SPORE PRINTS

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THE CONFUSING LIFE CYCLE AND TAXONOMY OF *CORDYCEPS SINENSIS*

Daniel Winkler

[Ed. Note: The following is an extract from "The Wild Life of Yartsa Gunbu (*Ophiocordyceps sinensis*) on the Tibetan Plateau" in the Spring 2017 issue of *FUNGI*, a much more thorough—and, as always with Daniel, beautifully illustrated—treatment of everything yartsa gunbu.]

Some of the most interesting recent research results regarding *Ophiocordyceps sinensis* (=*Cordyceps sinensis*, see Sung et al., 2007) are reports from Serkyim La Pass (Tibetan Pinyin: Segi La) above Nyingchi (Linzhi), Tibet Autonomous Region, published by Zhong et al. (2014), that hyphae of *O. sinensis* are not only present in and around infected ghost moth larvae (*Thitarodes* spp.), the hosts of the fungus, but actually present in herbaceous plants growing in *yartsa gunbu* habitat. Common woody plants like rhododendron and creeping willow (*Salix* sp.) have so far tested negative. However, *O. sinensis* hyphae were detected in the tissue of over half of the alpine grasses, forbs, and ferns tested! And not just in their roots, but also in their stems and leaves. In addition, the presence of hyphae in surprising quantities was detected within the digestive system of living larvae, indicating that the fungus might infect the insect via the digestive system (Lei et al., 2015).

Documenting that *O. sinensis* is present in plants is a total game changer! Practically speaking, it is extremely good news supporting assessments of resource resilience and making sustainable management much more feasible, since even when *yartsa gunbu* is intensely collected it seems that *O. sinensis* should persist for extended periods in the ecosystem. The limiting factor would be the "supply" of fresh larvae ready to be infected. However, stepping back and looking at the wider picture and having a more theoretical perspective as Lei et al. (2015) clearly point out, *O. sinensis* is an interkingdom colonizer! It has developed the capacity to overpower the immune systems of insects and plants and seems to need both for successful reproduction. Repeated interkingdom jumping when acquiring new hosts, e.g,. jumping from cicadas to *Elaphomyces* sp. truffles, is well documented among other *Cordyceps* species (e.g., Nikoh and Fukatsu, 2000).

Daniel Winkler

An alpine meadow seen on Serkyim La in early August at 4,600 m (15,000 ft) altitude in full flower. While the fruiting bodies of O. sinensis are long deteriorated, the fungus is still present within these plants. So far, its hyphae have been detected in the roots, stems, and leaves of the pinkish-flowering bistort (Polygonum macrophyllum), the white Cyananthus macrocalyx, a bell flower relative, and also in yellow buttercups (Ranunculus tanguticus). However, [there is] no report of O. sinensis being present in the depicted purple elephant's trunk (Pedicularis sp.) or tiny blue gentians.

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Contemporary Tibetan thangka showing Nyamnyi Dorje and Tibetans collecting and trading yartsa gunbu.

[*A thangka is a Tibetan painting on cotton, or silk appliqué, usually depicting a Buddhist deity, scene, or mandala. Surkhar Nyamnyi Dorje was a Tibetan medical practitioner of the fifteenth century and considered to be the founder of the Southern School of Tibetan Medicine, the school of Sur. One of his works mentions the Chinese caterpillar (Ophiocordyceps sinensis) for the first time in Tibetan literature.*]

Ophiocordyceps sinensis being present in plants and ghost moth larvae in its habitat might also explain why artificial cultivation of *O. sinensis* is still not feasible on a level that allows commercial production. You might think, wait a minute, what about all the *Cordyceps* products I can buy in any supplement store? Well, they are derived from ground-up dried anamorphic mycelium grown predominantly on grains.

An anamorph is the asexual form of a fungus, meaning without meiosis or the development of

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Ophiocordyceps sinensis freshly exposed in the ground. The back side of the ghost moth larva (Thitarodes sp.) is still encapsulated by a mycelium mesh that probably takes up moisture and possibly nutrients from its surroundings.

