Mushroom

The Journal of Wild Mushrooming

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◀ Small spalted bowl showcasing every type of spalting. Turned and spalted by Seri Robinson

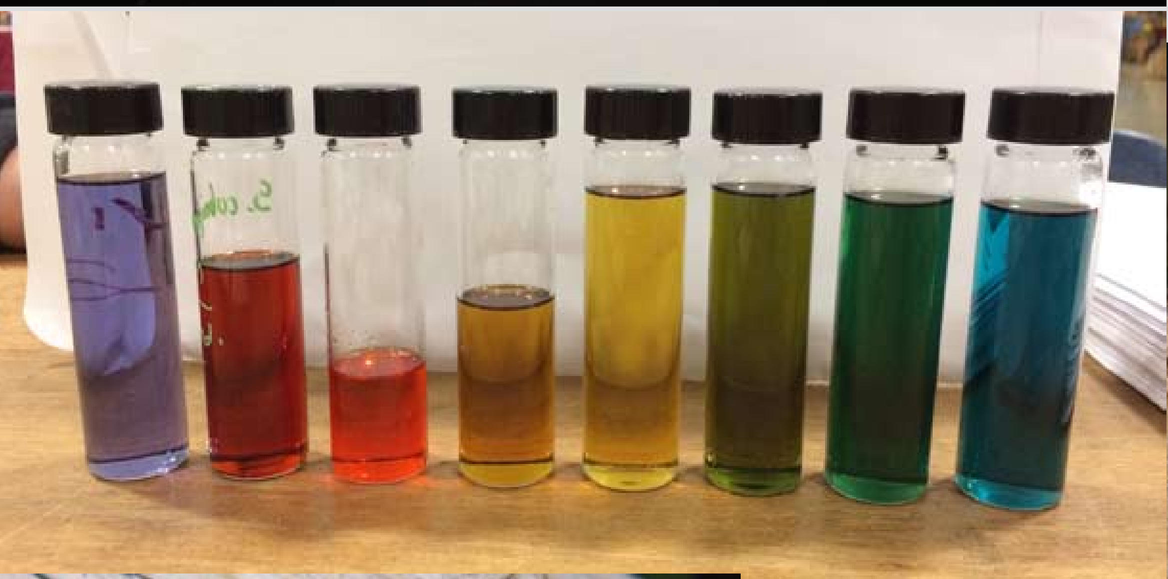
▶ (test tubes) Full range of colors available from the four primary spalting fungi: *Scytalidium cuboideum, Scytalidium ganodermophthorum, Chlorociboria aeruginascens, Chlorociboria aeruginosa*

▶ (Wood in the lower left corner) Green zone line from the Amazon rainforest of Peru. Many zone lines appear black but are actually just highly concentrated colors.

▼ (spalted wood just below) Red zone lines found in the Amazon rainforest of Peru

▼▼ (spalted wood bottom right corner) Red-purple pigment found in the Amazon rainforest of Peru

See the full article on p. 15!



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Cover Photo: *Amanita jacksonii* photographed by Walt Sturgeon. For more of Walt's photos, see the photo-essay on pp. 56-7.

Features

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The Newish Morels

by Bob Sommer and Leon Shernoff[1]

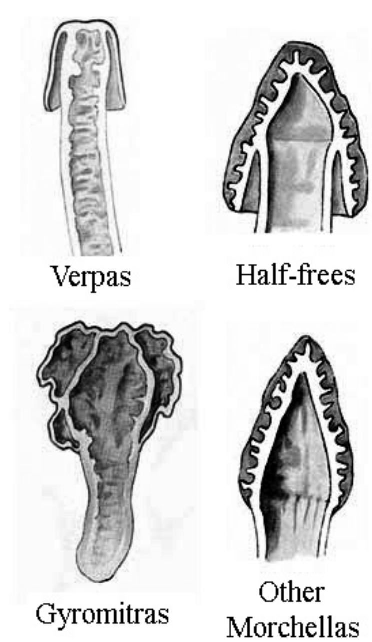
The morel is one of the best tasting and most sought after North American mushroom. The only risky look-alikes are *Gyromitra* species which are sometimes called false morels. They appear about the same time in spring as morels but are neither conical nor pitted. Morels dry easily and I don't wash them. I tap them on a hard surface to knock away any dirt particles.

Morels are edible and choice but should be cooked before eaten and the water discarded. Scattered or clustered in the wodds, or on bark, woodchips, fruiting from late winter to early summer. Some people can't eat them, which leaves more for the rest of us.

My last morel column in this journal was in 2004. Since then, several new morel species have been identified, mostly on the west coast of North America. I'm not sure how many of these names will be in field guides in 20 years but I'll describe their characteristics.

I'd rather hunt a tasty morel that may have a duplicate name than seek a dull *Agaricus* or *Lepiota*. But in this article I will be a splitter (to use an older taxonomy) rather than a lumper who tries to bring species together.

The DNA testing provides support for splitters not just in species but also in color categories. Back in 2004, one grouped morels into "yellows" and "blacks," with half-frees thrown in on their own as trouble-makers. With more refined distinctions being made now, mycology is now officially recognizing some new forms, including some new colors and color transitions.



Half-frees

These are true morels – with a honeycombed head – that have a head that projects a bit (like a skirt) where they meet the stalk (see the diagram on this page). They are easy to name, as only one species is recognized for each half of the country.

Morchella punctipes is the half-free morel that occurs widely east of the Rockies. *Morchella populophila* is a Northwestern species that occurs under black cottonwoods. *M. semilibera* is the name in most of your books; but this is one of those European species that turns out not to occur in North America.

Color categories and habitats

One can take the traditional color names as representing the color of the ridges on the honeycombed head more than the color of the head overall. The ridge edges of black morels will often look singed, because they are so much darker than the rest of the cap; and yellow morels can be quite brown in the honeycomb pits, but will have lighter ridges.

There are also three main habitats for morels. Some morels come out the year after forest fires, and these

[1] Bob is handling the west coast species and most of the general text here; Leon handles the eastern species and the text for the color-categories. Basically this is one of Bob's regular Easy Edibles columns with some extra ID information from Leon. The pronouns "I" and "my" all refer to Bob.

▲ Yellow *esculenta*-type morels (probably *Morchella americana*) showing the long, winding walls on the head, making for labyrinthine crannies.

are known as burn morels. Other morels come out under pretty much the same circumstances as other mushrooms – when their habitat is happy, the season is right, and they get enough rain. These are called "naturals." The third group comes out in "disturbed ground" – places where humans or nature have done excavation or other disturbances and rearrangements of the soil. In homage to the human role in many of these disturbances, these are called "landscape morels."

There is no intrinsic relationship between a morel's color and its lifestyle: all burn morels are black morels; we have both yellow and black "naturals"; and we have one yellow and one black landscape morel.

