What's your favourite fungus?

The One We Slice On Salads

Mushrooms are cultivated all around the world for human consumption. Global production is about 8 million metric tonnes per year, so mushrooms are big business!

The button mushroom (scientific name *Agaricus*) is the most extensively cultivated mushroom in the world accounting for about 30% of the total crop. For large scale production it is grown on composted straw and animal manure indoors where the temperature, humidity and carbon dioxide levels are tightly controlled. This allows large quantities of the mushrooms to be grown all year round. It is widely grown in Europe, America, China and Australasia.

The mushroom is the fruit body, which is formed from the mycelium. The mycelium is made up of long, thin whitish threads that grow buried in the compost. The beginning of a mushroom is called a pinhead; it is round and has a smooth surface. The mushroom then grows out of the compost and continues to mature above the surface where it can be harvested.

Mushrooms are incredibly good for you as they contain a high amount of protein and vitamins, have no cholesterol and few calories. Mushrooms can be included in your diet very easily because they can be added to salads, pies, omelettes, soups and pizzas.

As mushrooms have become increasingly popular, demand for more exotic species has meant that there is a good choice of different types in supermarkets and greengrocers. Other species available in most supermarkets include the Oyster mushroom (*Pleurotus*) and the Shiitake mushroom (*Lentinula*). You may also find the Paddy straw mushroom (*Volvariella*) and a whole range of others.

One you will not find in many English supermarkets is the Lingzhi mushroom (scientific name *Ganoderma*), which is unique in being cultivated for its medicinal value. In China it is used as an ingredient of medicines and is thought to be able to help treat a wide range of clinical conditions including bronchitis, heart disease and cancer.

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What's your favourite fungus?

The One That Makes Plant Roots Work

Plants gain their nutrients by absorbing minerals and water from the soil using their roots. But they do get quite a lot of help from certain species of fungi. The relationship appears to have started because the plant roots alone are not able to supply the plant with all the nutrients it needs. The fungi associated with plant roots are called **MYCORRHIZAS**, which increase nutrient availability to the plant. The numerous hyphae of the fungi greatly increase the surface area available for absorbing minerals. The hyphae can also go looking for food; because they can grow to areas of fresh nutrients when local supplies become depleted. The relationship between the plant and fungus is mutualistic. That means that both sides gain something from having the other present. The plant pays for the privilege of using this fungus to bring it nutrients by sharing up to twenty-five percent of the products of its own photosynthesis with the fungus. The fungus benefits by taking readily available sugars from the plant. Despite this 'tax' on its activities, the plant grows much better than it could without the mycorrhiza.

Some mycorrhizal fungi form a mat of fungal tissue around the root; the fungal cells grow between the cells of the plant root, but never actually cross the plant cell walls. These are called '**ECTOMYCORRHIZAS**'. In another mycorrhizal partnership (called **ENDOMYCORRHIZAS**) the fungal cells enter the plants cells. Inside the plant cells they make structures that absorb materials from the plant cytoplasm.

By greatly increasing the absorbing surface of a host plant's root system, mycorrhizas improve the plant's ability to tolerate drought and other extremes, like high and low temperatures and acidity.

It is thought that has many as 95% of all plants have mycorrhizal associations, showing just how important these types of fungi are for the growth of so many plants, including all the crop plants we need to feed the human population, and all the trees in all the forests.

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What's your favourite fungus?

The One That Digests Grass for Cows

Many animals including cows, sheep, goats, deer, and even giraffes, are known as ruminants. This is because they have a specialised four-chambered stomach needed for the digestion of their exclusively vegetarian diet. The first chamber the food enters is called the rumen, hence the name ruminant. The ruminant discussed here is the cow. Cows spend most of their time eating mainly grass and hay.

Plant cells walls contain cellulose, which is an excellent source of fibre in the diet of most animals. Fibre is important as it provides roughage which keeps the egestion of waste products regular. However cows themselves do not produce enzymes capable of digesting cellulose. The cow overcomes this problem by having special fungi in the rumen called chytrids; or more generally called rumen fungi. These fungi are anaerobic, meaning they are able to survive without oxygen. Even without oxygen, chytrids are able to digest plant cell walls by making specific enzymes called **cellulases**. The rumen acts like a large fermenter because the grass is stored there whilst the fungal enzymes from the chytrids break down the cellulose.

After the plant material is processed in the rumen, it is brought back up into the mouth of the cow. This material is now called 'cud' and the cow chews it up again to break it down further. When it is swallowed for the second time it passes through the next three chambers of the stomach. The chytrids are thought to pass from one animal to the next by being transferred in saliva, but they also occur in large number in cow dung. From the dung the fungi get attached onto surrounding grass. When another cow comes along and eats the grass, the fungi carry on their work in the new host.

The relationship between chytrids and ruminants is said to be symbiotic. This means that both the fungi and the cow benefit from having the other present. In this case the cow benefits because plant material the animal can't degrade is digested and turned into nutrients the cow can absorb. In return, the fungi live off some of the nutrients obtained from the cow's food, and live out their lives in the cow's rumen.

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What's your favourite fungus?

The One That Keeps Grandad Alive

Cholesterol is a type of fat that comes from animal products such as red meat and eggs. But humans can also make cholesterol – in addition to that obtained from the diet, the liver is also able to produce cholesterol. There are two forms of cholesterol. Cholesterol is needed for cell membranes and for the production of steroid hormones, but if we have too much it is stored in our blood vessels. Low density lipoprotein or LDL is the dangerous type; and high density lipoprotein (HDL) is the good type.

If we have too much cholesterol the body is not able to use up the excess. In such circumstances the excess cholesterol sticks to the inside walls of blood vessels. This build up makes the diameter of the blood vessels narrower and this restricts blood flow. If blood vessels that supply blood to the heart become clogged up like this it can cause a heart attack, because the heart muscle does not receive enough oxygen to function properly. This can lead to the death of a small section of the heart muscle, but in severe cases the heart attack can cause the person to die. So to control heart disease it is important that humans regulate their cholesterol level.

The most effective cholesterol lowering-agents are called Statins, and these are produced by fungi. The two fungi used to produce statins are called *Aspergillus terreus* and *Penicillium citrinum.*

Statins work by inhibiting the enzyme called 'HMG-CoA reductase' which is needed for the production of cholesterol. Statins block HMG-CoA reductase activity as they compete for the active site of the enzyme. If the activity of this enzyme is blocked the production of cholesterol is slowed down, and this in turn will significantly decrease the patient's cholesterol level. Statins also increase LDL-receptor production in the liver, which help clear the bad cholesterol from the blood stream.

Statins from fungi are of great importance as many people rely on them daily to help keep their cholesterol level normal, therefore reducing the risk of blocked blood vessels. There are three statin 'drugs' in the top five most widely prescribed pharmaceuticals – with annual sales in excess of £3 thousand million!

