All the plants in your garden. All the crops in your fields. All the trees in your forests, and the grass of your pastures. All depend on fungal associates in their roots to help them grow.

All your farm animals. Your beef and veal, including milk and dairy products. Not just cattle, but sheep, deer, goats, and even llamas, giraffe and antelope. Meat, certainly, but other products too, like leather, wool and other fibres. Each and every one depends on fungi in the gut to digest the grass.

THANK FUNGUS FOR THAT!

Some of the wonder drugs of today come from fungi. Statins control your cholesterol level to protect you from heart disease. Cyclosporin stops rejection in transplant patients. And we still depend on penicillin – the wonder drug of the 1940s. All from fungi!

Only fungi can degrade woody lignin. Without fungal wood decay the world would fill up with dead timber. Like it did in Carboniferous days when coal seams were laid down!

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Plants gain their nutrients by absorbing minerals and water from the soil using their roots. But they 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; by growing into areas of fresh nutrients. The relationship between the plant and fungus is mutualistic; which 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 25% 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 would 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 exchange nutrients with 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. As 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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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 we're most familiar with is the cow, and we al know that cows spend most of their time eating 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 excretion of waste products regular. However cows, like all animals, do not produce enzymes capable of digesting cellulose themselves; so without help they can't extract the nutrients the grass contains. 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 again to grind 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 materials 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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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? Well, it's broken down and recycled. Many small organisms like bacteria, insects, worms and many types of fungi break down the plant material. The resultant humus is nutrient rich and can be used by plants for their growth.

The cell walls of plants 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 that are incredibly strong. Brown rot fungi breakdown 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 sugar 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. 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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Most of us appreciate that if we have too much cholesterol the body is not able to use up the excess so it sticks to the inside walls of our blood vessels. This build up reduces the diameter of the vessels, 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. To control heart disease it's important that humans regulate their cholesterol level.

The most effective cholesterol lowering-agents we have today are called STATINS, and these are produced by fungi. The two fungi used to produce statins are called *Aspergillus terreus* and *Penicillium citrinum*. Statins inhibit enzymes needed to make cholesterol and production of cholesterol is slowed down. Add dietary control, and you can significantly decrease the patient's cholesterol level.

Today, many people rely on statins from fungi to help keep their cholesterol level normal; the drugs are credited with saving 7000 lives a year in the United Kingdom alone!

CYCLOSPORIN is another crucial wonder drug of today. It makes successful long-term transplant of livers, kidneys, hearts and lungs possible. This compound is produced by the fungus *Tolypocladium inflatum*. The fungus was isolated from a soil sample and screened in a search for antibiotics. The compound cyclosporin was found to be a weak antibiotic, but to have strong activity at suppressing the immune system (= IMMUNOSUPPRESSIVE).

This is the crucial role of this drug now. Our bodies are programmed to eliminate foreign things, and the body will naturally reject a transplant. 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. Lymphocytes are the cells that are able to detect foreign objects. They attach themselves to pathogens identifying them as things to be destroyed.

Following transplant operations cyclosporin helps prevent rejection 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 and will continue to function normally. Cyclosporin is currently the most effective and widely used immunosuppressive drug.

VISIT the BMS website at http://www.britmycolsoc.org.uk

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