Yellows

Yellow morels have a pale head, often with a yellowish cast to it when they are mature. There are two groups of yellows: one has randomly oriented, often twisted ridges; so the spaces between the ridges look less like honeycomb cells and more like twisty passageways. These can get pretty big. These are the ones that have traditionally gone under the lumper name of *Morchella esculenta*.

The other group has gone under the name of *deliciosa*. They're about half the size of the first group, and they usually have some pretty straight vertical ridges, so the spaces between them look more like honeycomb cells.

The big (esculenta-type) yellow morels

Morchella americana, M. ulmaria

Cap 20-110 mm tall, 15-40 mm wide. This is the most common yellow in North America, and is widely distributed throughout the continent. It can be quite dark when young, but becomes gray or yellow at maturity.

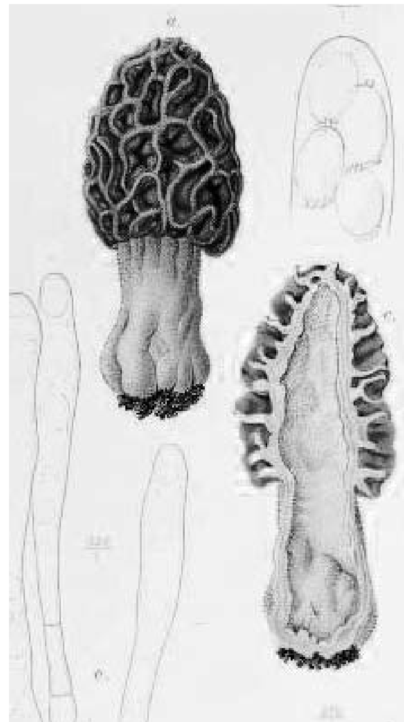
They start out life a pale grey and remain that color if they don't get much sunlight, leading some local folks to theorize that "grays" and "yellows" are a different species. And as far as eating goes, they might as well be, as they develop a very different flavor when they turn yellow.

M. ulmaria often appears identical to *americana*, and cannot be reliably told apart from it without sampling the DNA (leading to the synonym *M. cryptica*). It grows in Midwestern hardwood forests, especially under white ash, american elm, and tulip trees.

Morchella prava

Cap 30-60 mm tall, 20-50 mm wide, often roundish or even flattened, and the head is often dimpled or twisted. Its ridges are almost white from the beginning, but the pits can remain dark for quite a while. It occurs in states and provinces along the border between the US and Canada, from Quebec to Montana.

See also *M. rufobrunnea*, under the strange ones (below).



▲ *Deliciosa*-type morels, showing the more rounded cap and the cap cells that are not long and winding but also not vertically stacked. Illustration from Émile Boudier's *Icones mycologicæ, ou Iconographie des champignons de France,* Volume 2 (1910)

Little (deliciosa-type) yellow morels

Morchella diminutiva & sceptriformis

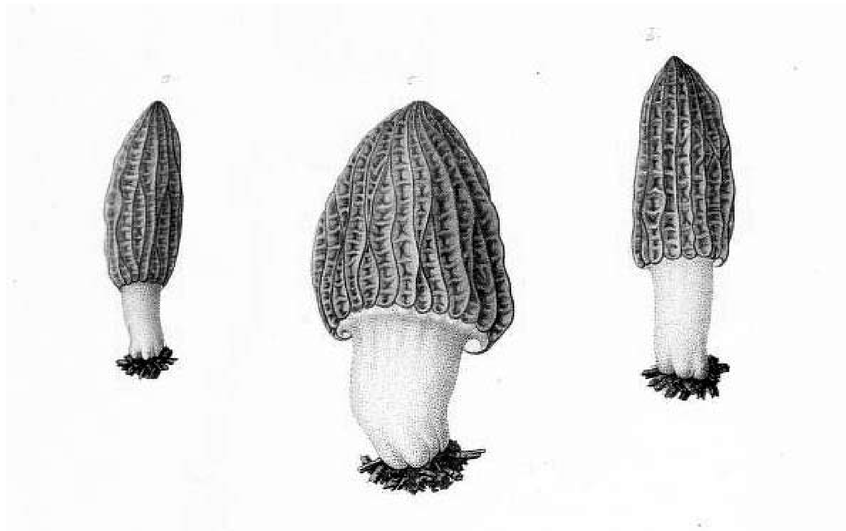
M. diminutiva has a cap 15-50 mm tall, 10-30 mm wide, and *sceptriformis* has a slightly larger size range. Otherwise, they are indistinguishable without a microscope. Their head tends to be more rounded – less tapered, less pointy – than *M. americana*.

M. diminutiva is found throughout North America, under a variety of hardwoods; *sceptriformis* is found in wet areas under tulip trees in the southeast (Virginia to northern Mississippi).

Black morels

Black morels can be all dark; or they can be tannish with dark ridges. When young they can be quite pale. But another way to tell them apart is that the pits on the cap tend to be vertically arranged – that is, the cap has many long, vertical ridges, connected by short crosswalls at irregular intervals, so their pits are often rounded rectangles. Kuo (2012) calls this arrangement "regularly laddered."

The half-frees are genetically closer to the blacks than the yellows, and this can be seen where the cap joins the stem. Although black morels don't have the full-fledged "skirt" of the half-free morels, the head of blacks will often project a little bit, creating a small groove under the overlap that Michael Kuo calls an "ant racetrack."



▲ The illustration from the original description of *Morchella eximia*, from Émile Boudier's *Icones mycologicæ, ou Iconographie des champignons de France*, Volume 2 (1910).
Typically for black burn morels, the cap is arranged in long vertical ridges with short crosswalls creating "regularly laddered" pits. The illustration also shows the "ant racetrack" groove between the bottom of the head and the stalk.

Black naturals

Morchella angusticeps, brunnea, septentrionalis/ pulchella

Cap 30-80mm tall, 20-50mm wide. The default natural black morel is *angusticeps* in the east, *brunnea* in the northwest. *Morchella septentrionalis* (which is probably the same as the European species *M. pulchella*) is a smaller, more northern species in the east that often fruits from or near fallen hardwoods.

Morchella snyderi

Cap 35-80mm tall, 30-50mm wide. Found in the northwest. The cap ridges are initially yellowish tan. They will darken as it ages or dries and become brown or black, but in the meantime, it is easy to mistake for a yellow morel. Kuo reports that "collectors often find *Morchella snyderi* in a sort of transition stage, in which the ridges are yellowish toward the bottom, but have begun to blacken toward the top." The stem develops ridges and pockets in maturity, and these are the best bet for telling it apart from other morels.

It is not a burn morel strictly speaking, but it will colonize burned areas before the other naturals do, and will come out the year after a fire on unburned areas within the aftermath of a fire.