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What's your favourite fungus?

The One That Makes Your Daily Bread

Everyone knows that yeast is added to bread in order to make it 'rise', but do you know what is actually happening in this process?

Yeast is a type of fungus that is unicellular. So the organism is just a single cell that is more-or-less round in shape. It is used in baking and also in brewing beers and ales and making wine because in anaerobic conditions (that is, when there is very little or no oxygen available) yeast ferments sugar to produce alcohol, carbon dioxide and water in the process called fermentation.

Equation: Yeast + Glucose → Alcohol + Carbon dioxide + Water

Brewer's yeast (scientific name *Saccharomyces cerevisiae*) ferments sugars in cereal grains to produce alcohol, in addition to various other products that affect the flavour. Baker's yeast (which is also *Saccharomyces cerevisiae*, but a special strain that tolerates higher temperatures) ferments sugars in the flour, but this time it is the carbon dioxide that's the useful product of the fermentation.

In bread making the yeast is added to the dough mixture (ingredients of which are flour and sugar) and the mixture is left for about 2 hours before baking. This is when the yeast action can be seen. Yeast cells produce the enzymes that use the sugar to generate carbon dioxide and alcohol. The carbon dioxide forms lots of bubbles in the dough. The gas cannot escape from the dough because it gets trapped by gluten, which is a really sticky protein found in wheat flour. As the yeast cells carry on fermenting, more and more carbon dioxide is produced, making more and more bubbles and causing the dough mixture to 'rise', or increase in volume very obviously. When the baker judges that the dough has risen enough, the bread is baked. During baking the alcohol evaporates in the heat of the oven, and the bubbly structure of the dough is turned into the open, spongy, structure of bread. Clearly, yeast plays a crucial role in the production of a food that is part of most people's daily diet. There are over 200 varieties of bread!

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What's your favourite fungus?

The One That Produces Agriculture's Leading Fungicide

Fungicides are chemical substances that kill or inhibit the growth of fungi. They are applied to crops such as cereals, rice, potatoes and tomatoes. Farmers need to protect their crops from pathogenic fungi because they are harmful to the plant they infect. Fungi are not able to produce their own food like plants do; this means that the pathogenic fungus steals nutrients from the plant it lives on. Crop plants are especially susceptible to disease because the plants are grown very close together so the disease can spread from one to the next easily.

The most devastating effect caused by a fungal infection was the Irish Famine of 1845. A disease called the potato late blight caused the failure of the whole potato crop in Europe. The Irish peasants were most seriously affected because they relied heavily on potatoes as their main food source. Loss of the crop led to the deaths of one million people in Ireland due to starvation. Another two million were forced to emigrate (many to North America) to escape the devastation at home. The organism that caused such great damage is called *Phytophthora infestans*, and it is still a serious disease of potatoes.

It is important that plants are protected from infections to stop such events occurring again. Fungicides can be applied to plants to give protection. The most widely used fungicides in the world today are a class of chemicals called the strobilurins, which were first discovered in 1977. Azoxystrobin is the most popular one, and is said to be a broad-spectrum fungicide. This means that it is effective against a wide range of fungal species. Strobilurin A was isolated from the pine cone fungus. It was seen that the substance was able to kill other fungal species. Today Strobilurins are produced synthetically. Strobilurins work by inhibiting mitochondrial respiration, by blocking electron transport. This means that the fungus cannot produce energy so can no longer grow and eventually dies.

Because Strobilurins are derived from a natural product, they are considered to be environmentally safe because they are rapidly degraded.

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What's your favourite fungus?

The One That Makes Cyclosporin to Combat Rejection in Transplant Patients

Transplant of livers, kidneys, hearts and lungs has been made possible by the discovery of Cyclosporin in 1976, a compound produced by the fungus *Tolypocladium inflatum*. The fungus was isolated from a soil sample and screened to test if any compounds produced by the fungus could be of medical use. The results were very positive as the compound Cyclosporin was found to have strong activity at suppressing the immune system (called immunosuppressive).

When a patient receives an organ transplant, the body recognizes the organ as a foreign object, just like it would a pathogen. Our bodies are programmed to eliminate such foreign things, because the object may be harmful to the body. This means that the body will naturally reject a transplant; and part of that rejection is that the organ is damaged so that it stops functioning. The detection and elimination of foreign bodies is carried out by the immune system, which is made up of several cell types that act to protect our bodies from potentially harmful organisms. Cells of the immunes system are equivalent to white blood cells and a particular sort, called lymphocytes, are the cells that are able to detect foreign objects. They attach themselves to pathogens identifying them as things to be destroyed by other white blood cells.

In transplant operations the donor's organ must be accepted by the recipient's body so that it can function properly and save the life of the patient. So in transplant patients the transplanted organ needs to be protected from the patient's own immune system.

This is where Cyclosporin is used. This compound helps stop the body rejecting a transplant by stopping the production of lymphocytes. If lymphocytes are not able to increase in number there is a greater chance that the transplant will not be detected by the body, and will continue to function normally. Cyclosporin has been used in transplant operations since 1983, and is currently the most effective and widely used immunosuppressive drug.

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What's your favourite fungus?

The One That Makes the Cheese

Cheese is produced as the result of milk changing from liquid to a semi-solid consistency; this change is known as coagulation. The resultant product is called a 'curd'. In order to cause milk to become more solid, special enzymes are used to coagulate the proteins in the milk.

Traditional cheese making used enzymes from animals. These enzymes called chymosin or rennet are obtained from the stomach membranes of ruminants such as cows. As the cheese industry expanded, people started looking for enzymes from other sources. Today around 80% of cheese-making uses coagulation enzymes from fungi, not animals. Two widely used fungi are the moulds *Aspergillus* and *Mucor.* The enzymes from the fungi make the proteins stick together into milk curds, which are then treated further to produce the final cheese.

Mould ripening is something different. This is a method that is used to add flavour to cheese, and has been in use for at least 2,000 years. As the name suggests fungi are also involved in this process. Blue cheeses such as Roquefort, Gorgonzola, Stilton, Danish Blue and Blue Cheshire, all get their strong flavour and odour from *Penicillium roquefortii*. The fungus is added to the cheese, which is then placed in storage at a controlled temperature and humidity. Adding the fungus to the cheese is usually done by coating metal rods or wires with fungal spores and sticking them into the immature cheese (you can often see the holes and the tracks of the wires through the cheese when you buy it). The fungus then grows through the cheese producing flavour and odour compounds.

Fungi are also used to change the texture of cheese. This is what happens in the case of Camembert and Brie cheeses. The two cheeses are ripened by the mould *Penicillium camembertii,* which is cultivated on the outside of the newly made solid cheese. As the fungus grows it releases enzymes into the cheese that digest the cheese proteins to make a softer (eventually creamy) consistency.

