SPORE PRINTS

BULLETIN OF THE PUGET SOUND MYCOLOGICAL SOCIETY
Number 570 March 2021

THE MYSTERIOUS EXISTENCE OF A LEAFLESS KAURI STUMP, KEPT ALIVE BY ITS FOREST NEIGHBORS

Sebastian Leuzinger & Martin Karl-Friedrich Bader
https://theconversation.com/, Feb. 14, 2021


Sebastian Leuzinger

Kauri tree stump in a rain forest in New Zealand with sap-flow sensors and other equipment attached.

Plants use their leaves to make food from the sun's energy and carbon dioxide. With very few exceptions of parasitic plants, no tree is known to grow without green foliage—or to be more precise, no tree can start life without leaves or some sort of green tissue containing chlorophyll.

But some may end up as "zombie trees" long after they lose all leaves and large parts of their trunk, either to disease or to the chainsaw.

Such undead tree stumps have been observed for almost 200 years, but the evolutionary and physiological processes leading to their existence remain a mystery. One reason is because they are rare. Another is because whatever happens on their journey from feeding themselves to being fed happens out of sight—likely below ground.

American forest ecologist Suzanne Simard has shown that trees send each other signals through a network of fungi buried among their roots. This underground communication includes warning signals about environmental change and the transfer of nutrients to neighboring trees before they die.

We suggest this supply can continue beyond the apparent death of an individual tree. By measuring water flow in the stem of a living kauri (*Agathis australis*) stump and its neighboring trees, we show underground connections are indeed likely responsible for the survival of the stump.

A living tree stump is clearly a biological oddity, and our key question is why such root grafts form.

Who Profits?

It is unlikely a tree that has lost its foliage (through wind-throw, disease, or when it is felled) subsequently knocks on its neighbors' door (or, more accurately, roots) to ask for carbohydrates. Instead, we must assume that these root connections had been in place earlier, while the stump was still a normal tree.

If that is the case, we can assume root grafting to be the rule rather than the exception, at least in species in which living stumps have been observed. But what are the evolutionary advantages? And why are the connections maintained when a leafless stump is no longer actively contributing resources?

cont. on page 3

FUNGUS CREATES FAKE FRAGRANT FLOWERS TO FOOL BEES

https://www.theguardian.com/, Feb. 17, 2021

Fungi have been discovered making fake flowers that look and even smell like the real thing, fooling bees and other pollinating insects into visiting them.

The fungus *Fusarium xyrophilum* infects the beautiful yellow-eyed grasses of *Xyris* species from Guyana in South America. The fungus stops the plant making its flowers and then hijacks the plant's reproductive system to create its own forgeries made entirely of fungal tissue.

The fake flowers are a similar size and shape with petal-like features that reflect ultraviolet light to attract pollinators, especially bees. The phony flowers even use fragrances to make themselves even more attractive.

The fraud is so convincing the bees and other pollinators visit them, expecting to get rewarded with nectar and pollen but instead become coated with fungal spores, which they unwittingly carry off to other *Xyris* plants and infect them.

This type of hoax is not unique but it is by far the most elaborate fungal mimicry known. The leaves of blueberries can be infected by *Monilinia* fungi, turning the leaves into hoax flowers that reflect ultraviolet light, give off a fragrant scent, and ooze sugar to attract insects that normally pollinate the plants but instead carry off the fungal spores.


K. Wurdack Smithsonian Institution

Two orange-yellow "blooms" at right are fungal mimics of flowers produced by yellow-eyed grasses, such as the one at left.

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CALENDAR

Mar. 9 Virtual Survivors' Banquet, 7:30 pm, via Zoom
Mar. 15 Board meeting, 7:30 pm, via Zoom
Mar. 23 *Spore Prints* deadline

BOARD NEWS

Luise Asif

Remember to vote for the 2021–2023 Board! Voting closes Sunday, March 7. Brief reminder instructions: www.psms.org → Member's Page → log in with your user name and password → scroll to "Engagement" in the Member's Area Features → click on "Elections."