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CALENDAR

June 3	Field Trip (see PSMS website). National Trails Day - no trail passes required.
June 13	Membership Meeting, 7:30 pm, CUH
June 19	Board Meeting, 7:30 pm, CUH board room
Aug. 22	*Spore Prints* deadline
Sept. 12	Membership Meeting, 7:30 pm, CUH

BOARD NEWS — Luise Asif

Under James Nowak's direction, the Sustainability & Ecology (Conservation) Committee will work toward PSMS becoming more active at the state level as regulations of public lands are developed. Anyone interested in joining this committee contact the board. Work continues to finalize the contract for the PSMS Annual Wild Mushroom Show this fall. With more flexibility of our website, the board is considering changing the membership options, such as multi-year. The contract for the Ben Woo Foray has been signed, and registration is open. Daniel Winkler will attend the Mycological Society of America Conference to learn more about the National Vouchering program and how the PSMS Bridle Trails Park study can tie into that program. More people are needed to become part of the Bridle Trails study. Until people are familiar with the vouchering procedures and can go out individually, groups meet alternate Mondays and Sundays.

MEMBERSHIP MEETING

Tuesday, June 13, 2017, at 7:30 pm at the Center for Urban Horticulture, 3501 NE 41st Street, Seattle


Huger Foote
Eugenia Bone

Our speaker for June is nationally known food and nature journalist Eugenia Bone, who will give a 60 minute illustrated talk about the culture of amateur mycologists and mushroom hunters, and the forays and festivals that attract fungus lovers from all over the country. It shares the speaker's adventures mushroom picking all over the world including porcini hunting in the West Elk mountains in Colorado, morel hunting on forest fire sites in Montana, *Cordyceps* hunting in Tibet, white truffle hunts in Tuscany, and hunts for, well, anything, in New York City's Central Park. The talk reports on all kinds of festivals, from the Breitenbush Mushroom Gathering, where you can hunt matsutake in old growth forest in the day and relax in hot springs at night, the Kennet Square mushroom festival, which is a celebration of the white button mushroom industry, to the Telluride Mushroom festival, the only mushroom festival that acknowledges hallucinogenic mushrooms. You will also meet many of the characters on the mushrooms scene. If you aren't in love with mushrooms by the end of the talk, you will at least come to appreciate the wacky subculture of mycophiles.

Founder of Slow Food Western Slope in Colorado and former president of the New York Mycological Society, Eugenia Bone has lectured widely to many mycological and gardening societies, and has been the featured speaker at a number of mushroom festivals. Her work has appeared in many magazines and newspapers, and she is the author of five books, including *Mycophilia: Revelations From the Weird World of Mushroom*s, which was on Amazon's list of best science books of 2011 and nominated for a Council on Botanical and Horticultural Libraries award. Her current project is *Microbia*: *A Journey Into the Unseen World Around You*, a study of life from the microbial point of view.

Will people with last names beginning with the letters A–K please bring a plate of refreshments to share after the meeting.

FIELD TRIP REPORT, APRIL 29 — Brian S. Luther

We had an excellent turnout on our first spring field trip, with 91 signing in, many of whom were new members. We also had pretty good weather with sun breaks throughout the day, although it did sprinkle on us for a while. An outstanding job of hosting was done by David & Wuqi Weber and Debbie Johnson working as a team, who provided all of us with a wonderful spread of breakfast coffee and snacks.

Erin O'Dell was the only field trip guide who volunteered for the day, so most people had to form groups and go out on their own. Thank you, Erin.

Around 50 different species of early spring fungi were collected and displayed on the picnic tables. Many members found Oyster Mushrooms (*Pleurotus ostreatus*) in good condition, and one group went to a burn that took place last year near Newhalem on the North Cascades Hwy. and brought back some morels. The 4 pm potluck was attended by nearly 20, and everybody left satisfied.

Daniel Winkler

Digging yartsa gunbu. You have to be very careful not to break the larva from the fungal fruiting body when lifting it out of the ground for two reasons. First, it is not clear in which direction the larva might project underground and, second, in some habitats the ground is covered by extremely dense Kobresia sedge mats, which need a lot of force to be broken.

a proper sexual organ; all the mushrooms we are familiar with as food are actually fungal sex organs. And the fruiting body of wild *yartsa gunbu*, which is growing out of the head of the larva, is just such a sexual organ. In mycology this is referred to as sporocarp, or spore-bearing structure. The fruiting body is also referred to as teleomorph when juxtapositioning to the anamorph. However, an anamorph mycelium has the capacity to grow propagules, often conidiospores. These reproductive cells are genetically just a clone of their parent organism (therefore called "asexual"). Thus some fungi can exist predominantly or even solely in this anamorph state.