In the days before refrigeration the only way to store milk for any length of time was to make it into cheese; which is why cheese making is a traditional industry all over the world.

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What's your favourite fungus?

The One That's Used in Fizzy Drinks

Fizzy soft drinks contain many chemicals. One of these is citric acid - a weak acid that is naturally found in citrus fruits such as oranges, lemons and limes. It is added to soft drinks to give a slightly sour taste, to stabilise the 'fizz' and also to serve as a preservative. The process of carbonation puts the 'fizz' in drinks. This is achieved by dissolving carbon dioxide in water to produce carbonic acid. The addition of citric acid creates a buffer that stabilizes the carbonic acid, so that the fizz remains in the drink after the bottle is opened.

Initially, citric acid was obtained from lemons, but since 1923 all commercial citric acid (600,000 tons every year) has been obtained from fermentation by *Aspergillus niger*, a filamentous fungus. Citric acid is the first product to be made from a cycle of conversions known as the citric acid, or Krebs cycle. This cycle occurs in the mitochondria of all living cells that use oxygen for respiration. The cycle is important, as it is part of the metabolic pathway that breaks down carbohydrates, fats and proteins into carbon dioxide and water to generate energy for the cell.

Aspergillus niger accumulates large amounts of citric acid. This is achieved by reducing the level of iron in the growth medium because the enzymes that convert citric acid into the next product of the cycle need iron. Keeping the iron content low stops the Krebs cycle before the citric acid can be converted, so the acid can be harvested and used commercially.

Large quantities of *Aspergillus niger* are grown on a medium containing sugar as its carbon source. The fungus grows at the surface of the medium and the citric acid product is released into the liquid below. The mould is then filtered out and the remaining citric acid collected. When citric acid is added to a solution it forms citrate ions. Citrates are excellent buffers for keeping the pH of acids steady. In the case of soft drinks, the citrate ions ensure that the carbonic acid remains stable, keeping the 'fizz' in your drink.

What's your favourite fungus?

The One That Veggies Like To Eat

In the 1960s there was concern over the future supply of protein from the traditional sources of cattle, pigs, poultry and fish. It was thought that the supply of these foods would not be able to match the world demand, and protein would have to be obtained from a new source. Projects were started to produce protein from microorganisms.

In 1964 it was decided to try to produce protein from filamentous fungi. Ideally, the fungus used should have good nutritional value, be easy to cultivate and inexpensive to produce. Three thousand species of fungi were collected and tested to see if they were suitable, the one finally chosen was called *Fusarium venenatum*.

This fungus is grown continuaously in a large fermenter at the optimum temperature of 30°C. Constant production and collection of the fungal biomass occurs. The product is then heated to 64°C so that the RNA is destroyed to make it safe for people to eat.

It's then filtered to remove the liquid medium, leaving behind what looks much like a sheet of raw pastry, which is then flavoured and shaped ready to be transported to the shops. This product is called 'Quorn' and has been on sale since 1980. It is available in a wide range of forms, such as burgers, sausages, mince and chunks. Quorn has been very successful, with annual sales of more than £15 million per year, and is popular with vegetarians who can obtain many nutrients from it that others get from eating meat.

Apart from the high protein content it is low in calories and saturated fats, contains no cholesterol and is rich in zinc, B-vitamins, and fibre. It is ideal for people who are watching their diet but who still want to enjoy the taste and texture of meat. This is because *Fusarium venenatum* is a filamentous fungus with a stringy consistency which is comparable to the texture of meat. The fungus also absorbs flavours well so can be altered easily during cooking to suit individual tastes.

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What's your favourite fungus?

The One That Makes Marmite

Marmite is made from brewer's yeast (scientific name *Saccharomyces cerevisiae*); which, after the beer has been made, is a major waste product of the brewing industry. The brewer's yeast is composed of lots of small fungal cells. In the nineteenth century, a German scientist called Leibig discovered that these yeast cells could be concentrated and turned into a nutritious food. To make Marmite the brewer's yeast is broken down to release soluble vitamins and amino acids. This soluble material is then concentrated and filtered, and more vitamins and flavourings are added to finally produce Marmite.

The original Marmite Company was set up in Burton-upon-Trent in 1902 and very soon after that Marmite first went on sale.

Marmite has very good nutritional value because there is a high level of vitamin B in the final product. Vitamin B helps prevent anaemia, helps regulate the liver, kidneys and nervous system and also increases energy levels. So having marmite on your toast for breakfast is a nutritious way to start the day. Bovril, too. Bovril used to be made from beef extract, but in November 2004 the manufacturers announced that the composition of Bovril was being changed from Beef extract to yeast extract. IT'S ALL GOOD FUNGUS!

LOVE IT OR HATE IT?

Either way it's good for you...

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What's your favourite fungus?

The One That Digests All the Old Timber

Ever wondered what happens to all the leaves that fall from the trees, or the branches that fall to the ground in storms, or when a tree dies? Somehow there's never a build up of all this organic matter, but what happens to it? Where does it go?

Many organisms like bacteria, insects, worms and many fungi are involved in the break down the plant material. Humus is the term used to describe material once it has been broken down; it is nutrient rich and can be used by plants for their growth.

Plant tissues are very strong. The components that provide the strength are cellulose and lignin. Fungi are very important for the decay of wood because they are the only organisms capable of breaking down **BOTH** cellulose and lignin.

Cellulose is a polymer of glucose that forms fibres which are incredibly strong. Brown rot fungi are responsible for the breakdown of cellulose. Brown rot fungi are so called because the lignin remains intact so the wood keeps its brown colour. The enzymes released by brown rot fungi break the cellulose chains into single molecules of glucose that can be re-used by the fungus.

Lignin is the other strong polymer. It is the second most abundant natural polymer on earth after cellulose. The fungi that break down lignin are called white rot fungi; this is because as the content of lignin is decreased, the wood becomes lighter in colour. White rot fungi degrade lignin by producing oxidising enzymes that are released from their hyphae – they 'burn' the wood in an enzyme-controlled way. Lignin contains phenols and the white rot fungi are the only organisms that can deal with them.

These two types of fungi have important roles in the recycling of nutrients. Without them, old plant material would not decay and the soil nutrients would be locked into an accumulating mass of undegradable biomass.

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What's your favourite fungus?

The One That's the Largest Organism on Earth

If you ask people what the world's biggest organism is, most will guess the Blue whale. They can grow up to 33 metres long and are the largest animals alive today. Whales are pretty big, but there's an even bigger organism that claims the title 'largest organism on earth'.