Derek 's inclusivity survey link was sent out to the membership on February 8. Please take a moment to respond; it takes only a few moments of your time. Reminder emails are being sent out. The replacement for the Yahoo Group list is up on the PSMS Website in the Members' Section.

Marion Richards, Wren Hudgins, and Danny Miller have begun short identification sessions conducted before each membership meeting. This will continue as long as there is interest and we are unable to hold live meetings.

The board is pleased to hold a virtual Mushroom Maynia in mid-May with Jeremy Collison chairing the event. Volunteer help will be needed. Following are a few areas where Jeremy would like your help. Contact volunteers@psms.org if you can assist or would like more information:

• Technical assistance for filming clips • Small group outing in local parks highlighting found mushrooms • Mushrooming stories, either written or filmed • Experiments with cultivation; garden, tubs, or grow chamber • Creating a video on various types of outdoor gear for mushrooming • Showing off your culinary skills by creating a video or providing photos and recipes.

These are a few things that are being considered. If you have another idea you would like to share, let us know.

Since an in-person Survivor's Banquet is not an option, a social hour will be held on Tuesday evening, March 9, via Zoom. Election results and the Golden Mushroom recipient will be announced. It will be a fun evening.

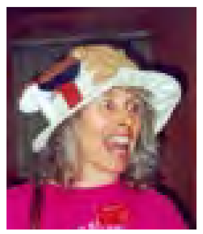
PSMS SURVIVORS' BANQUET

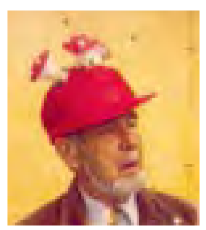
Marion Richards

Tuesday, March 9, at 7:30–9:30 pm via Zoom. This replaces our March general membership meeting.

Since we are unable to hold an in-person Survivors' Banquet, we have decided to hold a virtual social event in its place. This meeting will be casual and will be held on Tuesday, March 9, 2021, from 7:30–9:00 pm PST via Zoom.

We will offer a short lecture from one of our club members, announce our new board members, announce our Golden Mushroom recipient, showcase culinary creations (either sweet or savory, bonus for mushroom-looking creations), and last but not least, a mushroom-themed dress up contest. I will give the award forthe best mushroom costume with something artistic created with mushrooms in mind. We may also offer a short slide show of pictures from members of foraging finds and other fungi related interests. This will be a very casual event feel free to come and go. There will be time to mingle with other club members as well. The link to join will go out to all current club members a day before. We hope to see you there!





ONLINE ID HELP ADDED TO MEETINGS

Wren Hudgins & Danny Miller

In service of our club's emphasis on education, the Identification Committee will start hosting short online ID requests at 7:10 pm on evenings of membership meetings. The meetings will usually be open at 7:00 pm or possibly even a bit before for virtual socializing, then comes ID at 7:10 pm, and the evening program at 7:30 pm. There will only be a chance to entertain a few such requests per meeting, but unanswered questions can always be sent to ID@PSMS.org.

In high season we tend to get flooded with requests and can't get to them all. We prioritize serious inquiries that include clear photos of all angles of the mushroom and information on habitat, substrate, spore color, nearby trees, size, and any discernible odor. We like it if you try to identify your specimen first and give us your best guess and the reasons why you think that. If you don't hear back from us, that will mean that we aren't getting enough information to feel confident in our ID, or possibly that we are just overwhelmed.

To submit an ID question to us at a membership meeting, we ask that you complete an iNaturalist observation for your specimen and submit it to us at least two full days in advance of the meeting, i.e., by 7:30 pm of the Sunday evening prior to the meeting. More advance notice is obviously better than the minimum. Instructions for submitting an iNaturalist observation are below.

iNaturalist app INSTRUCTIONS

Download the "iNaturalist" app on your phone

Register in the app, or log in if you are already registered.