Interestingly, in the past anamorphs were known as Fungi Imperfecti, but mycological progress has shown that these anamorphs are not their own class of fungi but an "alternative life form." Furthermore, the anamorph discussion has gained some steam, since mycologists in 2011 met in Melbourne and adopted an International Code of Nomenclature (ICN) concept for algae, fungi, and plants whereby "1F1N" (= one fungus, one name) applies, which has led to the adoption of a multitude of new name combinations, since two genera may have to be combined into one (Hawksworth, 2011). For example, the source of the famous drug cyclosporine, an immuno-suppressor given to a patient receiving an organ transplant to avoid transplant rejection, was derived from *Tolypocladium inflatum*. Many years later Kathy Hodge et al. (1996) realized that *T. inflatum* was the anamorph of *Cordyceps subsessilis*! In 2007 *C. subsessilis* was transferred to the newly erected genus *Elaphocordyceps*, named for *Cordyceps* species parasitizing *Elaphomyces* truffles. Surprisingly the insect parasitizing *C. subsessilis* is closely related, thus it was transferred to *Elaphocordyceps* (Sung et al., 2007). Applying the new 1F1N concept, one of the two generic names (*Elaphocordyceps* and *Tolypocladium*) of this polymorphic species had to be dropped. Thus, anamorph and teleomorph are now both named *Tolypocladium inflatum* (Quandt et al., 2014). *Tolypocladium* was chosen over *Elaphomyces* due to its economic value as a source of cylosporine. In this realignment all the truffle *Cordyceps*, such as *Elaphocordyceps capitata* and *E. ophioglossoides* had to be transferred to *Tolypocladium* as well.

So far, artificial *C. sinensis* production has relied on growing the anamorphic mycelium. As it turns out, what is labeled in trade as *C. sinensis* seems not to be the actual anamorph of *O. sinensis*. Still, much of the medical research has been carried out using this mycelium, which also contains many of the active ingredients, the most famous being cordycepin. Growing the teleomorph—the actual fruiting body of *O. sinensis*—on a larva has not been successfully performed on a scale that has resulted in a commercially viable product. Great progress has been made in recent years, but since successful artificial production of the insect-fungus complex would promise hundreds of millions in revenue, not many details are published on the process and progress of cultivation. The fact that artificial production of a regular fruiting body (though attempted for many decades now) has been elusive, while the closely related bright yellow-orange fruiting bodies of *Cordyceps militaris* are successfully cultivated on a grand scale, is quite perplexing. But this may not be too surprising, taking into account that many years were spent on using the misidentified anamorph and that the reproductive cycle seems to include a stage in a plant.

Daniel Winkler

At the end of the season 'bu is dealt in all towns. Depicted here is the Yartsa gunbu market in Gyegu (Yushu) town, Qinghai Province. Photo shows fresh caterpillar fungi lying on a field bed, or cot, before being dried and cleaned by removing the mycelium that covers the larva. Fresh yartsa gunbu is priced by the piece; weighing does not work due to water content and soil in the mycelial coating. Since the price is based mostly on size, a lot of experience is necessary to negotiate a good price when buying fresh or partially dried caterpillar fungus.

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YARSA COLLECTION DATE ADVANCED DUE TO ELECTION

Manoj Badu

*The Kathmandu Pos*t, May 13, 2017

DARCHULA, Nepal - The government timetable for collecting yarsagumba in the Api Nampa Conservation Area of Nepal has been changed to avoid conflict with a local election.

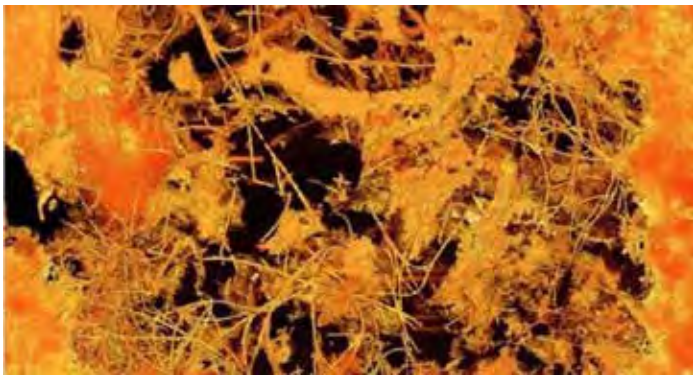
Yarsa collection is an important money making activity for locals. "Many youths will easily forget the election to go pick yarsa," said Bhumiraj Upadhyaya, chief conservation officer of the conservation area. "As we need people to be present during the second phase of the election, we have allowed them to conduct an early harvest."

