Welcome to BioInspire, a monthly publication addressing the interface of human design, nature and technology.

. . . .

BioInspire.24 2.24.05

EARTH’S NATURAL INTERNET

Healing the planet with mushrooms

Paul Stamets
www.fungi.com

Waves of mycelial networks intersect and permeate one another. This interspersing is the foundation of soils worldwide. Although the mycelia, under the microscope, are seemingly undifferentiated, their ability to respond to natural disasters and sudden changes in the environment is a testament to their inherent intelligence. I believe mycelia are Earth's natural Internet, the essential wiring of the Gaian consciousness. The recent creation of the computer Internet is merely an extension of a successful biological model

that has evolved on this planet for billions of years. The timing of the computer Internet should not be construed as happenstance. Sharing intelligence may be the only way to save endangered ecosystems. The planet is calling out to us. Will we listen in time? The lessons are around us. Will we learn?

Covering most landmasses on the planet, and indeed floating in the oceans, are huge masses of fine filaments of living cells from Fungi, a kingdom barely explored. More than a mile of these cells, called mycelia, can permeate a cubic inch of soil. Fungal mats are now known as the largest biological entities on the planet, with some individual mats covering more than 20,000 acres. The momentum of mycelial mass from a single mushroom species, growing outwards at one-quarter to two inches per day, staggers the imagination. These silent mycelial tsunamis affect all biological systems upon which they are dependent. As one fungus matures and dies back, a panoply of other fungi quickly comes into play. Every ounce of soil hosts not just one species, but literally thousands of species of fungi. Of the estimated 6,000,000 species in the world, we have catalogued only about 50,000. The genetic diversity of fungi is vast by design, and apparently crucial for life to continue.

Nearly all plants have joined with saprophytic and mycorrhizal fungi in symbiosis. Mycorrhizal fungi surround and penetrate the roots of grasses, shrubs, and trees, expanding the absorption zone ten- to a hundredfold, aiding in plants' quest for water, and increasing the moisture-holding capacity of soils. This close alliance also forestalls blights and is essential for longevity of the forest ecosystem. Throughout the lifespan of a Douglas fir, nearly 200 species of mycorrhizal mushrooms can be joined in this most holy of alliances. The interrelationships of these species with other organisms in the forest are just beginning to be understood. What we do know is that fungal complexity is the common denominator of a healthy forest.

Unfortunately, the loss of nearly 50 percent of the mycorrhizal mushroom species in Europe in recent decades forebodes impending ecological collapse. With the loss of fungi, disease vectors soon plague the forest. The diversity of insects, birds, flowering plants, and all mammals begins to suffer. Humidity drops, now-exposed soils are blown away, and deserts encroach, stressing resources even as human populations artificially expand beyond the carrying capacity of their resident ecosystems.

Mycoremediation

For the past four years I have been working with Battelle Laboratories, a nonprofit foundation whose mission is to use science to improve environmental health. Battelle is a major player in the bioremediation industry, and widely used by the United States and other governments in finding solutions to toxic wastes. The marine science laboratory of Battelle, in Sequim, Washington became interested, as their mandate is to improve the health of the marine ecosystem. Under the stewardship of Dr. Jack Word, we began a series of experiments employing the strains from my mushroom gene library, many of which were secured by collecting specimens while hiking in the old-growth forests of the Olympic and Cascade mountains. We now have applied for a patent utilizing mycelial mats for bioremediation, a process we have termed "mycoremediation."

Mycelia produce extracellular enzymes and acids that break down recalcitrant molecules such as lignin and cellulose, the two primary components of woody plants. Lignin peroxidases dismantle the long chains of hydrogen and carbon, converting wood into simpler forms on the path to decomposition. By circumstance, these and other fungal enzymes are superb at breaking apart hydrocarbons, the base structure common to oils, petroleum products, pesticides, PCBs, and many other pollutants.

After several years of experiments, we have made some astonishing discoveries. (I am continually bemused that humans "discover" what nature has known all along.) The first laboratory and outdoor studies showed that a strain of oyster mushrooms could break down heavy oil, removing over 97 percent of the toxic and recalcitrant polycyclic aromatic hydrocarbons (PAHs) and more than 80 percent of the alkanes. A pilot-scale project was carried out at a Washington State Department of Transportation (WSDOT) maintenance yard in Bellingham. WSDOT and Battelle each funded part of this experiment, in which three bioremediation methods and untreated controls were compared. Each test-and-control mound was about 10' x 10' x 3', or about ten cubic yards of contaminated soil. Two methods were applied by WSDOT and its subcontractor: one employed native bacteria, the other used engineered bacteria, and both required monthly fertilizing and tilling. Our group applied the living mycelia of oyster mushrooms. We inoculated three mounds of soil, each contaminated with a different mixture of diesel fuel, motor oil, gasoline, and other petroleum hydrocarbons.

After four weeks, the tarps were pulled back from each test pile. The first piles, employing the other techniques, were unremarkable. Then the tarp was pulled from our piles, and gasps of astonishment and laughter welled up from the observers. The hydrocarbon-laden pile was bursting with mushrooms! Oyster mushrooms up to twelve inches in diameter had formed across the pile. Based on our earlier tests, we estimated that most of the PAHs and alkanes had been broken down by this time. The mushrooms were tested and shown to be free of any petroleum products.