If you are charged for cell data usage, disable AUTOMATIC UPLOAD so you can wait until you are on WIFI to actually upload your observations. (APPLE: Click on the "ME" menu item, then click on the GEAR settings icon. ANDROID: Click the three horizontal bars in the top left then choose "Settings"). Now turn off "AUTOMATIC UPLOAD" and it won't use your data plan!

Click on OBSERVE

Take some photos! Get it from multiple angles showing every part of the mushroom! Before you click the shutter, check if the mushroom is washed out and missing details. If so, adjust the exposure to get the best picture.

WHAT DID YOU SEE? It may even be able to do computer recognition! Name it as best you can. Genus, Family, Order, Class, Asco vs. Basidio or simply Fungus is OK.

NOTES: Optionally add an important habitat detail, like "found on alder," and include anything unusual about this specimen, like "gill edges are pink!"

The app should automatically set the date and time of the observation, as well as your location. If the app warns you that there is no location data, the automatic GPS setting isn't turned on. Click where it says "No Location" and then click on the fancy arrow icon that selects your current location.

Once you are back home, don't forget to click on each of your observations to upload them once you're back on WIFI! (APPLE: Click on the "ME" menu item to see all of your observations).

To email one of your observations to ID@PSMS.ORG, click on the observation you are interested in, and then click the SEND icon (the box with the up arrow).

Zombie Tree, *cont. from page 1*

The short answer to these questions is we don't know. Root grafting, a phenomenon well known to foresters and gardeners, has barely been studied on a physiological basis. Much remains speculation.

A few evolutionary advantages for root grafting have been suggested, including increased resistance to wind-throw, kin selection (I will help you out if you are related to me), and increased access to water and nutrients coupled with the ability to shift those resources among trees.

The former two are more easily explained because all graft members benefit. But the latter is more difficult to understand.

Forests as Superorganisms

If forests feature interconnected root networks where water, carbon, and nutrients are exchanged, this would be equivalent to power, water, and gas grids supplying a city.

But what mechanisms control who gives and who takes? There is evidence that shaded trees are supported by non-shaded trees and the fact that stumps (pensioners) are still supplied with resources gives rise to the much bigger idea that forests act and survive as a whole—much like a single bee or ant has no chance to survive without being part of its colony.

Our discovery of the tight hydraulic coupling through root grafts suggests exactly that: a communal physiology among connected trees. This is a game changer for our general understanding of forest functioning. It shifts our perspective toward forest ecosystems as superorganisms.

But with all the advantages this may bring for the superorganism forest, root connections obviously imply a lack of social distancing. As with COVID-19, this makes it easy for pathogens to spread, especially in cases where the pathogen penetrates the vascular tissue, a tree's main transport route for water and carbohydrates.

Well into the 21st century, some great mysteries remain about how forests function. Research is particularly timely and relevant, given the rise in climate-induced forest dieback events due to more frequent and severe droughts, increased vulnerability to pathogens, and exposure to pests that come with warmer temperatures.

BRAZILIAN MUSHROOM STAMPS **Brian S. Luther**

Brazil is the largest country in South America and the 5th largest in the world and has an unbelievable biodiversity. My research has found five sets of Brazilian postage stamps (so far) that show fungi on them, with two of these being rather cryptic and requiring careful observation to see.

In the following table and text, M=mushrooms or fungi as the main illustration; MID=mushrooms or fungi in the design of the illustration, background, or border, but not the main stamp illustration; FDC=a first day cover, an envelope (cover) with the stamps affixed and cancelled on the day of issue, often with a cover illustration (cachet) of the same theme as the stamps; maxicard=a postcard with the stamps affixed and cancelled on the first day of issue, also often with a colorful illustration of the same theme; PP=presentation pack, an information brochure discussing the stamps, along with a set of stamps. All catalog numbers are from the Scott Postage Stamp Catalogue. R$=Brazilian Real; c=centavos.

Fungus-illustrated stamps from Brazil.