Michael Kuo named it after Leon Snyder, who first gave this mushroom a scientific name and description in 1938. Snyder's name was invalid because his type collection included more than one species of morel; but Kuo says he did not want Snyder's work to be forgotten, so he commemorated Snyder with this name.

Typical western burn morels

Morchella eximia, exuberans, sextelata

Black Morel, Pink Morel, "greenies"

Cap 20-80 mm. tall, 20-65 mm wide; edges bluntly rounded. Edges brown to pale brown to dark brown, often on burned soil, sometimes in abundance on lightly burned soil. They emerge early in the season, "right after [the] fruiting of the natural black morels" according to Beug et al (2014).

These three species cannot be distinguished from each other without further science. As with the yellow morels, there are many misapplied names for these.

When pale they can have a pink tint to them; and when darker they often have a greenish cast. They share these color forms with other western morels (especially *M. tomentosa*) and (as with "grey" yellow morels in the east) these colors do not indicate a different species of morel. To quote Beug (2014), p. 194: "Commercial pickers know these four burn morel species as "pinks" and "greens," but the coloration of each… is variable, and color cannot be used to distinguish between them."

The reason that Beug et alia mention "four" kinds of burn morels above is that they listed *anthracophila*, *carbonaria*, and *septimelata* along with *sextelata*, but Richard et al (2014, published later that same year) showed that the first three of these were the same thing as the European speces *Morchella eximia*. So everyone can feel better about not being able to tell them apart. Boudier's illustration from the original description of *M. eximia* is shown on the facing page.

Among the three recognized here, *Morchella exuberans* is microscopically unique: its ridges have numerous protruding cells with a rounded head, making them "capitate," and giving the reason for the synonym *Morchella capitata*. But to distinguish *M. eximia* from *M. sextelata*, it seems that one needs to run DNA.

Although we're calling these "western" species, there has been an exciting find for those of us who, in our childhood, haunted the burnt-out campfire sites of our local NY woods [cough, cough] in an attempt to find burn morels in the east. Miller et al (2017) identified *Morchella exuberans* as the burn morel at forest fires in Michigan and Tennessee.

The paper says these morels are found at "conifer burn sites," which might explain their relative infrequency in the east, where most of our forests are hardwoods. Besides the two burns examined in the paper, the authors also mention previous reports of burn morels from conifer forests Minnesota and Ontario.

The fuzzy burn morel: *Morchella tomentosa*

A distinctive black morel found in burn areas of western North America. When young the cap and stem are covered in dense hair. It appears bald in age but Beug et alia say that even then under the microscope one can still find "abundant… brown hyphal tips" on the stem and ridges.

It starts out silvery gray, usually becoming a dark uniform blackish in maturity but the black surface "soon cracking and breaking away to expose white to ivory underlying tissue" so that it looks blond in age. But there are no burn yellows.

This one fruits later than the other black morels: in late spring and summer, sometimes even August or Sept if the forest stays moist. It is most abundant at high elevations, and has a northern distribution, near the border with Canada.

Western landscape morel

Morchella elata (= *M. importuna*)

This black morel is one of our two landscape morels in North America. The other is the much more yellow(ish) *M. rufobrunnea*. *Morchella elata* is a typical black morel – pointy cap, vertically arranged ridges – but it comes out in "disturbed areas."

This was named as *Morchella importuna* by Kuo et al (2012) and that name is still very popular – we've retained it in Jack Waytz's article on p. 58 because more people in the western US have a concept for it. However Kuo (2012a) was absolutely correct when he said

> I will not be surprised when a much older, European name is found for *Morchella importuna*; I have studied a collection that was sent to me from Belgium, and verified through DNA

▲ Photograph of *Morchella tomentosa* by Michael Kuo, showing the fuzzy tomentum that gives it its name analysis – and there are several European morel species… that appear, based on photos, to match the morphology and ecology of *Morchella importuna*.

Richard et al (2014, also mentioned in the discussion of burn morels) indeed found that *M. importuna's* DNA was identical to the much older European species *M. elata*.

Other color-forms

Morchella frustrata (= *M. tridentina*)

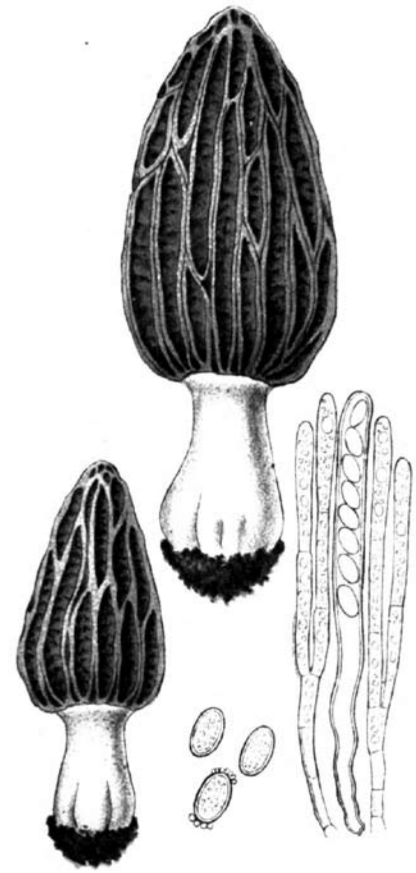
The name (given by Kuo) says it all. This species easily confuses. It is a black morel that isn't black. A PNW species, it is known as the "mountain blond." The only known competitors in ID are true yellow morels and *M. snyderi*. But it has the "ant racetrack" that yellows lack; and it doesn't develop the fancy stem of *M. snyderi*. It can be gray, brown, and occasionally even whitish.

The same 2014 paper by Richard et alia found that this is the same as the European species *M. tridentina*.

Morchella rufobrunnea

This is the yellow(ish) landscape morel. Cap (25-75mm) ridged and pitted with 10-20 primary vertical ridges and many secondary horizontal ridges, edges blunt or sharp. It darkens with age and bruises rusty brown to salmon when young.

O'Donnell et al (2011) found this to be the most basal current morel – that is, the one that genetically most resembles the ancestral morels from which all the current living ones evolved.



▲ Illustration from the original description of *Morchella tridentina* by Giacomo Bresadola, from *Fungi Tridentini Novi*, vol. 2, 1892.