Accordingly, locals of Darchula have been permitted to harvest the Himalayan "herb" beginning in early May, even though the management guideline specifies collection only from mid-May.

Yarsagumba [*Cordyceps sinensis*] is the world's most expensive medicinal fungus. It can fetch as much as $100 per gram on the Chinese market, making it more expensive than gold, which is currently about $1250 per ounce ($44 per gram).

SCIENTISTS ACCIDENTALLY DISCOVER WORLD'S OLDEST FUNGUS; MAY BE EARLIEST KNOWN MULTICELLULAR LIFE

http://www.siasat.com/, May 9, 2017



World's oldest fungus.

New Delhi - Researchers on Monday accidentally stumbled upon what is being called the oldest fungus ever discovered. Found in South Africa, the new discovery predates the previous oldest fungus by a margin of 1.2 billion years, and has raised questions on the evolution of these organisms.

The fungus, which can be considered neither flora nor fauna, has slender filaments that are bundled together like brooms.

The 2.4 billion-year-old microscopic creature could also be the earliest known specimen of the branch of life to which humans belong, researchers reported in the journal *Nature Ecology & Evolution*.

Up to now, the first fossil trace of eukaryotes—the "superkingdom" that includes plants, animals, and fungi, but not bacteria—dates to only 1.9 billion years ago. Earth itself is about 4.6 billion years old.

According to BBC, the find suggests that fungi arose not on land but in the deep sea. If not a fungus, the organism could be from an extinct branch of life that has not been described before.

Lead researcher Prof Stefan Bengtson of the Swedish Museum of Natural History explained how previously, scientists may have been looking in the wrong place for the oldest fossil fungi—on land or in shallow seas rather than in the deep sea.

It has long been assumed that fungi first emerged on land, but the newly found organisms lived and thrived under an ancient ocean seabed, tucked in the crevices of volcanic rock.

The ancient fungus-like life forms, found in fossilized gas bubbles 800 meters (2,600 feet) underground in South Africa's Northern Cape Province, are remarkable not just for their age but their origin, the researchers said.

Nobody was looking for them, explained co-author Birger Rasmussen, a geology professor at Curtin University in Bentley, Australia, who was examining lava samples from the Ongeluk Formation to determine their age.

"My attention was drawn to a series of petrified gas bubbles, and when I increased the magnification of the microscope, I was startled," he recalled. The bubbles were "filled with hundreds of exquisitely preserved filaments that just screamed 'life'," he wrote by email.

The plot thickened when Rasmussen realized that the surrounding lava was not 2.2 billion years old, as previously thought, but 2.4 billion years old. That extra 200 million years was significant because it straddles a critical threshold in Earth's geological history called the Great Oxidation Event—a rapid and massive outpouring of oxygen into the atmosphere.

Scientists not involved in the study said it was potentially paradigm shifting, but must be bolstered by further research.

GENE-EDITED GRAPES COULD FEND OFF MILDEW, REDUCE PESTICIDES

Brooke Borel

https://geneticliteracyproject.org/, May 10, 2017

Chardonnay grapes and wine.

Chardonnay is among the most popular and recognizable wines in the world. The grape's genes essentially have been passed down from a single plant in eastern France centuries ago. This genetic consistency can be seen as a good thing, as it keeps the grape recognizable. But its genes are also responsible for how it reacts to the environment, including the pests and diseases common to any vineyard.

In New Jersey, winegrowers spray fungicides 6 to 12 times a season to control downy mildew…. But a new technique, CRISPR, may allow scientists to tweak the genes of Chardonnay to become resistant to downy mildew.

"My hope is that we can engineer the plant internally to cut down infection," says Rong Di, a plant pathologist and molecular biologist at Rutgers. Her team is testing CRISPR on a grape variety called Dijon Chardonnay 76.

"The fungus will always be there," says Di. "But if the plants can [become] resistant, we don't have to spray so much."

But will consumers accept a new and sometimes controversial technology to save an old tradition?