Issue Date	*Scott Cat. No.*	*Value*	*Type*	*Subject*
10/22/1984	1955	120 c	M	*Pycnoporus cinnabarinus*
"	1956	1050 c	M	*Calvatia* sp
"	1957	1080 c	M	*Pleurotus* sp.
10/23/1984	1958	120 c	MID	Intl. Book Day (see text)
10/12/1995	2558	R$0.15	M	*Gymnopilus ventricosus*
6/5/2003	2884a	60 c	MID	Art on recycled glass (Vidro) bottles (see text)
6/5/2019	3416a	R$1.6	M	*Geastrum violaceum*
"	3416b	"	M	*Pycnoporus cinnabarinus*
"	3416c	"	M	*Oudemansiella cubensis*
"	3416d	"	M	*Clathrus chrysomycelinus*
"	3416e	"	M	*Clathrus columnatus*
"	3416f	"	M	*Hydnopolyporus fimbriatus*

Scott 1955–1957

In the first set of 1984 stamps, the illustrations on the three stamps are paintings; unfortunately the first two are not very attractive. The first is identified to species and is a very common fungus worldwide, but the other two show only generic names. Maxicards were issued for this set. Each of the three maxicards has the same exact color illustrations as on the corresponding stamp (but full postcard size), with the cancel being round with three stylized mushrooms inside. I show only one of these maxicards here (Scott 1957). The FDC for this set has all three stamps on it, along with a very plain black & white cachet having the same images as on the stamps and the same cancel as on the maxicards. The three stamps are affixed on the FDC in an unusual way: the stamps are not in denominational (value) order left to right, but instead Scott 1957 is placed between the others.

Scott 1955–57.


Scott 1957 maxicard.

Scott 1958

The second 1984 issue commemorates International Book Day and shows a girl on an open book with many other things and organisms, including a purple mushroom up in the far right-hand corner, which for some reason is covered with a fine mesh veil (you have to look carefully to see it). Except for having the stamp itself, the FDC issued for this does not show any fungi.

Scott 2558

This is the first of a set of two stamps (Scott 2558–59) issued to commemorate the Americas. Scott 2558 shows a clump of five *Gymnopilus ventricosus* in the lower left-hand corner, along with an alligator and some trees, etc. The fungus is just as prominent on the stamp as the other things shown, thus I place it in my M category. The FDC for this set has the two stamps, but neither the cancel nor the cachet show any of the mushrooms, so I don't show it here.

Scott 2558.

Scott 2884a

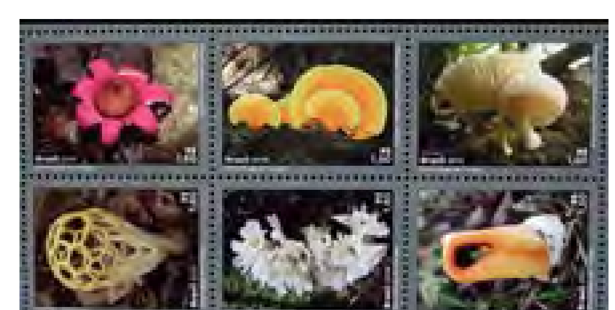
The 2003 stamp (Scott 2884a) is the first of four stamps in the set showing artistic items made from recycled materials, including glass, plastic, paper, and metal. This stamp shows three dark glass bottles, with the first illustrated with three stylized mushrooms, the largest showing gills underneath the cap and then two other buttons below. You have to look very closely to see these mushrooms—they're not obvious at all. The artist wrote "Licor de Café" (coffee liquor) on the bottom of the bottle as well. I have not yet seen an FDC issued for this set, but it most likely would not have any additional mushrooms on it anyway since the subject is recycled bottles.

Scott 2884a.

Scott 3416a–3416f

The 2019 set is quite nice. There are six stamps in the set, all good color photo images. The stamps are in a block with the top three oriented upright, but the bottom three are turned 90 degrees counterclockwise. All stamps are perforate and with gum. None of these stamps have scientific or common names on them, but are all labeled "Diversidade de Fungos" (Diversity of Fungi) and all are the same denomination. These six stamps come on a full sheet of 24 (thus four complete sets per sheet), and the sheet selvage is also illustrated with lignicolous mushrooms; these are also not identified, but may be *Oudemansiella cubensis*. Thus, if you only collected the set, not the sheet, you'd miss out on seeing more fungal illustrations.