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Some Morchella synonyms

The name in bold is the currently correct name, and it is followed by its synonyms

exuberans: capitata.
eximia: anthracophila, carbonaria, and septimelata.
elata: importuna
ulmaria: cryptica
americana: crassipes, populina
tridentina: frustrata

Mushroom

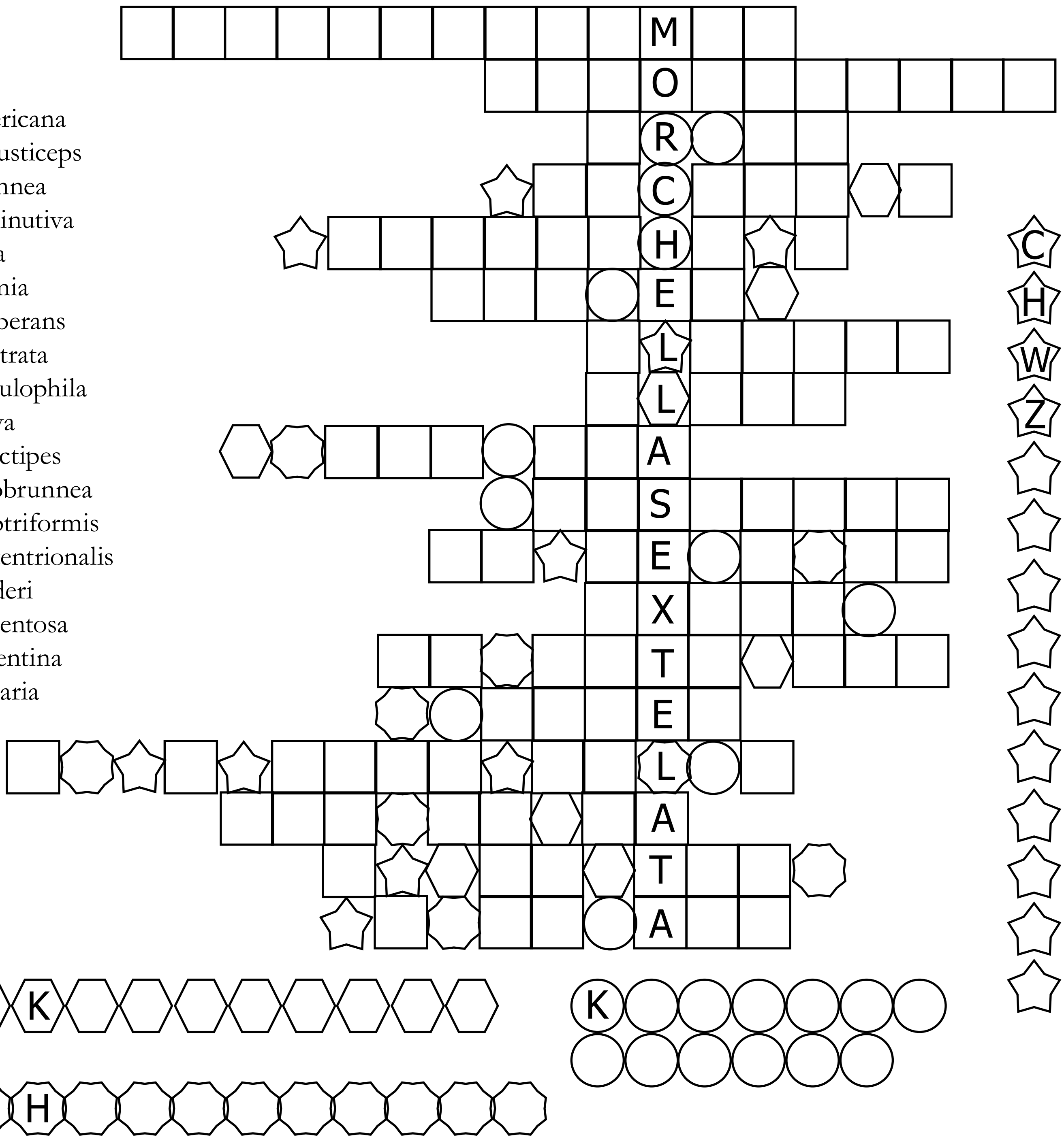
Morels, More Problems

by Donald Shernoff and Leon Shernoff

An acrostic is a set of words whose first letters spell out another word. This is a mesostic, a set of words with a middle letter that spells out another word, the scientific name of a morel. The cross words are all morel species names, and they are listed on the left below.

In addition, the letters in each of the non-square shapes can be unscrambled to form the name of a prominent morel taxonomist. Those have also needed some extra letters, which are provided in the sets of non-square shapes along with sufficient shapes to collect the appropriate letters.

americana
angusticeps
brunnea
diminutiva
elata
eximia
exuberans
frustrata
populophila
prava
punctipes
rufobrunnea
sceptriformis
septentrionalis
snyderi
tomentosa
tridentina
ulmaria



Remembering Maggie Rogers

by Will & Betty Gering

Mary Margaret (Maggie) Rogers was born in Seattle, WA. on August 4th, 1933, joining parents George and Eathyl Salisbury in Kingston, across Puget Sound from Seattle. Maggie's father was a chemist in Seattle; her mother an elementary teacher.

Sister Betty was born a year and a half after Maggie, as the family continued life in a cabin on their Kingston property. Shortly after Betty's birth, a fire erupted, consuming the property, forcing them to move to Seattle, where they were taken in by paternal grandmother Nana until a piece of property north of Seattle (Alderwood Manor, WA) became the new home. Around this home was logged-off land which provided opportunity to prowl and learn about "the woods."

With the family still growing, a move to larger quarters was effected in 1940. In 1943 Maggie's father suffered a cerebral hemorrhage, lingering for six months before passing away. Two daughters and a two-year-old son required her mother to return to teaching.

After Maggie's mother re-married, brother John arrived in 1945. Shortly thereafter, yet another move – this time to another cabin in the woods near Monroe. In 1949 Bruce filled out Mom's quiver. Life now was a very

▲ Maggie was drawn to mushrooming at an early age.

primitive existence, (off the grid) where the kids learned to carry water from the creek canyon and to study by the light of kerosene lamps.

The woods were a constant draw for exploring, picking berries and discovering morels and breadloaf mushrooms. Sometimes they served as a "meatless" dinner. Who knows how Maggie knew they were safe to eat?

Graduating Monroe High School with honors and a scholarship to Western Washington College in Bellingham, Maggie earned her teacher's certificate in 1955. She worked in the library where her love of books decided her future as a librarian.

After Maggie married, she moved to Vancouver, WA., teaching at Hudson's Bay HS and serving as the librarian. She continued to take college classes and received her Master's from the University of Oregon. During these years she was studying calligraphy, tree identification and grafting, colored pencil sketching, and dyeing fabrics with mushrooms. Her wonderful, witty and welcome hand-written and decorated notes and letters were always accompanied by clever drawings, cartoons, and poetry.

She loved classical music, fine art and good books, but mushrooming was her special avocation for many years. Her interests many and varied, her 85 years were filled with the wonder of life, living each day with curiosity and awe. Her interest in mushrooming took her all over the world, teaching and always learning more. She loved her many years as a member of Oregon Mycological Society for many years, leading forays, photographing and serving in many capacities, both local and nation-wide.

