What are Fungi?

Fungi are NOT plants and NOT animals, but a completely different Kingdom

We are all familiar with mushrooms, toadstools, brackets etc. but these are just the fruit bodies, equivalent to the flowers of flowering plants. Fruit bodies are just the 'tip of the iceberg'. The main body of the fungus - the mycelium – is made of long thin interconnected 'threads', hidden in the things upon which they feed. A few fungi live as individual cells – yeasts. Fungi are not like plants that contain chlorophyll, and can use carbon dioxide from the air to make food. They have to feed on plant, animal and microbe cells, tissues and bodies. Many fungi feed on dead cells but some feed in association with living cells and some fungi kill other organisms for food. All fungi feed by secreting enzymes that break down big molecules into small ones, e.g. sugars, that can be absorbed into their bodies.

Natural garbage disposal agents

When plants and animals die their dead tissues must be broken down to release the nutrients locked up in them, otherwise ecosystems would run out of nutrients, and plants would be unable to grow. Fungi that feed on dead tissues are the 'garbage disposal agents of the natural world' – they are the world's best recyclers. They form humus and improve soil quality. In our gardens they are one of the main operatives within our compost heaps.

85% of plant species depend on fungi

Fungi have been intimately involved with the evolution and spread of land plants since they first appeared in the fossil record. They form intimate relationships with their roots (called mycorrhizas), spreading far out from the plants and securing vital nutrients and additional water that the plants need to grow. Mycorrhizas are essential to plant health in the natural environment, and indeed it is believed that it was this relationship that allowed plants to colonize land 450 or so million years ago. A surprising 18-20% of the sugars made by plants through photosynthesis can be passed to the fungus to help it grow. They also form underground networks linking different plant species, and can transfer nutrients between them. Without mycorrhizas life on this planet would not be as we know it today. The extent of fungal material in soil is enormous and difficult to estimate, but it has been claimed that there is about 2.2 tonnes of fungi in soil for every person on Earth. The surface area of soil fungi has been estimated as 2-9 times that of Earth, and a single square metre of soil has been calculated as containing 16,000 km of fungal threads.

Lichens – born survivors of extreme environments

In the same way that mycorrhizas are fungi joined intimately with the roots of vascular plants, intimate mixtures of fungi with green algae or cyanobacterial cells form whole new species - **Lichens**. The fungus partner again supplies water and mineral nutrients and the other partner provides sugars. This relationship enables Lichens to withstand extreme environmental conditions, e.g. very hot, cold and dry environments, which the individual partners could not cope with.

Humans depend on fungi for food and wonder drugs

Fungi are used in food production. Yeasts are used to ferment beer and wine and used as a raising agent in bread. Fungi are used commercially to produce enzymes used in food products, chimosin to make cheese and pectinases to increase juice production and 'peel' fruit, acidity regulators and antioxidants in soft drinks, and when making chocolate to remove the bitterness from cocoa beans. Lots of antibiotics, e.g. penicillin, are made by fungi; this is one of the moulds you see on old bread. Not everyone appreciates the extent to which the pharmaceutical industry relies on fungi, the following uses are just some examples: Statins, to control cholesterol; cyclosporin, used to prevent transplant tissue rejection. Fungi are used in the conversion of plant sterols to produce contraceptives and anti-inflammatories.

Fungi are also used in the production of the enzymes in biological washing powders and for making 'stone-washed' jeans!

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Biocontrol in our gardens

A few, and it is only a relatively few, fungi feed as pathogens or parasites on living plants. Honey fungus (*Armillaria mellea*) attacks forest and garden trees and shrubs. Dutch elm disease, caused by *Ophiostoma novo-ulmi*, has destroyed our mature elms reducing it to a hedgerow species. *Phytophthora infestans* – potato blight – caused the Irish potato famine in the mid 1800s reducing the population of Ireland by about 20-25%. On a smaller scale, *Taphrina* species cause leaf curl of fruit trees, powdery mildews cause losses of a wide range of plants, including grapes, wheat, onions, cucurbits. Rusts and smuts affect cash crops. However since some fungi are aggressive to others, these can be used as biological control agents of some plant pathogens.

Invertebrates fall prey to fungal infections, for example pea aphids are killed by *Erynia neoaphidis*, but this can be turned to our advantage. Formulations of some of these pathogenic fungi are now available commercially to control weeds and insect pests, these formulations are more environmentally friendly than using chemical pesticides. A few fungi can cause nasty disease in humans, but thankfully this is very rare in Britain.

Fungi and climate change

Fungi play a major role in global chemical cycles. They lock up perhaps 5 gigatonnes (i.e. 5 000 000 000 000 kg) of carbon in their tissues, but more importantly are involved in liberating around 8 gigatonnes of carbon into the atmosphere through the decomposition of wood and other plant materials. This compares with 6.6 gigatonnes released through human activities each year. If this balance between locked up and released carbon changes, then it could have further consequences for climate change.

Fungi are responding dramatically to Britain's changing climate. In autumn the first fruit bodies are now seen much earlier and the last fruit bodies are seen much later. The alteration in fungal fruiting mirrors increases in late summer temperatures and increases in autumn rainfall that have occurred since 1975. Many fungi, especially those that grow on dead plant material, now also fruit in spring. This means that fungi are now active for much longer, which will affect recycling and carbon dioxide release in natural ecosystems. Fungi that form mycorrhizas with deciduous trees have responded differently to those that form mycorrhizas with conifers, and this is probably because the plants are responding differently.

Climate change and chytridiomycosis

Amphibians across the globe are dying from a new and rapidly-emerging infectious disease, chytridiomycosis. The disease is being caused by a species of waterborne fungus called a 'chytrid' - and the chytrid is being spread around the world by human means, principally the global trade in amphibians. So why is climate change important in a fungal-disease of amphibians? The ability of the chytrid (*Batrachochytrium dendrobatidis*) to infect and cause disease in an amphibian is dependent on temperature and moisture availability. Therefore, as climates change, the 'environmental envelope' that is associated with the ability of the chytrid to cause disease changes too. It now seems likely that amphibian species that were previously not at risk from the fungus are becoming infected and dying as the climate of their habitats changes. Here, climate change is driving amphibian extinctions by exacerbating the effects of this new, and devastating, disease.

Climate change, fungi and food security

Fungi, as we all know, cause a range of plant-diseases. We also know that many disease-causing fungi thrive in warm and wet conditions. Therefore, it is not surprising to find that as climates are predicted to change, the distribution and amount of plant-fungal disease is expected to increase. Within the UK, as summers become warmer and wetter, then the amount, and timing, of fungal diseases will change. Food-security of the UK needs to take into account future patterns of plant-disease if we are to continue to grow plants in the manner that we have previously been accustomed. The geographical range of many pathogens is limited by effects of climate on over-wintering of the fungal pathogen. For example, warmer winter temperatures increases survival of the rust fungus, *Puccinia graminis*, increasing the disease on grasses. Likewise the arrival of new insects that can carry pathogen spores, and changes in the survival of these vectors over winter, will affect pathogenesis of plants. The geographic range of *Phytophthora cinnamomi* in Europe is expanding in response to increased temperatures allowing the fungus to overwinter further north and at higher altitudes. This fungus causes root rot and die back of forest trees, fruit trees and a wide range of ornamental plants.