Block showing four sets of Scott 3416a–3416f.


Close-up of Scott 3416a–3416f.

In the table and discussion below I've provided the species ID for these as best I can determine. *Geastrum violaceum* is known only from S. America. *Pycnoporus cinnabarinus* is found widespread worldwide in both tropical and temperate zones. The 2021 Scott Catalogue incorrectly lists this mushroom as "*Laetiporus Gilbertsonii*." That species does not occur in S. America. The stamp photo shows only a pileal (cap) view, but the form of the conks' attachment is not like that species at all. Because of its color and form I believe the correct identification of the fungus on Scott 3416b is as I've listed both in the text and table. For an absolute confirmation I'd need to see the pores underneath, which are not shown. Since, as I've mentioned, none of the stamp photos are labelled in this set, the Scott Catalogue must have gotten this info from the PP, which erroneously listed it as that species. *Oudemansiella cubensis* is known from North and S. America. *Clathrus chrysomycelinus* is known from Central and S. America, but has also been reported from Arizona. *Clathrus columnatus* is widespread both in tropical areas and in many places in N. America, and *Hydnopolyporus fimbriatus* is found in South America, Central America, North America, and Europe.

I was told by a Brazilian stamp dealer that neither FDCs nor maxicards were issued for this set, but the Brazilian postal authority did issue a PP for this set, which is fortunately in both Portuguese and English. It shows the stamps in color on the cover and provides a brief introduction about fungi in a few paragraphs, as well as discussing each of the six species illustrated in the set.

I've previously discussed the mushroom stamps from two other S. American countries: Uruguay (Luther, 2013) and Peru (Luther, 2015).

References

Luther, Brian S. 2013. Uruguay mushroom stamps show a Dermatophyte. *Spore Prints 497* (Dec.), p. 4. Online and in color at www.psms.org

Luther, Brian S. 2015. Mushroom stamps from Peru. *Spore Prints 508* (Jan.), pp. 7–8. Online and in color at www.psms.org

Advice to the Novice Mushroomer

In fields and in woods, in fall and in spring,
A mushroomer's guide I used to just bring,
To help me best know, right on the spot,
Whether this one, or that, was edible, or not.
On each it took me quite some time,
To key in on color, size shape, or the slime,
But absolute certainty had never resulted,
Only when experts were later consulted.
So my basket contained only those few that I took,
After cautiously studying some pages in a book,
While my comrades ran round and quickly collected,
Baskets of goodies that I must have neglected.
I thus would advise you, if you are able,
To take new finds home, and, laid out on the table,
With guides and spore prints, allaying all fears,
Learn a few new species for following years.

—Boris Subbotin
The Spore Print. LA Myco Soc.

BENEATH THE CANOPY, LICHENS SHROUD ALASKA'S COASTAL RAINFORESTS

Jake Buehler

https://www.hakaimagazine.com/, Sept. 18, 2020

In the isolated fjords of southeast Alaska, lush rainforest plunges down to meet the cold Pacific. There, among the fog and raven calls, is a glut of biodiversity. Tattered, leafy lichens stretch out on cedar limbs or hang as unkempt, verdant beards. Other varieties blanket rocks as tangerine freckles and carpets of seafoam antlers.

According to new research, this cold coastal region harbors more lichens—composite organisms composed of algae or cyanobacteria living in symbiosis with fungi—than almost anywhere else on Earth.

More than a decade ago, Toby Spribille, a mycologist at the University of Alberta, answered a call from the U.S. National Park Service to inventory the lichens of Alaska. In their initial sweep, he and his colleagues found a staggering 766 different lichens in just 52 square kilometers of the Klondike Gold Rush National Historical Park. That find made the team wonder if temperate rainforests nearer to the water-drenched coast were equally rich—if not richer—in lichens.