This living thing is estimated to be between 1900 and 8500 years old, it spans an area of 2,200 acres (that's about the same as 1,220 football pitches) and weighs at least 150 metric tons. This makes it among the heaviest, but certainly the largest and oldest living thing on this planet. You must have guessed it by now; it's a fungus!

The common name of the fungus is the 'honey mushroom' as during Autumn it produces golden-coloured mushrooms. Its scientific name is *Armillaria ostoyae*. This gigantic fungus was found in the Blue Mountains of eastern Oregon in America, and is a pathogen of the roots of trees. Being a pathogen means that the fungus is harmful to the tree on whose roots it lives. The fungus takes water and carbohydrates from the tree and so interferes with its growth.

The tree eventually dies owing to lack of nutrients. The fungus is hidden, because it grows underground extending its hyphae from tree to tree in special structures called rhizomorphs. It cannot be tracked easily on the surface, but because the fungus slowly kills trees it has infected, it makes the leaves turn yellow as they become starved of nutrients.

By looking for trees with yellow leaves the mycologists were able to map the presence of the fungus. Because it grew over such a large area, a helicopter was used to obtain an aerial view of the forest showing all the trees that had been infected.

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What's your favourite fungus?

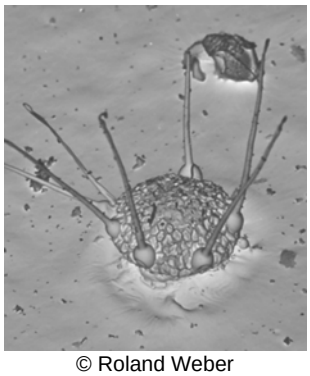
The One That Can Fly!!

A pathogenic fungus called *Phyllactinia guttata* infects trees such as hazel, birch and alder. The infection is commonly called powdery mildew because the fungus produces a large number of spores that cover the underside of leaves rather like a covering of felt.

For the fungus to be able to infect other trees the spores must be carried by the wind to other destinations. This fungus produces spores that are adapted to have an ideal shape for dispersal by wind.

The spores have two types of modifications for this. One is a set of thin, arm-like appendages that stick out from the spore. The other is a construction that produces a slime droplet that faces downwards away from the underside of the leaf. These two developments ensure that the spores will spread to infect other trees.

In autumn the arm-like appendages dry out and as they do so they bend upwards to push against the leaf, detaching the spore from the leaf surface. Once the spore is free, the arms give it a shape similar to a shuttle-cock so it can be carried by the wind with the slime droplet hanging down. The slime droplet makes sure that the spore sticks on properly when it lands on a leaf or stem of another tree, so that it can infect that tree in the following year.



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What's your favourite fungus?

The One That Produces the Highest Pressure Known in Nature

Magnaporthe grisea, commonly known as the 'rice-blast fungus', is a pathogen that causes a major disease of rice. This important disease destroys rice crops that could feed 60 million people each year, making it the most devastating agricultural disease in the world. Because this disease can be economically devastating, everything about the fungus becomes very interesting to scientists as they try to find ways to combat the pathogen. This story about the method the fungus uses to infect a rice plant comes out of this research.

When a fungal spore lands on the leaf of a rice plant it produces a tube which swells at the tip. The tip swells due to stored glycogen and lipids being converted into sugars and glycerol. The sugars produce a concentration gradient (an 'osmotic potential') that causes water to move from the rice plant into the tip of the tube. The resultant swollen tip is now called an 'appressorium'.

The appressorium has a thick wall all around it; the only opening is where it touches the leaf forming a small pore. The purpose of an appressorium is to build up enough pressure to be able to force a hyphal strand through that pore and into the leaf. It is the intake of water that does this, causing a hydrostatic pressure of up to 80 atmospheres to build up within the appressorium. The appressorium produces adhesives that firmly fix it to the leaf surface so that all the pressure is focused on the one spot where the hypha is forced into the leaf.

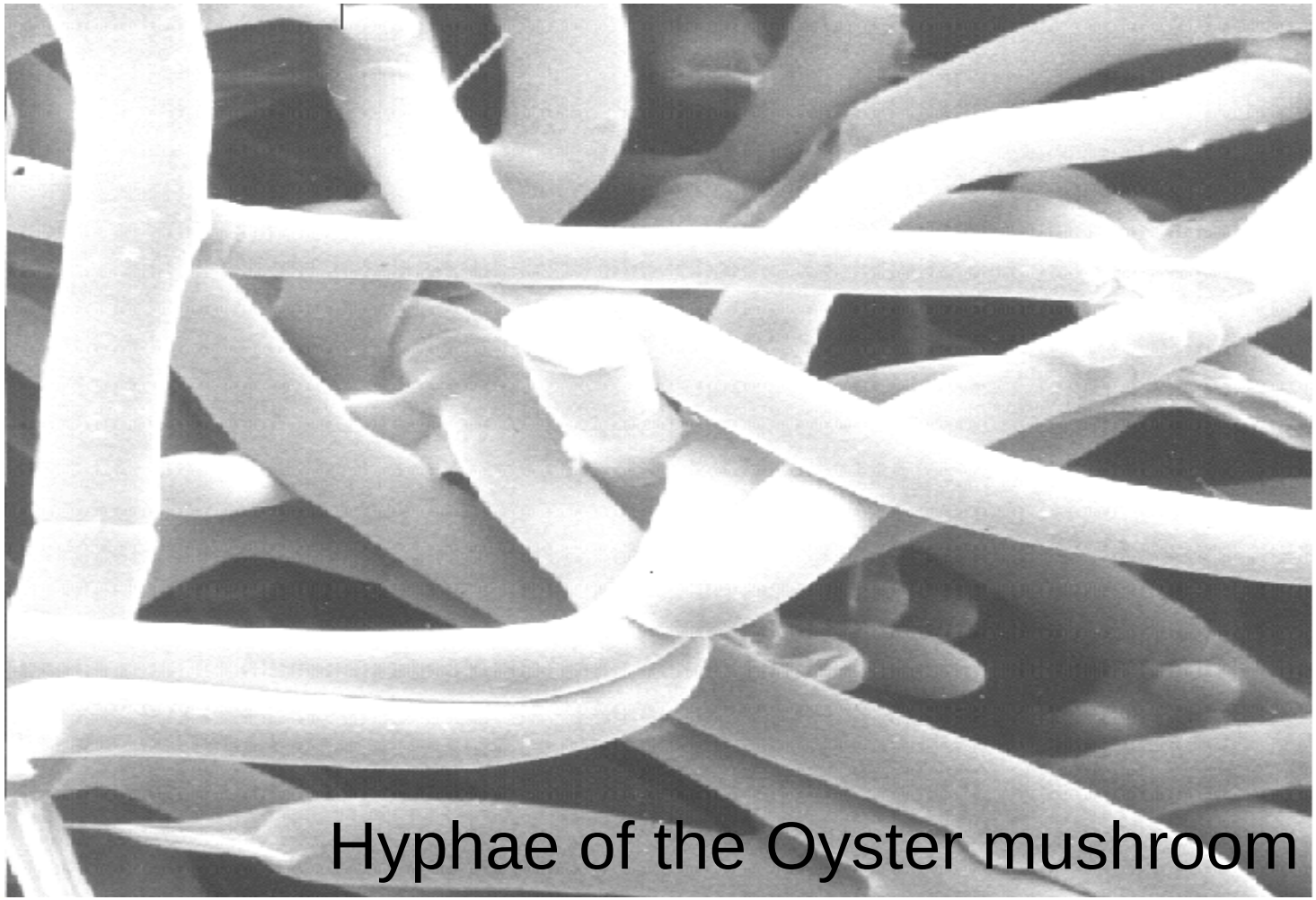
Once inside the plant the fungus grows between the plant cells and steals the plant's nutrients. The fungus eventually grows so much that the rice plant dies because it does not have enough nutrients to survive.