Many of her hours and days were spent learning more about wild mushrooms and sharing her knowledge with many like-minded friends far and wide. From Switzerland to the British Isles and Russia, she made lifelong friends and corresponded with them for many years. She left journals filled with her amazing adventures.

There is so much more to tell, but we are all blessed to have been a part of her colorful life for over 80 years.

Betty Gering is Maggie's sister. All photo courtesy of her and George Salisbury, Maggie's brother. There are two more photos on the next page.

Mushroom

Two photos of Maggie Rogers (see appreciation, p. 10)

A Term Defined

Illustrations by Anne Yen
Definitions by Jason Cortlund

Gleba

From Latin, the noun "gleba" describes the spore-bearing part of Gasteromycetes, fungi that include species of puffballs and stinkhorns. The fetid, dark tissue at the top of the stinkhorn *Mutinus elegans* is its gleba.

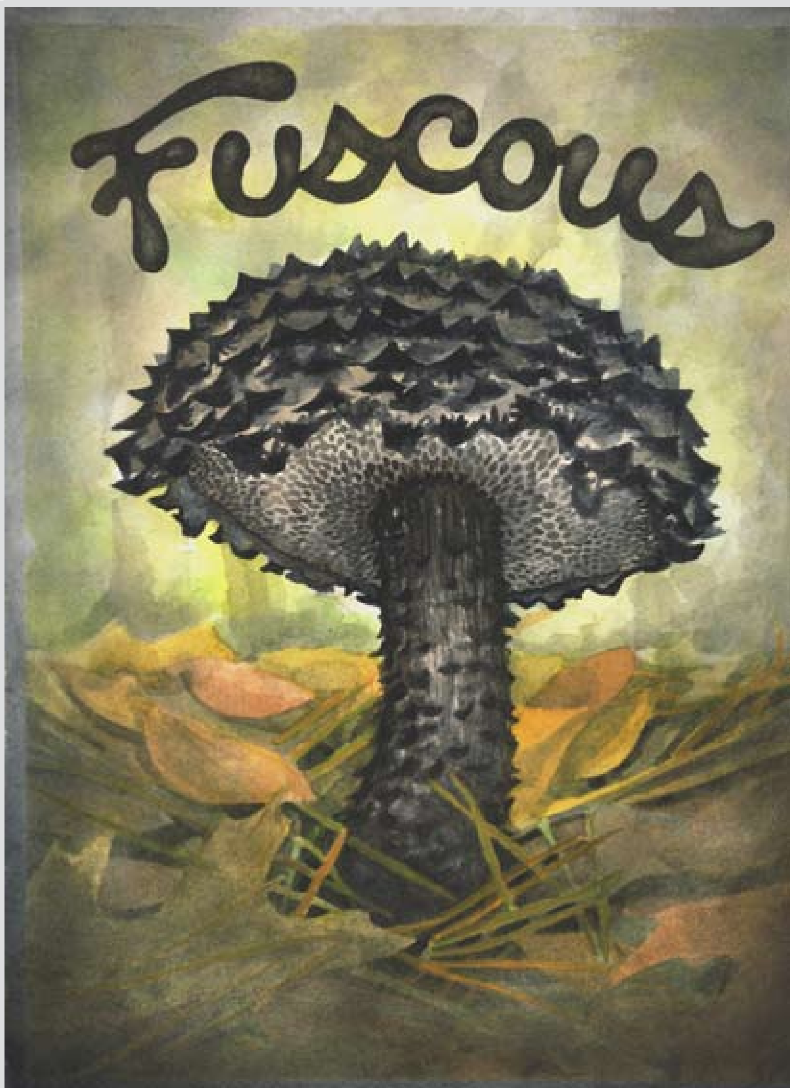
Fuscous

From the Latin fuscus meaning dark, swarthy, or tawny. The adjective "fuscous" (pronounced FUHS' kuhs) is a color description that refers to something of a brownish-grey hue or something that is dark or dusky. The bolete commonly referred to as Old Man of the Woods (*Strobilomyces floccopus*) certainly fits that description.

Flabelliform

The adjective "flabelliform" (pronounced flah-BELL-ih-form) comes from Latin and describes something that is shaped like a fan. While many species of polypore fungi growing from wood could be accurately described as flabelliform, few specimens would make a more elegant fan for keeping cool this summer than *Ganoderma lucidum* —also known as lingzhi or reishi.

A Term Defined: Gleba, Fuscous, and Flabelliform, first appeared in the Summer 2011, Autumn 2011, and Summer 2012 issues, respectively, of the New York Mycological Society (NYMS) newsletter. Artwork was revised by the artist for this publication and text was reprinted with permission by NYMS.



The Origins of Symbiosis

Four of the original papers that initiated the concepts we use today

Heinrich Anton De Bary

Schwendener: The Lichens as Parasites of Algae (1869)

The first publication on the symbiotic nature of lichens

van Benedén: Animal Parasites and Messmates (1876)

In which van Benedén published his concepts of mutualism and commensalism

De Bary: The Phenomenon of Symbiosis (1879)

De Bary did not like van Benedén's concepts, and came out with his own more general concept of symbiosis.

Frank: On the Nourishment of Trees Through a Root-symbiosis with Underground Fungi (1885)

The paper that gave us the term mycorrhiza

Except for the van Benedén, which is a long book, all four works are presented complete and unabridged, with study questions for classroom use.

Simon Schwendener

All the original engravings are included. Additional modern illustrations are provided through links on the supporting website, http://www.mushroomthejournal.com/symbiosis

van Benedén: The assistance rendered by animals to each other is as varied as that which is found among men. Some receive merely an abode, others nourishment, others again food and shelter.... But if we see, by the side of these paupers, some which render to one another *mutual* services, it would be unflattering to call them all either parasites or messmates (*commensaux*). It would be more just to call these latter kinds *mutualists*, and thus mutuality will take its place by the side of *commensalism* and of parasitism.

de Bary: Parasitism, Mutualism, Lichenism, and so on, are equally valid special cases of that general type of association that I call Symbiosis. If one wants to differentiate these primary categories further, then one might come up with antagonists locked in perpetual combat, or mutualists that each promote the welfare of both symbionts. But upon close examination, one cannot really endorse a sharp distinction between the categories. A sharp distinction is also missing in the other direction, that is between a "strict" symbiosis of connected symbionts with a common household, and the multitudinous relationships of organisms to one another that go under the name of social relations.

Frank: [this paper] concerns the fact that certain trees nourish themselves ...in symbiosis with the mycelium of a fungus, which carries out the function of a wet-nurse and takes over the entire nourishment of the tree from the soil. The whole body is thus neither entirely root nor entirely mushroom. Instead, as in the thallus of the lichens, a combination of two different species forms a single morphologically integrated organ, which can perhaps be suitably called a mushroom-root, or "mycorrhiza".