So in 2012, Spribille and an international team of researchers set out to survey much of Alaska's Glacier Bay National Park and Preserve. After months spent hunting down lichens, they collected nearly 5,000 specimens representing 947 species.

Those numbers reflect "tropical levels of lichen diversity"—comparable to what's found in Costa Rica, says Spribille.

The team's efforts, published recently in *The Lichenologist*, also uncovered many new species. Some 10 percent of the lichens couldn't be categorized into a known species, and 27 new species were discovered.

Though coastal Alaska is a lichen hotspot, that diversity doesn't seem to extend to other organisms. Amphibians in Alaska, for example, are roughly 100 times less diverse than in the tropics says Spribille.

Lichen-forming fungi, however, may disperse over long distances, which may allow them to thrive where other species can't readily colonize. In the Arctic, Spribille says, there are places of "mind-bogglingly" high fungal diversity.

Spribille adds that lichen diversity in Glacier Bay may be especially great since the area has had a very long legacy of coastal rainforests. In southeast Alaska, coastal areas such as Glacier Bay are thought to have been spared from severe climatic swings, allowing the rainforests to survive multiple glacial periods.

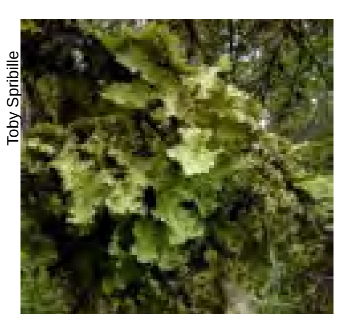
Microclimates within habitats can also contribute to this diversity, says Karen Dillman, an ecologist with the U.S. Forest Service who was not involved with the study. For instance, trees that only experience precipitation as fog will have different lichens than trees that get completely washed with rain, she says.

Out in the drippy rainforests, there are likely even more lichens waiting to be found.

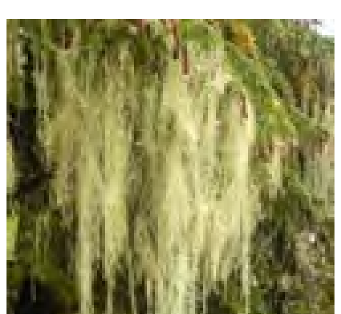
"The biodiversity of southeast Alaska is written in its fungi and in its moss," Spribille says. "You can't assume that you've found everything."

Toby Spribille

A sweep of Alaska's Glacier Bay National Park and Preserve found nearly 950 lichen species, including this toy soldier lichen.



Toby Spribille



Toby Spribille

Lettuce lung lichen (left) and Methuselah's beard lichen (right).

IMMUNE SYSTEM PRIMED AGAINST INFECTION BY GUT FUNGI

https://www.technologynetworks.com/, Feb. 8, 2021

Common fungi, often present in the gut, teach the immune system how to respond to their more dangerous relatives, according to new research from scientists at Weill Cornell Medicine. Breakdowns in this process can leave people susceptible to deadly fungal infections.

The study, published Feb. 5 in *Cell*, reveals a new twist in the complex relationship between humans and their associated microbes and points the way toward novel therapies that could help combat a rising tide of drug-resistant pathogens.

The new discovery stemmed from work on inflammatory bowel disease, which often causes patients to carry larger than normal populations of fungi in their guts. These patients often develop strong antibody responses against mannan, a molecule common to a wide range of fungal species. However, Dr. Iliyan Iliev, associate professor of immunology in medicine in the Division of Gastroenterology and Hepatology at Weill Cornell Medicine, noticed that healthy controls in these studies also had some level of anti-fungal antibodies. "There was no actual evidence for fungal infections in the healthy individuals that we examined, so we started thinking about the possible function of those antibodies," said Dr. Iliev, who is senior author on the study and a member of the Jill Roberts Institute for Research in Inflammatory Bowel Disease.

