungal growth. It even deposits faeces in the wound to feed the fungus.

Experiments have shown that snails raised on uninfected leaves don't grow and are more likely to die. So the snails have become dependent on the fungus.

Why do we need them?

So why do we need fungi and lichen?

Again, we have a simple answer.

We need them because plants and animals need them.

Plants need Fungi and Lichen



- Lichen make soil.
- Fungi prevent erosion.
- Fungi recycle nutrients.
- Lichen make nitrogen accessible.
- Symbiotic partnerships.
- Parasitic relationship.

Plants need fungi and lichen because:

Lichen break down rocks to make soil.

Fungi bind the soil together and prevent erosion.

Fungi decompose organic matter so nutrients are released back into the soil.

Lichen fix nitrogen from the atmosphere and release it into the soil.

Some plants have a partnership with fungi from which they mutually benefit.

Some plants use fungi as their sole source of nutrients.

Animals need Fungi and Lichen



- Animals eat plants, plants need fungi.
- Fungi release nutrients for consumption.
- Fungi and lichen are food.
- Fungi make homes for them.
- Fungi and lichen are their homes.

Animals need fungi and lichen because:

The plants they eat need fungi.

The animals they eat eat plants that need fungi.

Fungi release nutrients for consumption, either into the soil or into their guts.

They eat fungi and lichen.

Fungi make homes for them – such as holes in trees.

Fungi and lichen are their homes.

We need Fungi and Lichen



6,000 year old rock art
Selva Pascuala, Spain

© Juan Francisco Ruiz López
<http://www.ancient-origins.net/history-ancient-traditions/tripping-through-time-fascinating-history-magic-mushroom-007474>

For a very long time, we humans would have needed fungi and lichen for the much the same reasons as other animals. We then began to use them for other things.

Some time in the distant past, we began to use them for heightened recreational or religious experiences, for medicines to make us feel better and dyes to make our possessions look nicer.

About 10,000 years ago, we discovered how to use yeast to bake bread and make beer and other fermented drinks. A little later came cheese, wine and wine vinegar.

A 5,300 year old frozen body found in the Alps, dubbed Ötzi the Iceman, had some fungi with him when he died. Two pieces of medicinal polypore were tied to one of his wrists and his fire-starting kit contained another polypore that's used as tinder.



Ancient Roman floor mosaic

Mark Cartwright
CC BY-NC-SA 3.0
<https://www.ancient.eu/image/4463/>

By Roman times, bread, cheese and wine making were well developed industries.

The Ancient Romans also loved eating mushrooms. They possibly knew how to cultivate them and we do know there was a big trade in truffles from Africa.

For the Romans, wine wasn't just a pleasant beverage. It was also the base ingredient for many medicines.

The Romans also applied mouldy bread to wounds to fight infection and poisonous mushrooms were used more than once for political gain.

Fungi



- Enhance our foods and drinks.
- Improve our health.
- Improve our hygiene.
- Improve our crop yields.
- Clean up the planet.
- Future fuel sources.
- The building blocks of our future.

We still use fungi and lichen for food and medicines, but since we've learned how to extract specific chemicals from them, our uses have become a lot more sophisticated.

Over 100 fungal enzymes are used commercially. We use them to make flavourings and preservatives for our food. We use them to make vitamins to boost our health, antibiotics to control infections, statins to lower cholesterol, and other drugs to prevent organ transplant rejection and to fight cancer. They are also ingredients in our toothpaste, cosmetics, laundry detergents and bleaches.

We are finding ways to use parasitic fungi to control weeds, plant diseases and insect pests. Special strains of mycorrhizal and endophytic fungi are being developed to help make our crops be more robust.

Some decomposer fungi can degrade pesticides, solvents, dyes and even explosives. White rot fungi are very good at removing toxic organic compounds such oils from the soil. They also have a huge potential in turning our agricultural wastes into biofuel.

Research is being done as to how we can use mycelium as building materials, packaging and clothing.

Lichen



- Dyes.
- Scents.
- Archaeology and geology.
- Biological sensors.
- Many future possibilities.

Lichens still provide us with dyes for wool and fabric but also for making litmus paper.

They provide us with scents for perfumes and deodorants.

Some are helping archaeologists and geologists date ancient stone surfaces.

And others are being used as biological sensors that give us information about the environment.

In the future, lichens may also provide us with preservatives, antibiotics, and sunscreens.

As more research goes into fungi and lichen, we are finding more things we can do with them.

And every day new species are being found with potentials yet undreamed of.

How can we look after them?

I don't need to tell you that species all over the world are becoming extinct because of the pressures we humans are putting on them. Sadly, that also includes fungi and lichen.

Protecting the Great Barrier Reef, saving the whales or a rare and beautiful orchid are all equally noble causes and generally accepted, but mentioning that you also want to save the mushrooms tends to raise a few eyebrows.

But as we have just seen, fungi and lichen are just as important and in their own ways just as vulnerable.

Fungi and Lichen need:



- Clean air
- Clean water
- Good food
- Interaction with others
- A safe home

So what can we do? If you think about it, most of it is just common sense. Like us, fungi and lichen need clean air and water, good food, good friends and a safe place to live in.

We need to protect them from the overuse of fertilisers and fungicides, not only in agriculture and forestry, but in our own gardens as well.

We need to think about how much we dig the earth over in our farms and gardens.

We need to protect the plants and animals that interact with them and are a part of their lives.

And we need to conserve where they live – the forests and wild places. Microhabitats are also very important to preserve, such as a patch of leaf litter in your garden or a fallen tree in a park.

And then there's the big one, climate change. That just affects everything.



Finally, we need to learn more about fungi and lichen.

Not only about all those undiscovered species, but the ordinary common species as well. So much of what they are and what they do is so poorly understood.

All around the world there are organisations, large and small, professional and non-professional, all dedicated to mycology and lichenology.

These are just a few of them.

Fungi and Lichen



So what can you do?

The next time you come across a fungus or a lichen, stop a moment to look at them. Think about what I've said. If you are with someone, point it out to them and talk about it.

Spread the word.

Fungi and lichen truly are amazing things and we really can't live without them.

Thank you.