CREEPY, ORANGE FUNGUS ATTACKING MICHIGAN JUNIPERS

Rebecca Finneran

Michigan State University Extension, May 8, 2017

Rebecca Finneran, MSU Extension

Cedar-apple rust, Gymnosporangium juniperi-virginianae.

Each spring, rainfall brings out the best in plants in our forests and landscapes. Fresh, colorful foliage emerges and the world transforms before our eyes. If you are looking closely, for about one week each spring during the rainy weather you will also see something magical happen in our native cedar (juniper) trees. A bright orange, gelatinous blossom that kind of looks like Raggedy Ann's hair adorns the cedars like Christmas decorations. While common fungi, including morels, have been popping up everywhere, this fungus expands with the warm rainfall to exhibit many "squid-like tentacles" that are sure to delight the curious.

Cedar-apple rust is the common name for the disease caused by the fungus *Gymnosporangium juniperi-virginianae*. It rarely causes significant damage to the junipers (cedar) where it lives for half of its life. According to Jan Byrne, plant pathologist for Michigan State University Diagnostic Services, the weather we have been experiencing is just right for this science fiction-looking fungus to show up.

In the past week or so, the woody galls have bloomed with the gelatinous fruiting structures. This phase of the fungus is known as the telial stage and it is even more interesting to touch. For a mom, anything that replicates ooze, silly putty, or other slimy substance can be the best entertainment the outdoors provides.

From a science perspective, rust fungi lead interesting lives. This one alternates between two hosts, according to Byrne. The big, orange, "Jell-O fingers" produced on the cedar in May give rise to tiny spores that are carried by wind to the alternate host—an apple or hawthorn. The gall on the cedar will quickly dry up and hang on the tree for several years.

Although this disease does not threaten the health of the cedar, it can prematurely defoliate non-resistant apples, crab apples, and hawthorns where it lands and completes it life cycle later this summer. Leaves will first show a classic spot that typically is bright orange to yellow with a lighter, outer ring. The underside of the leaf may show light colored, cup-shaped structures. Fruit can also be disfigured.

For the most part, this disease is more of a curiosity than a threat to either plant. However, in some instances, it does warrant a control strategy. If you have a valued hawthorn or crab apple, MSU Extension suggests removing the alternate host (cedar) that is in close proximity as an option. Since fungicides will not eradicate the blooming gelatinous galls, a more likely solution is to prune out the galls in the cedar this fall to avoid infection next spring, according to Byrne.

Most landscape junipers show a fair amount of genetic resistance. The most affected plants are the Eastern red cedars that grow prolifically along the roadside. When using hawthorn or crabapple in new landscapes, take note if there is a large population of wild cedars in nearby areas.

NEW MAJOR GENE-EXPRESSION REGULATOR IN FUNGI

DOE/Joint Genome Institute

Science Daily, May 8, 2017

Just four letters—A, C, T, and G—make up an organism's genetic code. Changing a single letter, or base, can lead to changes in protein structures and functions, affecting an organism's traits. In addition, though, subtler changes can and do happen, involving modifications of the DNA bases themselves. In eukaryotes, one such modification involves adding a methyl group to base 6 of adenine (6mA).

In the May 8, 2017, issue of *Nature Genetics*, a team led by scientists at the U.S. Department of Energy Joint Genome Institute (DOE JGI) report the prevalence of 6mA modifications in the earliest branches of the fungal kingdom. Though fungi have been around for a billion years and collectively are capable of degrading nearly all naturally occurring polymers and even some human-made ones, most of the species that have been studied belong to just two phyla, the Ascomycota and Basidiomycota. The remaining six groups of fungi are classified as "early diverging lineages," the earliest branches in fungal genealogy.

"By and large, early-diverging fungi are very poorly understood compared to other lineages. However, many of these fungi turn out to be important in a variety of ways," said study first author and DOE JGI analyst Stephen Mondo. "Consider the Neocallimastigomycetes—these fungi are one of the most powerful degraders of plant biomass currently known and have a tremendous arsenal of plant cell wall degrading enzymes which may be useful for bioenergy production. They are a good example of how exploring these understudied lineages leads to valuable biological and technological insights."