The team developed a platform that allowed them to determine which gut fungi are targeted by antibodies in the blood of individual patients. They detected a strong response against the yeast *Candida albicans*. Turning to experiments in mice, Dr. Iliev and Itai Doron, a Weill Cornell Medicine Graduate School of Medical Sciences doctoral candidate in the lab and lead author on

the study, found that colonizing the animals' guts with *Candida albicans* caused them to develop antibodies against the fungus in their bloodstreams, even though they didn't develop blood-borne fungal infections. Instead, the animals' immune cells appeared to transport fungal antigens to the spleen, stimulating the production of circulating antibodies in the bloodstream. "Those fungi just educate that immune response," Dr. Iliev said.

In patients with suppressed immune systems, such as organ transplant recipients and some cancer patients, fungi in the gut can invade the bloodstream and cause life-threatening infections. Dr. Iliev and his colleagues mimicked this process by treating mice with immunosuppressive drugs. When a *Candida* species colonizes the gut of these mice, the fungus moves into the bloodstream, causing a fatal infection. Treating the mice with purified anti-fungal antibodies from donor animals protected the immunosuppressed mice from these infections. The same strategy worked against infection with either *Candida albicans* or the emerging pathogenic yeast *Candida auris*, which has become a major cause of fungal disease in immunosuppressed patients and the elderly in recent years.

Collaborating with researchers at INSERM in Paris, France, the Weill Cornell Medicine team also looked at serum from patients with mutations in a gene called CARD9. This mutation affects a critical adapter protein in the immune system, leaving the affected individuals susceptible to severe fungal infections. Dr. Iliev's team found that the serum of these patients lacked the anti-fungal antibodies normally seen in serum of patients without this mutation. Experiments in mice confirmed an essential and specific role for CARD9 in priming the production of anti-fungal antibodies.

The results suggest that normal intestinal fungi such as *Candida albicans* may function as a kind of intestinal vaccine against fungal infection in healthy people, by inducing the production of blood-borne antibodies that can target multiple species of potentially pathogenic fungi. When those fungi do enter the bloodstream, the antibodies bind them and target them for destruction by cells of the immune system. In patients with suppressed immunity, the anti-fungal antibodies may decline, leaving them vulnerable to fungal infection. New therapies that involve either stimulating the production of anti-fungal antibodies, or injecting such purified antibodies directly into patients' bloodstreams, could potentially help combat these increasingly common infections.

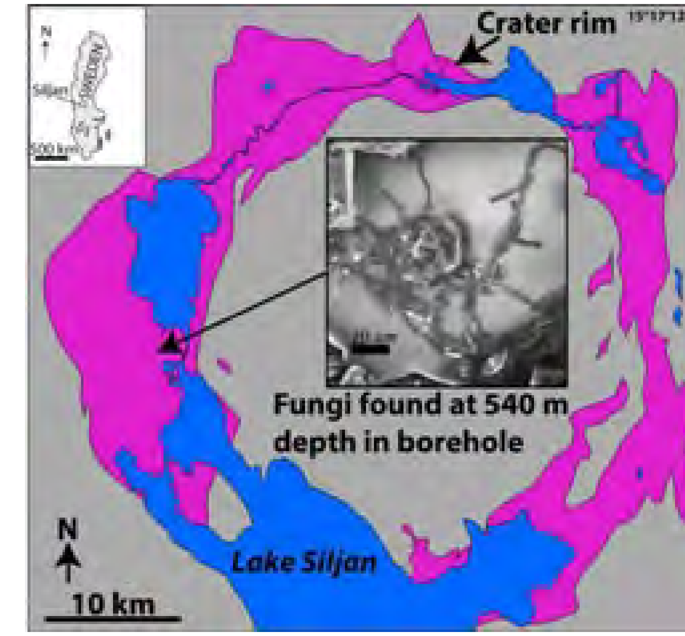
If that approach works, it would be a welcome development. "Many fungal infections in immunosuppressed patients and elderly patients are happening by translocation of pathogenic *Candida* species from the gastrointestinal tract, and the survival rates upon systemic spreading are alarmingly low," said Dr. Iliev.

