Far from being a load of old rot, fungi could save the world, says Richard Webb

WHAT do you call a man with a mushroom on his head? A fun guy. Paul Stamets, though, is deadly serious. He is on a mission to save the world, and his choice of headgear tells you how he plans to do it. “We need to invest in fungi,” he says.

Mention the word fungus to most people, and the likely response is a shudder. Fungus is the mould on bread, the mildew on the ceiling, the infection in an unfortunate place. But that’s a tad unfair. Fungus is also the yeast that made the bread and our frothing pint of beer, not to mention the blue graining in our gourmet cheese. As with many long-term relationships, humankind and mould are bonded in love and hate.

If Stamets and his ilk get their way, this relationship is about to experience a fresh bloom of love. A slew of fungal technologies is creeping out of the woodwork, and they promise everything from better drugs, environmentally friendly materials and green fuels to... well, tomorrow’s fashion tips. Is this the dawning of the age of the fungus?

In point of fact, fungi have always been our allies, says Lynne Boddy, a mycologist and passionate advocate of mushrooms at Cardiff University in the UK. “Without fungi, planet Earth wouldn’t work,” she says. “You would be up to your armpits in dead stuff.”

Most of their action happens out of sight. A fungus might have a toadstool poking up from the forest floor or a tree stump, but its business end lies in a mass of filaments called the mycelium that can spread vast distances beneath. “A mushroom is just the tip of the iceberg,” says Boddy. “Except there’s only nine-tenths of an iceberg below the surface.”

Consider Armillaria solidipes, also known as the honey mushroom. In the Malheur National Forest in eastern Oregon, outcrops of its attractive yellow fruiting body are the only visible sign of what is thought to be the world’s largest organism. As was first recognised in 1992, its single subterranean mycelium is more than 2000 years old and extends possibly as much as 10 square kilometres.

Fungi have more to offer than just bulk,
though. “They are remarkable chemists,” says Boddy. The mycelium is also the fungus’s chemical powerhouse, secreting enzymes that break down surrounding organic material – or even rocks – and so release the nutrients into the soil. Many fungi also produce volatile chemicals to defend their territory against bacteria, insects and other fungi.

Boddy’s speciality is wood-decaying fungi. “They are good fighters,” she says. In her lab, she observes the elaborate strategies they develop to ensure they are first in the buffet queue to feed on juicy dead wood, including throttling each other’s mycelia and producing clouds of chemicals to beat back competitors.

The chemical activity of some mushrooms has long been held in high esteem. There’s the effects of magic mushrooms containing the psychoactive ingredient psilocybin and, more prosaically, the antibacterial properties of the soil-dwelling genus *Penicillium*. Mutual antagonism between fungal species has also been exploited, for example in the use of *Phlebiopsis gigantea* spores to control *Heterobasidion annosum*, a major cause of root rot in conifer plantations.

Gary Strobel, a microbiologist at Montana State University in Bozeman, thinks there are many more possibilities. A decade ago, while on a field trip to an area of ancient forest in Patagonia, he found a wood-decaying fungus whose chemical fug seemed to consist largely of volatile organic compounds of the sort found in diesel fuel. The fungus has since been identified as a strain of *Ascocoryne sarcoides* – commonly known as jelly drops on account of its purple, gelatinous fruiting bodies. Back in Bozeman, Strobel built a reaction vessel like an overblown kitchen sink to see if he could get it to do the same in the lab.

After a lot of tinkering, he had a fungal mix

**“Fungi are good fighters, throttling each other and making clouds of chemicals to beat back competitors”**

that might make good biofuel, while honey mushrooms (below right) can stretch for miles underground
that took just three weeks to turn dead leaf matter into a serviceable “mycodiesel” fuel. “I’ve put it into my motorbike and it works just fine,” he says. Unlike conventional ways of making biofuels, such as using yeast to ferment cash crops into ethanol, this process could potentially feed off freely available agricultural waste. Strobel is now working to commercialise the idea.

Eben Bayer thinks this fungal fuel might one day power a mushroom motor. CEO of a company called Ecovative, he made his name with biodegradable mushroom packaging, supplying the computer giant Dell among others. But he doesn’t stop there. “If you think plastics are a wonder material, mycelium should be in that same category,” he says.

Like plastic, mycelium is formed of a flexible polymer material, in this case chitin. It’s fully biodegradable – and smart to boot. Given different starting materials, temperatures and humidity, it can be coax ed to grow to different densities and orientations and so produce materials with a wide range of properties such as tensile strength. “We point it in the right direction and it takes care of the details,” says Bayer. His company is currently cooking up projects from medical implants that make synthetic bone using mycelium as a scaffold to fire-resistant insulating foam – and even moulded mushroom parts for electric cars.

For Stamets, such solutions are small mushroom fry. While the hats he wears are a symbol of mushroom technologies past (see “Mushrooms à la mode”, far left), he sees us marching towards a sunlit fungal future. In 2008 he gave a talk at a TED conference entitled “Six ways mushrooms will save the world” that has since been viewed 1.7 million times and counting. “He is the epitome of mushroom fame,” says Bayer.

“The path to the future is the path of the mycelium,” says Stamets. It sounds like cod philosophy, but his company, Fungi Perfecti, has amassed more than 30 mushroom-based patents spanning a range of environmental and medicinal applications. His biggest idea is “mycorestoration”: applying what he describes as “guilds” of appropriate fungi to soil to enhance productivity, clean up contamination and speed up carbon sequestration to mitigate climate change.

Other inventions include “mycofoams”, floating hemp socks filled with mycelium that secrete oil-destroying enzymes in contaminated water. His most recent patents are on what he claims is a universal insecticide and an antiviral substance derived from the wood-decaying fungus *Laricifomes officinalis*, commonly known as agarikon or quinine conk, owing to its extremely bitter taste.

Fuels, medicines, materials, environmental clean-up services – the breadth of potential fungal applications is underlined by a banner on the website of Bayer’s company. After the Stone Age, various metal ages and the plastic age, it declares, “welcome to the Mushroom Age.” That’s not entirely tongue-in-cheek, says Bayer. “We’re actually pretty serious about that.”

Stamets is even more definite. If we want a quick, easy fix to problems of human health, environmental degradation and the drivers of climate change, we need to embrace the suite of services offered by our fungal brethren – and fast. “Time is short, very short,” he says. And if it doesn’t work, he’ll eat his hat.

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