The Old Art and New Science of Spalted Wood

by Seri Robinson

No, it's not just moldy firewood. Spalted wood—wood that has been colonized by pigmenting, wood-decaying Ascomycetes and Basidiomycetes—has an ancient and current history in wood design.

A Little History

They heyday of spalted wood was in the 1600s in Germany, where several guild families created wall paneling, ceilings, and other large-scale flatwork for the royalty of the time. Its known use dates back to the early 1400s, and it persisted in intarsia (small pieces of solid wood being glued up to create a larger image) and marquetry (small pieces of veneer being glued up to create a larger image) until the 1700s, when synthetic colorants became more prevalent.

As Europe charged towards the Industrial Revolution, spalted wood moved from royal palaces and churches to upper middle class furniture. The 1700s saw spalted wood more in bureaus and boxes than walls or ceilings. Unfortunately, the use of spalted wood (and to some extent, where to find it and how to 'make' it) was a closely guarded guild secret. When the guilds fell apart during the Industrial Revolution, much of the collective art and craft knowledge was lost to time.

Some Definitions

Today, spalted wood is broken into three sub-types. The first, white rot,is the lightening of the wood (often to white) by the removal of lignin via white-rotting fungi. It is also sometimes achieved through a dense cluster of white fungal hyphae in one area. The second type, zone lines, are melanin or other relatively high molecular weight pigments secreted by fungi (secondary metabolites) that form winding lines in wood. The third type is pigmentation, which is still fungal secondary metabolites, but tends to be lower weight pigments that are secreted in patches inside wood instead of in a firm line. Some spalting falls between two categories, such as the black melanin of *Xylaria polymorpha* which forms lines so wide they often look like black mats, and many blue stains that secrete black and brown melanin that appears blue due to how light interacts with the surface of the wood.

Many types of fungal coloration are mistaken for spalting. Most mold fungi, for instance, are not capable of breaking down wood cell walls nor are their pigments capable of deeply penetrating wood. Hence, the *Trichoderma* and *Fusarium* in your life don't qualify. However, mold fungi like *Scytalidium cuboideum*, which is also a soft-rotting wood decay fungus is a spalting fungus. Basically, if it secretes pigment and can decay wood, it is a spalting fungus.

Spalting Revival

The process of spalting, and how spalted wood occurs in the forest, is well understood by science. Due to European guilds and the Industrial Revolution, however, whatever communal knowledge was held about spalted wood by artists and crafters did not make it into the modern era. As such, wood artwork from the 1400s-1700s that contain, in particular the blue-green from *Chlorociboria* species, was thought to be synthetic or at the very least, not from fungal sources.

Then a few enterprising scientists and art restorers began to ask questions in particular about the blue-green colored wood in many German and Italian intarsias and marquetries in the 1990s, foremost among them Dr. Robert Blanchette (USA) and Dr. Hans Michaelsen (Germany). They found fungal hyphae in the old intarsia and concluded that what had been suspected artificial color was actually due to fungi, and named *Chlorociboria* species the culprit, as this genus is the only known one on the planet to produce the distinctive blue-green color on wood.

Top left: Heavily spalted *Chlorociboria*-stained wood from Alaska
Top right: Close up of *Chlorociboria sp*. fruiting bodies
Above: Multicolored spalted wood done through live inoculation of the fungi into sound wood
Above right: Orange zone lines on *pashako* wood from the Amazon rainforest of Peru
Right: Red pigment of *Scytalidium cuboideum* in liquid culture, being used to dye paper pulp

Top left: Wallpaper samples dyed with spalting fungal pigments as part of a class at Oregon State University in the Renewable Materials program. The paper was also handmade by the students.
Top right: Spalted wood cut into veneer and pressed into flooring
Above left: Hand woven small rug with the fibers dyed from spalting fungal pigments. Rug was woven and dyed by a student at Oregon State University in the Renewable Materials program.
Above: Close-up of the rug
Left: Large spalted bowl showing the full range of spalting fungal pigments. Turned and spalted as a collaborative work by Mark Lindquist and Seri Robinson.

It has thus been confirmed across many artworks that spalted wood is present and was a commodity product back at the time the works were made. Modern use, however, has been somewhat limited. The first breath of the revival came in the 1960s, when the father/son duo of Melvin and Mark Lindquist used spalted wood (primarily zone line type) in their woodturning. As the family gained popularity and their work moved from craft turning to sculpture (and moved into major art museums), so too did spalted wood move along with it. Today the work of Melvin and Mark Lindquist, primarily with spalted wood, can be found in museums like the Renwick Gallery (Smithsonian) and the Metropolitan Museum of Art, among many others.

The popularity of the Lindquist work placed spalted wood at the forefront of the US woodturning consciousness. It still resides there today, and woodturners are the most likely segment of the US population to be able to tell you what spalted wood actually is. Interestingly though, science has taken a shine to spalted wood, and what those fungal pigments might mean in other areas.

Biology

Although no one is 100% sure why spalting fungi make their secondary metabolites, the most plausible answer is resource capture. Zone lines are generally composed of melanin—a high molecular weight pigment—that keeps fungal hyphae out of a given area. The pigments, in contrast, are released throughout the wood and have some antimicrobial properties (hence the *Chlorociboria* patent mentioned below). For slow growing fungi, the ability to color the wood first and colonize at their own pace seems like an outstanding evolutionary advantage. This also explains why the pigments are so durable: if a fungus takes years to decades to colonize a piece of wood, the pigment has to stay put, through any environmental condition.

Because the pigments and zone lines are released for competition and resource capture, it's not uncommon to have spalting fungi grow in laboratory media and not spalt. Spalting tends to be a response to stress, whether from other fungi or poor environmental conditions. Hence, adding things to media or wood, such as nitrogen sources and sugars, can have the unintended consequence of slowing the pigment production instead of speeding it up!

Modern Science

Scientists have long been fascinated by spalted wood. As chemistry grew from alchemy in Europe in the late 1700s (it is important to note here that chemistry was far more advanced in other regions, however here we are focusing on Western European spalting and so then Western European chemistry), scientists began to experiment with the blue-green color from *Chlorociboria* species. In particular they were interested in extracting the pigment, a feat that was successfully accomplished many times, using a variety of (relatively toxic) solvents, from about the 1800s onwards.

Once extracted, however, the pigment didn't have much value. A use for xylindein (the name for the pigment from *Chlorociboria* species) was patented in the early 1900s as a fungicide, however this does not appear to have ever gained much traction. Zone lines were also heavily studied around this time, and there is still much fascination about how they form (and a ton of scientific literature on the subject).