EUROPE'S LARGEST METEORITE CRATER IS HOME TO DEEP ANCIENT FUNGI

Henrik Drake

https://phys.org/, Feb. 18, 2021

Fractured rocks of impact craters have been suggested as suitable environments for deep colonization of microbial communities. In a new study published in *Communications Earth & Environment*, a team of researchers shows that fungi have colonized deep parts of the largest impact crater in Europe, the Siljan impact structure in Sweden. Intriguingly, the fungi seem to have been fueling methane production in the crater.

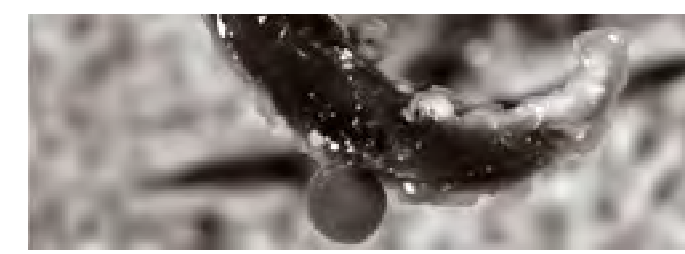


Linnaeus University

Graphic figure showing Lake Siljan.

At the scenic Swedish lake of Siljan, an impressive impact structure of more than 50 km in diameter formed almost 400 million years ago. In newly retrieved bore cores from drillings deep into the crater, a team of researchers has found fossil evidence of fungi.

The researchers examined an intensively fractured rock section at 540 m depth level in the crater and noted fine filamentous structures in the rock. After closer examination in the laboratory, it became clear to them that the filaments were fossilized remains of fungi—fungi that withstand the oxygen free environment at these depths.



Linnaeus University

Close-up showing fungus.

The relative abundance of different isotopes of carbon and sulfur within minerals found in relation to the fungi suggested to the researchers that the fungi were involved in methane- and sulfide-forming processes in relationships with other inhabitants of the deep biosphere—bacteria and archaea.

Henrik Drake, of the Linnaeus University, Sweden, and lead author of the study, explains the discovery: "The findings suggest that fungi may be widespread decomposers of organic matter and overlooked symbiotic partners to other, more primitive, microorganisms, thereby capable of enhancing the production of greenhouse gases in the vast rock-hosted deep biosphere."

Radioisotopic dating of tiny calcite crystals formed following microbial methane formation revealed an age of the fungi fossils to around 39 million years ago, more than 300 million years after the meteorite impact.

cont. on page 8

"We propose that the anaerobic fungi decomposed organic bituminous material in the fractures and produced hydrogen gas that fueled methanogens. This would be the first *in situ* finding of ancient anaerobic fungi linked to methanogenesis at great depth in the continental crust," says Magnus Ivarsson, at the Swedish Museum of Natural History and co-author of the study.

The impact structure, with a ring zone of down-faulted Paleozoic sediments, has been optimal for deep colonization of fungi, because energy sources in the form of organics and hydrocarbons from overlying shales have migrated throughout the fractured crater.

"The preserved organic molecules that we could detect in the fungal remains give us additional evidence for a fungal origin and also for the proposed biodegradation pathway of shale-derived hydrocarbons, ultimately leading to production of methane at depth," adds co-author Christine Heim of the University of Cologne, Germany.

Drake says, "Microorganisms and their strategies for survival and colonization of Earth's most hostile environments continue to amaze and surprise us, and here we add another fungal piece to the deep biosphere jigsaw puzzle."

The results are presented in the article "Fossilized anaerobic and possibly methanogenesis-fueling fungi identified deep within the Siljan impact structure, Sweden" in the Nature journal *Communications Earth & Environment*.

Try 'em

There are mushrooms that can kill you.
Some will nauseate or chill you.
And there's others that will fill you
with delight.

Some are simply unhygienic.
And a few hallucinogenic
Which will land you in a clinic
in a fright.

So the thing to do is fry them.
Get the wife and kids to try them.
Then it's easy to identify them.
Right?

—Ralph Nolan

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