Many of the fungal genomes used in the study were sequenced as part of the DOE JGI's 1000 Fungal Genomes initiative aimed at producing at least one reference genome for every family of fungi. For the study, the team used 16 fungal genomes sequenced using the Pacific Biosciences sequencing platform. While the technology was used with the goal of attaining very high quality genome assemblies, DOE JGI scientists have now additionally taken advantage of this sequencing platform to explore epigenetic (5mC, 6mA) modifications. They discovered very high levels of 6mA in fungi, where up to 2.8% of all adenines were methylated, confirming these findings using multiple independent methods. The previous record holder for genomic 6mA, noted Mondo, is the alga *Chlamydomonas reinhardtii* (sequenced and annotated by the DOE JGI), in which just 0.4% of adenines were methylated.

GIANT GERIATRIC FUNGI

Nick Iadanza

MushRumors, Oregon Myco. Soc., May/June 2017

Conks, the woody, shelf-like growths on trees, are the fruiting body of a wood-rotting fungus that has infected a tree. Some, like *Ganoderma* and *Fomitopsis*, are perennial, adding a new growth layer during each growing season. These polypores are the major wood-rotting fungi, and cause considerable damage to timber resources. Fruiting occurs only several years after the tree has been infected, and by that time, the mycelium within the tree

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Giant Geriatric Fungi, *cont. from page 5*

has digested the cellulose in the heartwood, with the rot extending several feet above and below where the fruiting body occurs.

The fact that woody conks add a new spore layer each growing season makes it possible to determine their age. These layers look like growth rings in a tree, and the age of a fruiting body can be determined roughly by sectioning the conk and counting the tube layers. One author counted 37 layers in a specimen of *Ganoderma applanatum* (artist's conk). Another growing on a 150-year-old maple tree in New Hampshire was 47 years old and weighed 42 pounds. Ages of 50 to 70 years have been reported for some of this species. For the parasitic form of *G. applanatum*, the fungus will continue growing as long as the infected host plant survives.

Bridgeoporus nobilissimus (Fuzzy Sandozi), a species found in the Washington and Oregon Cascades, Olympic Peninsula Coast Range, and northern California, is the largest polypore in North America. A specimen collected in Lewis County, Washington, weighed 290 pounds (measuring 56 inches by 37 inches). It occurs on large noble and silver fir and western hemlock. The fruit bodies are long lived, and more than 100 tube layers per fruit body have been found.

A conk growing on an elm tree in Britain's Kew Royal Botanic Gardens (*Rigidoporus ulmarius*, giant elm bracket), once regarded as the largest living mushroom, weighed 626 pounds. It died after foxes built a den beneath it; unfortunately, its age was not determined.

The aging process using spore layers is accurate only in temperate climates where there is usually only one growing season, and the size of a conk may not be indicative of age. A giant polypore, *Phellinus ellipsoids*, with an estimated weight of 880–1100 pounds, was found on tropical Hainan Island in southern China, and was estimated to be only 20 years old.

If you are tempted by a conk while foraging, consider the longevity of a perennial conk before removing it from a tree. Will you use it or are you merely destroying something Mother Nature took a long time to create?

LUMINOUS FUNGI—WHAT MAKES THEM GLOW IN THE DARK?

Chromatography Today, May 15, 2017

Many people have heard about, and seen, fireflies lighting up the evening sky as chemical reactions in the insect's body cause the release of light. The phenomenon—bioluminescence—happens in other animals like fish and worms. Perhaps one of the best examples is when boats disturb phytoplankton in the sea which then emit a light that produces a glow in the boat's wake.

Now a paper published in the journal *Science Advances* carries a report from a team that explains how fungi also glow in the dark. There are apparently around 80 species of fungi that glow, or exhibit bioluminescence in different parts of the globe. But why do they glow and what makes them glow?

Glow in the Dark Mushrooms

Researchers first reported on *why* mushrooms glow in the dark rather than how. In a paper in *Current Biology*, a team reports that fungi use bioluminescence to attract insects such as beetles and flies. These insects then carry the fungal spores away to help the mushroom to reproduce and spread to new habitats—helping to ensure that the species survives.

But the team also discovered something special about one species of mushroom—*Neonothopanus gardneri*. It can tell the time. Well, perhaps not when Coronation Street is on, but, it uses its circadian clock to tell the mushroom when to glow. The circadian rhythm or clock is simply the 24-hour rhythms that are observed in many living things which control physiological processes like sleep. But in this particular mushroom, the clock told the mushroom when it was dark enough for them to glow—so that they didn't waste valuable chemical energy glowing in the sunlight. But this didn't tell the researchers *how* the mushrooms glow.