After eight weeks, the mushrooms had rotted away, and then came another startling revelation. As the mushrooms rotted, flies were attracted. (Sciarid, Phorid, and other "fungus gnats" commonly seek out mushrooms, engorge themselves with spores, and spread the spores to other habitats.) The flies became a magnet for other insects, which in turn brought in birds. Apparently the birds brought in seeds. Soon ours was an oasis, the only pile teeming with life! We think we have found what is called a "keystone" organism, one that facilitates a cascade of other biological processes that contribute to habitat remediation. Critics, who were in favor of using plants (as in "phytoremediation") and/or bacteria, reluctantly became de facto advocates of our process, since the mushrooms opened the door for this natural sequencing.

By the study's end point at twelve weeks, the total petroleum hydrocarbons were reduced by mycoremediation, and the soil had been enriched by the treatment and by the development of a complex community. The soil was tested and shown to be nontoxic and suitable for use in WSDOT's highway landscaping.

Another discovery involves the use of some of my mushroom strains in the destruction of biological- and chemical-warfare agents. Most of the research is currently classified by the Defense Department, but we can tell you, for example, that certain of our proprietary strains have been shown to break down surrogates of sarin and soman, similar to the potent nerve-gas agent Saddam Hussein was accused of loading into missile warheads during the Gulf War. This discovery is significant, because these compounds are very difficult to destroy by any other method. Our fungus did so in a surprisingly effective manner.

Mycofiltration

When I first moved to my property in Kamilche Point, Washington, I installed an outdoor mushroom bed in a gulch leading to a saltwater beach where clams and oysters were being commercially cultivated. An inspection showed that the outflow of water from my property was jeopardizing the quality of my neighbor's shellfish, with the bacteria count close to the legal limit. The following year, after the mushroom mycelia colonized the beds, the coliform count decreased to nearly undetectable levels. Mycelia can serve as unparalleled biological filters. This led to the term I have coined, "mycofiltration": the use of fungal mats as biological filters.

In still another series of experiments with Batelle, one significant discovery involved an old-growth-forest mushroom that produced an army of crystalline entities advancing in front of the growing mycelium. These three-dimensional pyramidal structures appear to attract motile bacteria such as *Escherichia coli* by the thousands, and to summarily stun them. The advancing mycelium then digests the E. coli, effectively removing them from the environment.

We believe that buffer zones around streams work primarily because of the mycelia resident in the first few inches of soil. Buffers with multi-canopied trees and shrubs combined with grasses (and the debris fall-out they provide) afford a mycologically rich zone, filtering out run-off from adjacent farms, highways, and suburban zones. The mycologically rich riparian zones are cooler, attract insects which lay larvae (grub for fish), and then foster bird life. Once the riparian zones achieve a plateau of complexity, they become self-sustaining. Amazingly, I have not heard a single researcher ever mention the primary role fungi play in riparian buffers, let alone the purposeful introduction of mycelial colonies to protect watersheds. This method is ingeniously simple in its design and yet seemingly out of the grasp of politicians. The prejudice against mushrooms is a form of biological racism—mushrooms are just not taken seriously.

Mycofiltration is a natural fit to John Todd's Living Machine use of estuary ecosystems to break down toxic wastes. The marriage of upland use of mushroom mycelia with estuary environments could solve some of the greatest challenges threatening our ecosystems, and truly give meaning to the word "sustainability." We are currently moving toward unifying these two friendly technologies.

What our team has discovered, even given our elementary research, is that the fungal genome has far greater potential in treating a wide variety of environmental and health concerns than we could have conceived. Although we have looked at just a few of the mushroom species resident in the Old Growth, clearly these ancestral strains of mushrooms have survived for millennia due to their inherent ability to adapt. These adaptive mechanisms are the very foundation of ecological stability and vitality in a rapidly changing environment. Mushrooms are "smart" fungi. We should learn from our elders: native peoples worldwide have viewed fungi as spiritual allies. They are not only the guardians of the forest. They are the guardians of our future.

Paul Stamets has been a dedicated mycologist for over thirty years. Over this time, he has discovered and coauthored four new species of mushrooms, and pioneered countless techniques in the field of edible and medicinal mushroom cultivation. He received the 1998 "Bioneers Award" from The Collective Heritage Institute, and the 1999 "Founder of a New Northwest Award" from the Pacific Rim Association of Resource Conservation and Development Councils. —from bio on www.fungi.com

. . . .

Used with permission from Whole Earth Magazine, issue no. 98, fall 1999. Available on the web at **http://www.wholeearthmag.com/ArticleBin/275.html**

. . . .

BOUT THE PUBLISHER:
John Mlade is a green building professional in Chicago. He is also a member of the Biomimicry community. Visit www.biomimicry.net for more information.

TO CONTACT THE PUBLISHER:
Email John Mlade at BioInspire@yahoo.com

FOR YOUR FREE SUBSCRIBTION:
www.colostate.edu/services/acns/listserv
1.Click on “Subscribe to one of CSU’s other lists”
2.Scroll to BioInspire

TO UNSUBSCRIBE:
www.colostate.edu/services/acns/listserv
1.Click on “Unsubscribe to one of CSU’s other lists”
2.Scroll to BioInspire

. . . .