The enormous pressure produced by the appressorium is the highest pressure recorded in any living organism to date!

WHAT ARE FUNGI?

- Fungi are not classed as animals or plants, they have a Kingdom of their own to which they belong.
- They range from being just a single cell, like the yeasts, to others that cover hundreds of acres of land.
- Most fungi are said to be filamentous. This is because the main body of the fungus is made up of thin, thread-like filaments that are called hyphae, which form the mycelium.
- Fungi are divided into four groups depending on their characteristics
    - Chytridiomycota
    - Zygomycota
    - Ascomycota
    - Basidiomycota

WHAT ARE FUNGI?



Hyphae of the Oyster mushroom

FFI6

KINGDOM FUNGI

To date, **100,000** species of fungi have been discovered.

It is thought that there are over one million species still to be found.

The fungi that most people are familiar with are those that form **fruit bodies** or mushrooms.

Fungi can live in many habitats including the arctic, tropical rainforest, fresh and salt water. However, most fungi live in soil.

- People that study fungi are called **Mycologists.**
- Fungi are not able to produce their own food as plants do.
- Fungi are said to be **SAPROTROPHS**, because they live on dead organic matter such as leaves and wood.
- To obtain nutrients fungi secrete special **digestive enzymes** which degrade organic material outside the mycelium. The degraded compounds can then be ingested.

Reproduction

Fungi are able to reproduce both sexually and non-sexually.

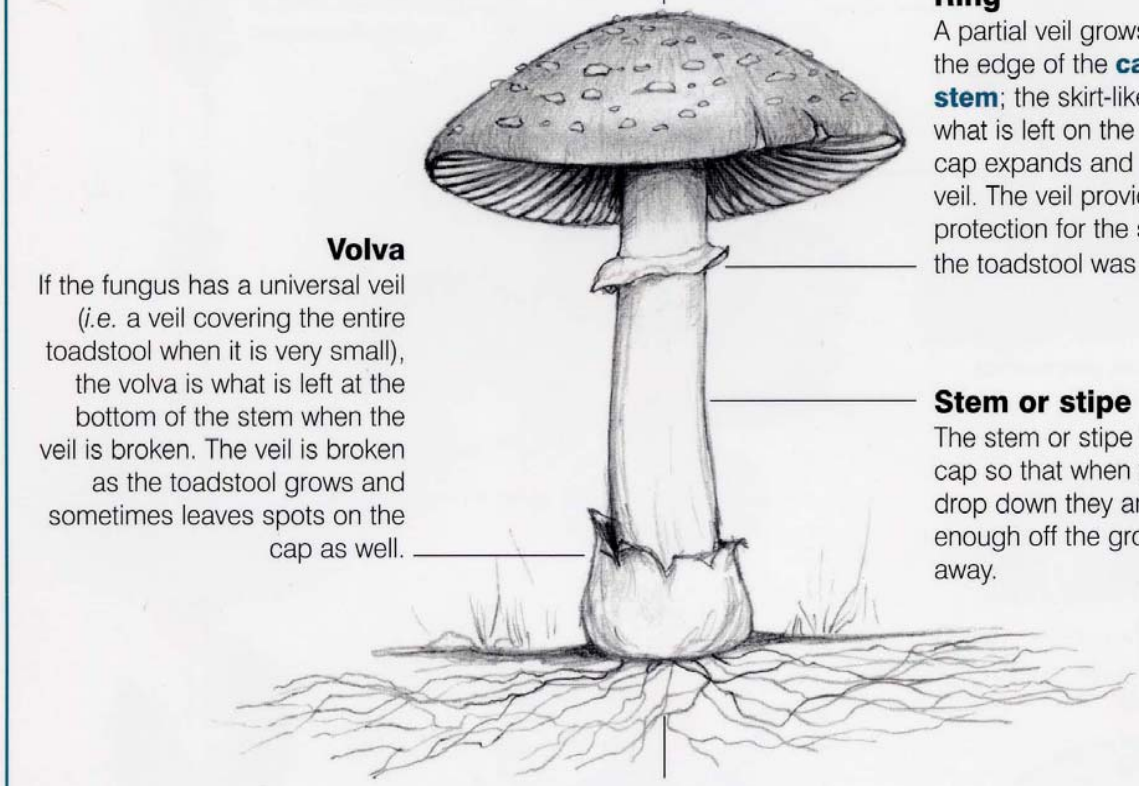
Individuals can be produced that are genetically identical to one another by the fungal cells breaking up.

Fungi are not classed as males or females. Fungi have thousands of different sexes, which are determined by genes which make up their mate type.

The products of reproduction are spores. These are small compartments which house the genetic information of the fungus.

Spores are usually dispersed from fruit bodies such as mushrooms, truffles and puffballs. Once dispersed the spore can germinate producing a new fungal colony.

Parts of a Fungus



Cap

The cap supports and protects the **gills**, **pores** or **teeth** where the spores are produced.

Ring

A partial veil grows between the edge of the **cap** and the **stem**; the skirt-like ring is what is left on the stem as the cap expands and breaks the veil. The veil provided extra protection for the spores when the toadstool was young.

Volva

If the fungus has a universal veil (*i.e.* a veil covering the entire toadstool when it is very small), the volva is what is left at the bottom of the stem when the veil is broken. The veil is broken as the toadstool grows and sometimes leaves spots on the cap as well.

Stem or stipe

The stem or stipe holds up the cap so that when the spores drop down they are high enough off the ground to drift away.

Mycelium

The mycelium is the hidden 'body' of the fungus. It finds food for the fungus and when conditions are suitable it is able to produce a toadstool.