Lucifer has the Answer

Now an international team from Japan, Brazil, and Russia has isolated the chemical reactions that fungi utilize to glow. They determined that the glow in mushrooms is due to the interaction of the compound luciferin and the enzyme luciferase in the presence of oxygen forming a compound called oxyluciferin.

They analyzed the reaction using high performance liquid chromatography and mass spectrometry and state that the light is emitted when the oxyluciferin releases an oxygen molecule and returns to its ground state. The energy released in this reaction is emitted as green light—the light seen by the insects the fungi hope to attract. The use of mass spectrometry to analyze samples for novel compounds is discussed in the article "Tackling the chromatographic analysis of novel psychoactive substances with High Resolution Mass Spectrometry."

The same reactions are used by many other species to emit light, and the researchers could even tune the reaction to produce different colors of emitted light. The work might help researchers in genetics, who could use genes that code for light in their research.

POISONING ON SOUTH WHIDBEY **Kyle Jensen**

Whidbey News-Times, May 16, 2017

According to South Whidbey Fire/EMS Deputy Chief Wendy Moffatt, two adults on South Whidbey accidentally poisoned themselves by eating mushrooms picked on their property, where they had foraged fungi for years. Moffatt said they could be described as mushroom experts, but she wouldn't say where on the island they were. Details are unclear owing to the Health Insurance Portability and Accountability Act, which protects patient privacy.

CHEERED BY CHILDREN, SHIITAKE FARMER BACK ON HIS FEET AFTER NUCLEAR CRISIS

Kyodo

http://www.japantimes.co.jp, May 11, 2017


Kyodo

Kyusuke Sasaki

MORIOKA, IWATE PREF. - Kyusuke Sasaki, 63-year-old shiitake farmer in Iwate Prefecture, nearly quit after his mushroom business was knocked out by the March 2011 Fukushima nuclear disaster. But letters of support from junior high school students expressing the hope to see a resurgence in shiitake farming lifted his spirits and encouraged him to press on, resulting in the resumption of shiitake shipments this spring—the first time in six years.

Sasaki, whose father had passed down his shiitake business in Ichinoseki, 150 km north of the crippled Fukushima No. 1 plant, is determined to revive Iwate as a major mushroom producer, even though his own production capacity has dropped to less than one-tenth of its pre-disaster peak.

After the government banned shiitake shipments from affected areas in April 2012 owing to high radiation levels, Sasaki devised a cultivation method that would meet safety standards by using trees grown outside the prefecture.

Together with local students, he planted shiitake spawn in about 2,000 tree trunks two years ago. Each log is about a meter in length.

This past February, Sasaki and about a dozen other farmers finally obtained approval to begin marketing their mushrooms. "Every single one is filled with the heart of every supporter," Sasaki said.

Wild edible plants and mushrooms grown on trees are vulnerable to radioactive contamination because they so easily absorb the elements of their environment, including toxic substances.

The triple core meltdown forced Sasaki to stop harvesting mushrooms and to abandon about 20,000 shiitake logs. Fellow growers gave up farming one after another after receiving compensation from Tokyo Electric Power Company Holdings Inc., which managed the now defunct Fukushima No. 1 power plant.

During the uncertainty that followed the shipment ban, Sasaki prepared to resume work by cutting undergrowth for decontamination. He was about to throw in the towel in spring 2015 when a bundle of letters changed his mind. In the envelopes were hand-drawn pictures of shiitake mushrooms with inspirational messages, such as "Shiitake are powerful" and "Never give up." The letters had been written by schoolchildren and organized by Sasaki's acquaintance.

Sasaki is not sure whether consumers will welcome mushrooms from his farm, but he aims to continue cultivating shiitake and move on to the next stage—i.e., resuming the use of local tree trunks.

"It would have been wiser to call it quits, but growing yummy shiitake would be tantamount to returning the favor to everyone (who has supported me)," Sasaki said.

According to the health ministry, food restrictions still applied to municipalities in 14 prefectures as of April. The 14 include Aomori and Shizuoka prefectures, which are more than 350 km north and 300 km southwest, respectively, of the Fukushima plant.

RADIATION-RESISTANT MUTANTS AT CHERNOBYL PAVE THE WAY FOR LIFE ON MARS

Becky Ferreira

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Comic book logic dictates that a high dose of radiation will turn you into the Hulk, Godzilla, Radioactive Man, or any number of other radiation-induced superbeings. In real life, it's more likely to cause deleterious mutations, as shown by major ecological damage in nuclear meltdown fallout zones like Chernobyl and Fukushima.