The real meat of spalted wood research started in the late 1970s/early 1980s, when two masters students from Brigham Young University started really trying to understand the mechanisms behind spalted wood as an art material. Although their work didn't go much beyond their thesis

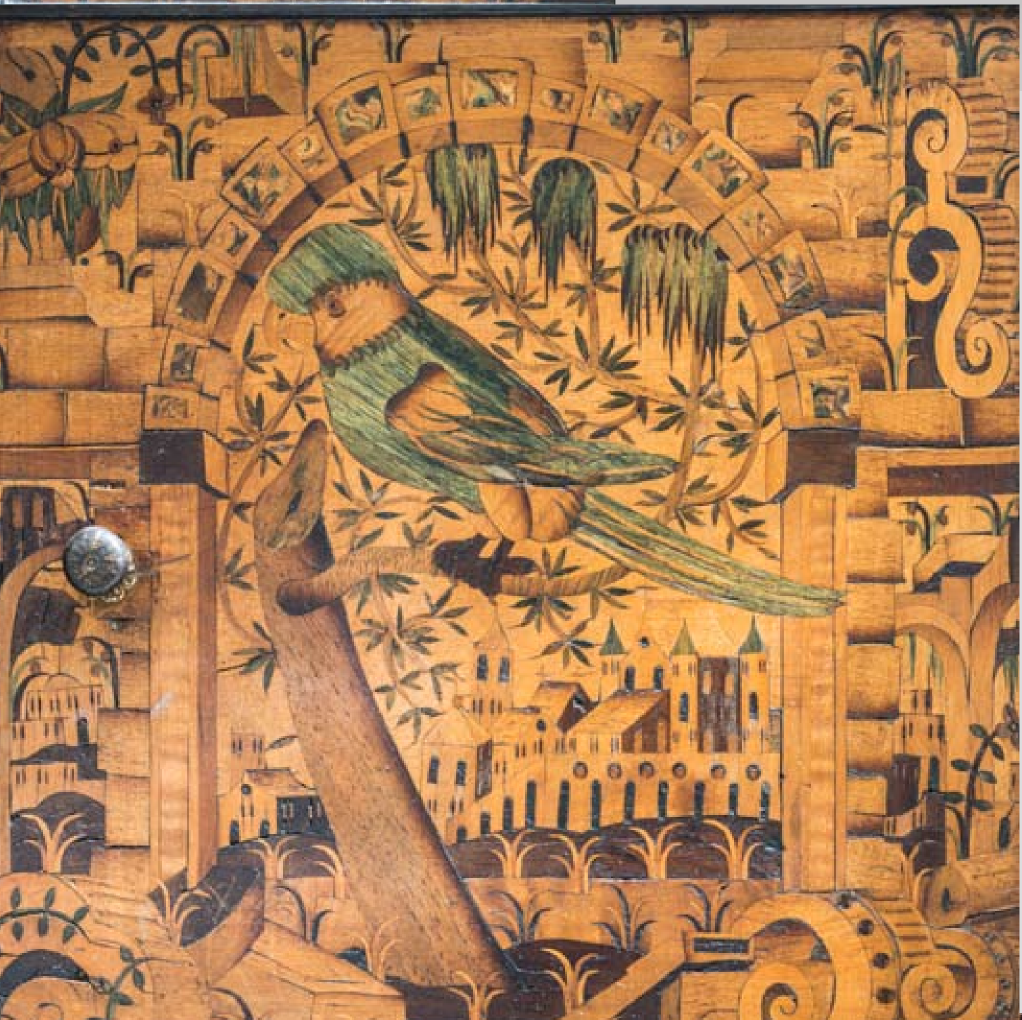
Spalting Around the World

Spalted wood occurs everywhere on the planet, and has a history with most cultures. As spalting research expands, researchers at Oregon State University have been able to visit different areas to learn about their historic and current use of spalted wood, and the myths that surround it.

For instance, spalted wood does not appear to have a history of use in historic woodcraft in Chile, but is used somewhat frequently today by artisans—particularly blue-green *Chlorociboria* wood—which is quite plentiful in the forests there. A potential reason why spalted wood was not used historically was told to Dr. Robinson in a 2018 trip to Chile. According to local legend, a small man called a 'trauco' lives in Chiloe forests. He is quite ugly and has no feet but is apparently irresistible to women (and was the method by which the people explained unplanned pregnancies for many generations). Blue-green wood on the forest floor is not to be touched, as it is the poop of the trauco and thereby quite dangerous.

Historical spalting: Bureau from the Bilbao Museum in Spain. Spalted wood (blue-green from *Chlorociboria spp.*) can be found on the interior and side panels. Made between 1560-1570, when blue-green spalted wood was in its heyday, as there were no other synthetic or natural pigments that had the same longevity in the blue range. Manufactured in South Germany.

Above left: side panel
Above: interior drawer
Left: panel detail



Historical spalting:
Cabinet from the National Museum of Decorative Arts, Spain (1600), decorated with images of birds. Manufactured in South Germany. All blue-green is from *Chlorociboria spp*. Overview and close-ups of some panels. Middle left is extreme close-up of the top-left panel.
Some synthetic blue and green pigments were coming up around this time, but none had the longevity of blue-green spalted wood, and so the use of spalted wood persisted.

(in terms of spalting induction), the flame was picked up again in the 2000s, when spalting research really took off—and is now a major research focal point for the Applied Mycology Laboratory at Oregon State University.

What does spalted wood research look like? On the zone line end, it's a lot of pairing fungi up on Petri plates and on sterilized wood blocks to study their interactions (and their melanin production). For the pigments it's more growing the fungi in liquid culture to stress them and cause mass pigment production so that the pigment can be harvested and applied to wood independently of the fungi, thereby decreasing or eliminating decay.

The pigments have also found applications outside of wood. Xylindein is under investigation as a thin film for solar cells and batteries—work supported by the National Science Foundation. Pigments from *Chlorociboria* and *Scytalidium* species can be used in inkjet printers to print textiles and soon, photos. The pigments are used as decking protection due to their UV resistance as tints in artists' paints. And so, so much more.

The components of spalting fungi that make them such excellent wood colorants translate well into other mediums, such as textiles and glass. As the fungi responsible tend to be fairly slow growing and the fungi are generally not primary wood colonizers, the pigments must be able to withstand rain and sunlight over decades. These properties also make them somewhat difficult to work with, as they cannot be extracted with water or ethanol, and scientists must often rely on stronger solvents such as dichloromethane (think paint stripper).

The potential applications have finally outweighed the frustration, however, and now spalting fungi are more than just an ancient art form and curiosity. Those interested in learning more about the deep world of spalting can get more information on the science from my website https://www.northernspalting.com, and more on the history from my book *Spalted Wood. The History, Science, and Art of a Unique Material* (Schiffer Publishing 2014).