From *The Fungi Name Trail* by Liz Holden & Kath Hamper

Fungi and Us

- Many useful products have been isolated from fungi which have been of great benefit to humans.
- Certain activities of fungi are also used to produce food and drink.
- Some examples are shown opposite.

- **Derived from fungi**
  - Antibiotics
  - Agents to lower cholesterol
  - Immune system suppressants
- **Used in the manufacture of**
  - Beer
  - Chocolate
  - Cheese
  - Bread
  - Fizzy drinks
  - Enzymes for washing powders

FFI6

Fungi and Termites

- Fungi can be useful to some sorts of insects.
- A type of termite in Africa lives on plant material. However, because plants have tough cell walls they are quite difficult to break down. So even after digestion, lots of the nutrients are still present in the faeces.
- These types of termites have developed a clever strategy to obtain more nutrients.
- They cultivate a type of fungus by using their faeces as compost. The fungus is able to use the left over nutrients in the faeces to grow.
- The fungus then provides the termites and their larvae with a rich food source.

Fungi and Ambrosia Beetles

Another relationship where fungi are used by insects is the use of ambrosia fungi by the ambrosia beetle.

This type of beetle lives inside tree trunks, and the females bore passages in which to lay their eggs.

The mother uses the ambrosia fungus is to feed the newly hatched baby beetles.

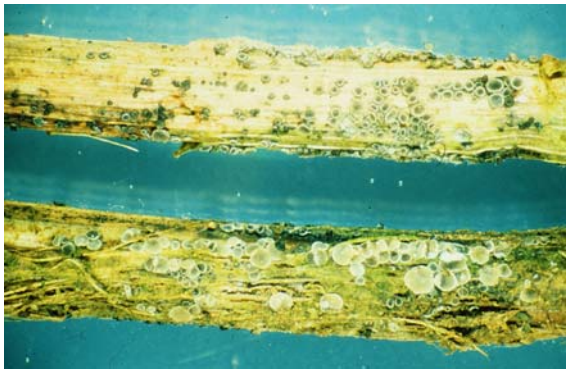
This is achieved by the mother infecting the wood with the fungus by carrying some from a previous nest.

By the time the eggs hatch the fungus has grown on the walls of the tree trunk, providing an easily accessible food source for the larvae.

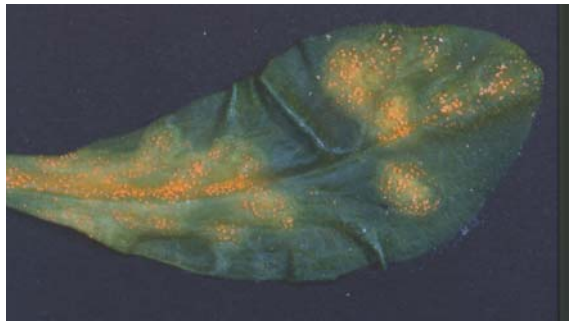
Fungal Infections

- Fungi can infect plants and animals; including humans.
- Masses of spores cause discolouration of the leaves so infections of plants are called smuts, rusts, spots and other names describing the symptoms.

Tarspot of sycamore



Eyespot of wheat



Leaf rust of daisy

FFI6

Fungal Infections

- Plants that are infected are weakened because the fungus absorbs nutrients from the plant on which is it living. Because of this weakened state plants are more likely to be affected by other forms of parasite and other stresses (like shortage of water), and the yield of crop plants is greatly reduced.

Humans as hosts

- Human fungal infections are divided into three groups.
- The first of which are **superficial infections**.
- These are infections of the outer layers of the skin, the hair and nails. Infections of the skin are specifically known as dermatomycoses.
- Examples are athlete's foot and ringworm (yes, it's a fungus, not a worm!).

Subcutaneous fungal infections

- The second group are the **subcutaneous** fungal infections. This is when the deeper layers of the skin are infected, and sometimes even bone.
- The organisms usually cross the protective barrier of the skin at the site of a cut. Most of these organisms live in soil.
- Deep skin infections include **Mycetoma** and **Chromoblastomycosis**.

Systemic Mycoses

- Fungal infections that enter into the body and invade internal organs are called **systemic mycoses**. Infection can arise from inhalation of fungal spores, although such cases are not usually life threatening.
- Most people that suffer from a systemic fungal infection are usually sick already. The fungus is said to be 'opportunistic' because if the person was healthy the fungus would not usually cause any serious harm.
- If someone is sick the body is less able to defend itself against pathogenic organisms, they therefore have an increased risk of susceptibility to infectious fungi.

References

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- Moore, D. (2001) *Slayers, Saviors, Servants and Sex: An Expose of Kingdom Fungi*. Springer-Verlag, New York.
- Assinder, S. & Rutter, G. (2001) *How the Mushroom Got its Spots.* Published jointly by the British Mycological Society and BBSRC.
- http://microbiologyonline.org.uk/
- http://www.doctorfungus.org/educatio/index.htm
- http://www.mushworld.com

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The Fungi Name Game

Instructions
The object of this activity is to pick the true names from the fake fungal names. Students are encouraged to shout out names to find the real names, which form a path of touching squares from the top of the grid to the bottom.

Cross-out (or obscure if using an OHP) the fake names to show the progress of the path.

REAL NAMES
Blueleg Brownie
Dingy Twiglet
Drumstick Truffle-club
Earpick Fungus
Frosty Funnel
Lawyer's Wig
Lemon Disco
Mousepee Pinkgill
Plums and Custard
Silky Piggyback
Turkey Tail
Witches' Butter

FAKE NAMES
Booty Mould
Bubble Puff
Chalk and Cheese
Cherry Bonnet
Coffee Hump
Deadly Spider
Double Jewel
Flutter Devil
Hairy Stinkweed
Mottled Fairy
Peacock Oyster
Rabbits Tail
Slimy Donkey
Smooth Talon
Square Pore
Turtle Truffle
Wasp Crabtree
Waxy Sheep

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The Fungi Name Game

COFFEE HUMP	**EARPICK FUNGUS**	**DINGY TWIGLET**	**BUBBLE PUFF**	**HAIRY STINKWEED**
WASP CRABTREE	**TURTLE TRUFFLE**	**PLUMS AND CUSTARD**	**SQUARE PORE**	**WAXY SHEEP**
DEADLY SPIDER	**SILKY PIGGYBACK**	**TURKEY TAIL**	**WITCHES' BUTTER**	**SMOOTH TALON**
DOUBLE JEWEL	**LEMON DISCO**	**FLUTTER DEVIL**	**SLIMY DONKEY**	**BOOTY MOULD**
MOTTLED FAIRY	**FROSTY FUNNEL**	**LAWYER'S WIG**	**DRUMSTICK TRUFFLE CLUB**	**BLUELEG BROWNIE**
PEACOCK OYSTER	**CHALK AND CHEESE**	**RABBITS TAIL**	**MOUSEPEE PINKGILL**	**CHERRY BONNET**