These contaminated regions have become a popular destination for scientists interested in the immediate and long-term impact of radiation on wildlife, which has led to the formation of intriguing niche disciplines, like radioecology and radiobiology.

Understanding how living organisms adapt to radiation doses has a range of applications, from medicine to conservation, but one of the most overlooked is preparation for long-duration human space missions and interplanetary colonization, both of which involve sustained exposure to higher radiation doses than what we experience on Earth's surface.

An experiment conducted on the International Space Station last year examined this idea with the help of eight fungus species from the Chernobyl exclusion zone that sprung up in the wake of the 1986 meltdown, and two of them—*Cladosporium* molds—seem to prefer radioactive surfaces. The fungal samples were curated by a team led by Kasthuri Venkateswaran, a senior research scientist at NASA's Jet Propulsion Laboratory, who goes by Venkat for short.

"The radiation seen at Chernobyl is high, but this black fungi popped up first [after the meltdown] compared even to the bacteria," Venkat told me over the phone. "That is how we selected those fungi, from such a radiation-rich environment. These fungi persisted due to some sort of protein-coding and biomolecule information that protect against the radiation level."

Would ingesting such a hardy mold give one radioactive superpowers? Not quite—or more accurately, not yet. The eventual goal of Venkat's research is to develop a fungi-based "sunblock" for outer space radiation that could be used to protect humans from the harmful effects of long-term exposure. The fungi were returned to Earth just a few months ago, so the results are preliminary, but Venkat and his colleagues are eager to pursue the research further.

"We have to take all the precautions before building a human habitation on Mars and beyond," he told me.

In addition to helping humans become more radiation-resistant, studying the wildlife in fallout regions can also yield insight into engineering crops that can survive the radiation environment beyond Earth—especially highly irradiated worlds like those in the Jupiter system.

The Chernobyl exclusion zone is significantly more radioactive than the interior of proposed long-duration spacecraft, which makes it a bad direct analogy to outer space. But the ways in which crops develop tolerance to contaminated environments is rich with clues about surviving sustained doses of cosmic radiation.

"Radiation-resistant genes can be incorporated into yeast cells that produce beer so that humans are willing to go to space—they will have a better beer to drink," Venkat said, as one example.

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Radiation-Resistant Mutants, *cont. from page 7*

Fallout zones are also useful testbeds for studying astrobiological questions about the search for aliens on other worlds, and the origins of life on our own planet. Flax crops grown at Chernobyl in the decades since the meltdown have demonstrated increasing resistance to contamination, for instance, leading some researchers to wonder if their genes are a kind of vestigial time capsule to the dawn of life on Earth.

"My favorite speculation is that when life on Earth was evolving, radioactivity was much more present on Earth's surface than is today," Martin Hajduch, a senior scientist at the Slovak Academy of Sciences' Institute of Plant Genetics and Biotechnology, said of his research into Chernobyl flax. "And so the plants are somehow 'remembering' it, [which is] what helped them to adapt in Chernobyl's radioactive area."

In this way, the world's worst nuclear disasters, which have threatened the health of our planet, may now help us understand our origins on Earth, and learn to survive the harsh conditions beyond it.

GETTING THE MOST FLAVOR OUT OF DRIED MUSHROOMS

Heather Yamada-Hosley

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Dried mushrooms are a quick way to add flavor depth to any dish, especially soups, stews, and sauces. They already bring a lot of oomph on their own, but you can add even more flavor when cooking with dried mushrooms by changing what liquid you rehydrate them in.

Most of us just throw dried mushrooms into hot water, cover them (so they rehydrate faster), and wait for the water to be absorbed. That's fine—you end up with a tasty, mushroom-infused liquid that you can use as a stock base—but if you swap the water for stock or wine, you can make something with a much richer flavor. The mushrooms gain more flavor from the wine or stock, and you also get a mushroom-infused stock mixture that you can either use in your current dish or save for another time. I recommend heating the stock up before adding in the mushrooms as it'll make them rehydrate faster. For the same reason, if you're using white wine, try to bring it to room temperature before soaking the mushrooms.

This will be the last newsletter until September.
Here's to a good summer!

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