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The Fungi Name Game

Here's the grid with the fake names greyed-out

COFFEE HUMP	EARPICK FUNGUS	DINGY TWIGLET	BUBBLE PUFF	HAIRY STINKWEED
WASP CRABTREE	TURTLE TRUFFLE	PLUMS AND CUSTARD	SQUARE PORE	WAXY SHEEP
DEADLY SPIDER	SILKY PIGGYBACK	TURKEY TAIL	WITCHES' BUTTER	SMOOTH TALON
DOUBLE JEWEL	LEMON DISCO	FLUTTER DEVIL	SLIMY DONKEY	BOOTY MOULD
MOTTLED FAIRY	FROSTY FUNNEL	LAWYER'S WIG	DRUMSTICK TRUFFLE CLUB	BLUELEG BROWNIE
PEACOCK OYSTER	CHALK AND CHEESE	RABBITS TAIL	MOUSEPEE PINKGILL	CHERRY BONNET

Scientific names

As you can see, the common names are descriptive and memorable, and the same approach is used for scientific names.

The main difference is that scientific names are part of a standard worldwide classification system of all living things. So there are internationally-agreed rules to producing scientific names. Also, scientificnames are generally in Latin (a few are based on the Greek language), which means that whatever the native language of the scientists, they always use the same name for the same organism. Scientific names consist of two words: the name of the GENUS followed by a name for the SPECIES.

Genus names are nouns that can come from anywhere. For example, oak is always *Quercus*, the beech tree is always *Fagus*, the pine tree is always *Pinus*, and these names are used because they are the classical Latin names that were used in ancient Rome. Other names are made up to be descriptive of the organism (like *Helianthus*, which literally means sun-flower), or to commemorate some famous person (like *Eugenia* which was named for Prince Eugene of Savoy, who was a patron of botany and horticulture), while other names come from other languages (like *Narcissus* (daffodil) and *Anemone* (anemone) that come from ancient Greek).

Species names are often descriptive (like *deliciosa* for delicious, *foetida* for foul smelling, *squamosa* for having scales).

References
http://en.wikipedia.org/wiki/Scientific_classification
http://botanicallatin.org/
http://atshq.org/articles/beechwp1.html
http://atshq.org/articles/beechwp2.html

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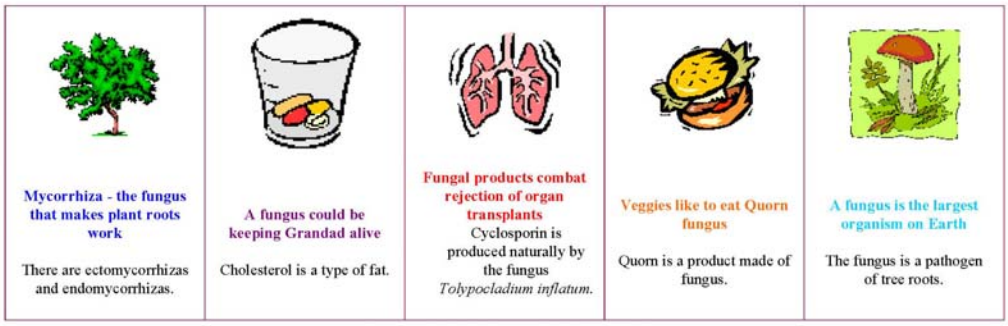
What's your Favourite Fungus?

Card Game



There are 8 suits of cards.

Each suit tells one fungus story

Each card gives one of 6 different facts about the fungus story concerned.

There are also a couple of jokers!

So now you know enough to play the ***Favourite Fungus*** card game.

The cards are shuffled and 5 dealt to each of 4/5 players. Surplus cards placed in the centre, face down. Object of the game is to collect five facts relating to one story (that is, one cartoon logo).

Player to left of dealer starts by taking top card from the central deck, decides whether to keep or discard, and then discards one card, FACE UP, to start a discard pile alongside the main deck.

Players after that choose in turn whether to take top card from discard pile or undisclosed card from main deck, and again maintain their own hand of cards at 5 cards by discarding the picked-up card or another card from his/her hand.

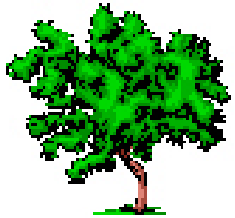
As soon as a player has collected all five cards in a story (which may include one of the jokers), he or she ***WINS*** by declaring "***My Favourite Fungus!***" and putting their cards on the table for all to see.

Wood-rotting fungi digest the timber

Brown rot fungi break down cellulose.

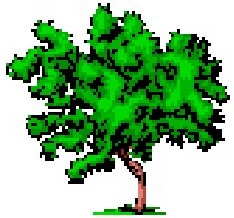
Wood-rotting fungi digest the timber

Bacteria, worms, insects and some fungi break down dead plant material so that the nutrients can be recycled.



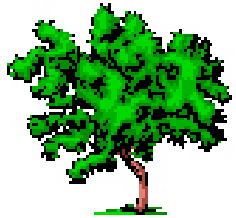
Mycorrhiza - the fungus that makes plant roots work

The plant shares up to 25% of its photosynthetic products with the fungus.



Mycorrhiza - the fungus that makes plant roots work

There are ectomycorrhizas and endomycorrhizas.



Mycorrhiza - the fungus that makes plant roots work

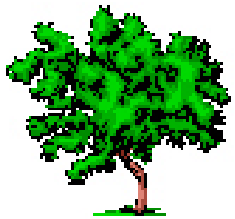
Mycorrhizas increase nutrient availability to plants, as they increase the absorptive surface area.

Wood-rotting fungi digest the timber

White rot fungi break down lignin.

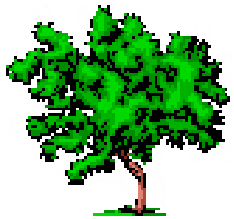
Wood-rotting fungi digest the timber

Plant cell walls contain cellulose and lignin that make them strong.



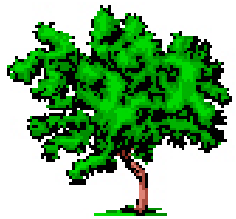
Mycorrhiza - the fungus that makes plant roots work

Mycorrhizas improve the plant's ability to withstand environmental extremes.



Mycorrhiza - the fungus that makes plant roots work

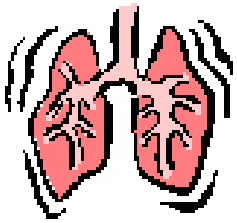
It is thought that has many as 95% of all plants have mycorrhizal associations.



Mycorrhiza - the fungus that makes plant roots work

The mycorrhizal relationship is mutualistic because both plant and fungus gain from having the other present.

FF20



Fungal products combat rejection of organ transplants

The immune system usually kills anything foreign that enters the body, this causes transplant rejection.

A fungus is needed for our fizzy drinks

Citric acid is a product of the Krebs cycle in metabolism.

A fungus is needed for our fizzy drinks

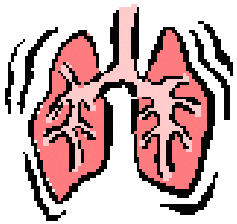
Citric acid is produced by the fungus *Aspergillus niger*.

A fungus is needed for our fizzy drinks

Soft drinks contain citric acid.

Wood-rotting fungi digest the timber

Brown and white rot fungi produce digestive enzymes to degrade wood.



Fungal products combat rejection of organ transplants

Cyclosporin is an immunosuppressant.

A fungus is needed for our fizzy drinks

Citric acid keeps the carbonic acid stable, so the drink stays fizzy.

A fungus is needed for our fizzy drinks

The fungus is grown in a fermenter on a medium of sugar.

A fungus is needed for our fizzy drinks

Citric acid gives a sour taste, but is also a preservative.

Wood-rotting fungi digest the timber

Fungi are the only organisms known to be able to break down both cellulose and lignin.

Fungi digest grass for cows

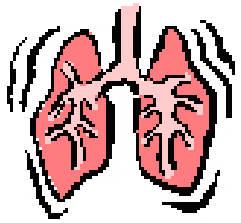
Chytrids pass from one cow to another by being transferred in cow dung.

Fungi digest grass for cows

Cows have fungi called chytrids living in their stomachs.

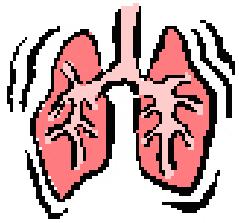
Fungi digest grass for cows

Cows are ruminants.



Fungal products combat rejection of organ transplants

Cyclosporin prevents rejection of an organ transplant.



Fungal products combat rejection of organ transplants

Cyclosporin is produced naturally by the fungus *Tolypocladium inflatum*.

Fungi digest grass for cows

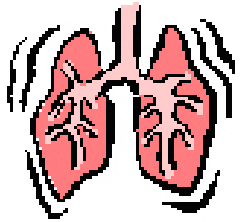
The chytrids live off some of the nutrients in the cow's food.

Fungi digest grass for cows

The chytrids produce cellulase enzymes to break down the cellulose

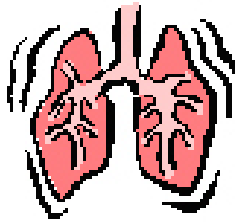
Fungi digest grass for cows

Cows can not digest the cellulose in plant cell walls.



Fungal products combat rejection of organ transplants

Cyclosporin has been used since 1983.



Fungal products combat rejection of organ transplants

Proliferation of lymphocytes is inhibited by cyclosporin.

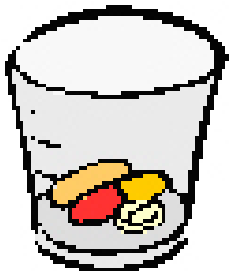
FF22

A fungus is the largest organism on Earth

The giant fungus weighs about 150 tons and covers 2,200 acres.

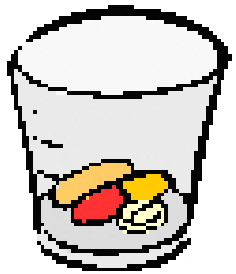
A fungus is the largest organism on Earth

A fungus called *Armillaria ostoyae* is the biggest organism in the world.



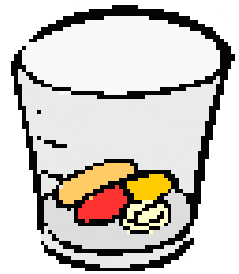
A fungus could be keeping Grandad alive

Aspergillus niger and *Penicillium citrinum* are the fungi that produce the statin drugs



A fungus could be keeping Grandad alive

Low density lipoprotein is the dangerous type of cholesterol.



A fungus could be keeping Grandad alive

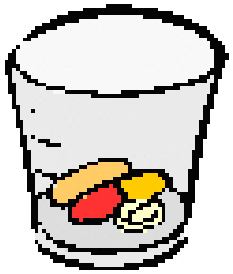
Cholesterol is a type of fat.

A fungus is the largest organism on Earth

It lives in the Blue Mountains of eastern Oregon in the USA.

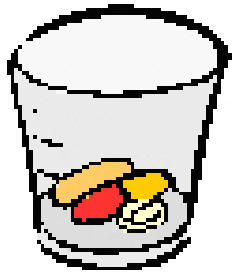
A fungus is the largest organism on Earth

The common name for the fungus is ‘honey mushroom’.



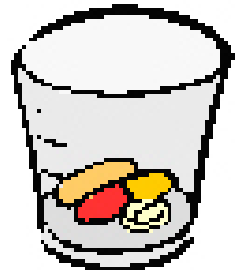
A fungus could be keeping Grandad alive

Statins block the enzyme needed for the production of cholesterol.



A fungus could be keeping Grandad alive

Statins are cholesterol-lowering drugs.



A fungus could be keeping Grandad alive

Excess cholesterol may block blood vessels causing heart attack.

JOKER

What do you call someone who parties every night?

A FUN GUY!

Veggies like to eat Quorn fungus

Quorn has the texture of meat, and can be modified to taste like meat.

Veggies like to eat Quorn fungus

Quorn fungus is filamentous, and is grown continuously in two large fermenters.

Veggies like to eat Quorn fungus

Quorn is a product made of fungus.

A fungus is the largest organism on Earth

The fungus is a pathogen of tree roots.

JOKER

What did the bus driver tell the last passenger?

THERE'S NOT MUSHROOM INSIDE!

Veggies like to eat Quorn fungus

Quorn is available as burgers, sausages, mince and chunks.

Veggies like to eat Quorn fungus

Quorn is low in fat, high in protein and zinc, and contains B vitamins.

Veggies like to eat Quorn fungus

The Quorn fungus is called *Fusarium venenatum.*

A fungus is the largest organism on Earth

The fungus causes the leaves of the trees on which it lives to turn yellow; eventually the tree will die.

JOKER

What did the zoospore say as it was leaving the zoosporangium?

"After you, I encyst!"

Veggies like to eat Quorn fungus

Quorn has the texture of meat, and can be modified to taste like meat.

Veggies like to eat Quorn fungus

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Veggies like to eat Quorn fungus

Quorn is a product made of fungus.

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The fungus is a pathogen of tree roots.

JOKER

A fungus went into a bar and saw some algae at a table.
They took a lichen to each other!

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