Seri Robinson is the assistant professor and Gene D. Knudson Forestry Chair, Department of Wood Science & Engineering, Oregon State University

Historical spalting:
Cabinet from the National Museum of Decorative Arts, Spain (1600), Manufactured in South Germany. While not all the green is from spalting fungi, the leaves on the sides and front panel are from *Chlorociboria spp.*

Getting Started at Knowing Mushrooms

by Lee Schuler

I'm a fungal foraging guide. It's kind of a weird story, so I want to tell you about it. A few years ago, my first mushroom hike happened though a local community environmental center. A mutual friend of the director had outed me as a mycophile and they asked if I'd accompany their environmentalist on one of their regular nature hikes, to loosely offer any insight I had about the fungus we encountered. It sounded fun and I would be getting paid, so of course I said yes. The hike was listed on their website and adjusted to include me.

To my surprise, we ended up with a larger turnout due to the interest this community had in my (extraordinarily feeble) mushroom identification abilities. Their nature hike had suddenly turned into a mycology tour. It was terrifying and embarrassing for me, as I was not prepared to host any kind of large educational outing. I held back much of what I felt I knew in the fear that I'd inadvertently offer some misinformation or mistakenly express something in a way that could possibly result in someone getting sick. I was sweating and stuttering and worrying for the entire hour and a half.

I feel like I received 25-30 questions I didn't know the answers to, but we hiked and talked and we all laughed a lot, so I made it through. At the time I was slightly ashamed of my own performance, so I thanked everyone and left as quickly as I could. They unexpectedly called the following week to express their satisfaction with the resident turnout and the hike itself. They requested that I come back again for my own 3 hour hikes a few times a season. They also granted me access to private and even some protected areas to develop new hikes and look for anything I could offer. I had unwittingly and very randomly acquired a new, very cool part-time job.

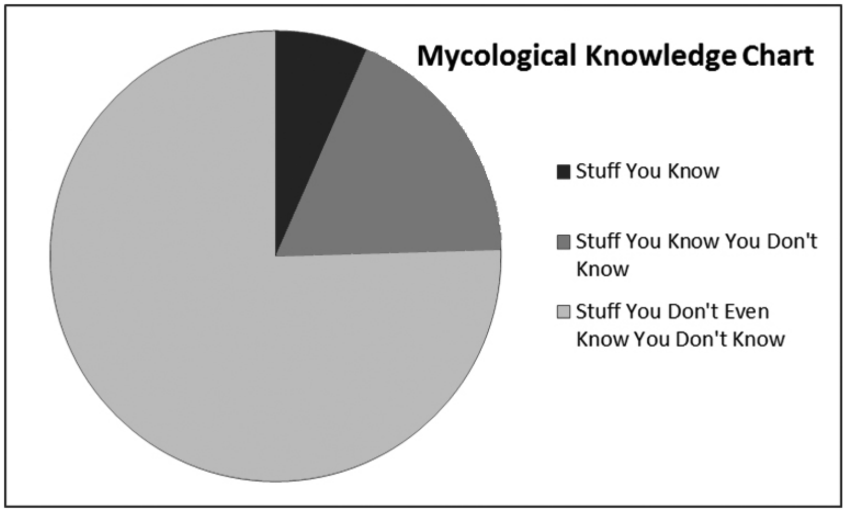
All of this has been a really big deal for me, and I never saw it coming. I knew I felt I owed it to the people I'd be guiding on these hikes to amp it up and dive deeper into fungal anatomy and some microscopy to further develop my knowledge base and myself, as I had internally vowed to never go into a fungal hike sweating and worrying again.

I slowed down my indoor cultivation hobby and shifted my focus onto wild ID and harvesting, although at any given time you will find a fruiting bag or log somewhere in or around my house. In my fifth year, I'm still not always completely confident with on-the-spot identification when it isn't a known edible or a known toxic species. I have made it to the point where I know what I don't know, I know how to positively find out, and I'm able to sometimes succumb to the idea that I may have almost no idea what I'm looking at in some moments.

The journey into wild mushrooming is a humbling one indeed as the more you learn, the more complexity you'll uncover. I find myself turning more to online forums than my field guides at this point, and I'm eternally grateful to the incredibly knowledgeable and passionate mycologists I've encountered or become friends with. Watching people who know what they're talking about argue through a tough ID is the best learning tool there is, in my opinion.

I offer more than the environmental center walks now. I offer educational walks on people's property to tell them what they have and help to enable them to harvest wild food from their own land. I offer hikes for small groups at local parks occasionally. More recently, I've been asked to offer informational displays and classes at a few outdoor festivals. All of these things are quite literally the things of my dreams, and I would be happy to do them on my free time for no charge at all. I do actually complete most of it in my time off from my day job, but it's even been integrated lightly into my Dept. of Environmental Protection duties. All of this still strikes me as somewhat odd because I didn't aspire to teach anything to anyone. I don't feel technically qualified to teach these things. I simply happen to know a little bit more than the other guy who also knew a bit, so here we are. Honestly, I don't particularly enjoy the teaching aspect of it but I'm so incredibly passionate about mycology and fungal foraging that I rarely think of it as teaching.

To close, I decided to compose a short step by step analysis of how this happens for other beginners who want to start on the road to becoming mushroom foragers, since the very first question I'm always asked is;



"Where do I start to learn the things you know about mushrooms?"

Step 1

Be passionate about everything biological.

No, really. If you don't take note of everything going on in the ecosystem you're foraging, you're often going to be misled about what you think you've found. Learn about fungal ecology and mycorrhizal relationships. Learn to identify plants and trees, and pay attention to these fungal companions. And start using binomial nomenclature, even if you aren't a biologist or have any formal science background. I was formally educated in Biology and Environmental Science here in PA at East Stroudsburg University, where I focused on microbiology and ecology. I now work in entomology and public health (not my plan, but paths often curiously lead where they may). Being a biologist has helped, obviously, but it isn't necessary and these things can be accomplished with enough commitment and passion.

Step 2

Understand that you have no idea what you're talking about.

I don't mean this completely literally, of course. I have gotten to the point where I can say that I'm quite skilled in fungal cultivation and fungal foraging. I'm confident enough to talk about it with seasoned mycologists when the rare opportunity presents itself. I feel as though I know more about it than most of the other people I encounter. I have only scraped the surface and dug a little, and I've also made a fool of myself on many occasions believing one thing to be another. Please see the mycological knowledge chart for a visual representation of what it's actually like to learn about mycology. Just know that you'll need to be committed to fungal study, and need to commit to learning in general because as with most of the cool and complex things in life, you'll never be able to stop.

Step 3

Commit to learning.

You will need field guides. You'll need to study the field guides, but more importantly you'll need to be outside studying the fungus in its habitat and taking in all of the ecology around you. When you have no idea what you've found take pictures and go home to figure it out, with help if need be. Never decide that you just don't know. Keep going until you figure it out – every single time. Experience and correcting your own misunderstandings will be your best teachers.

Step 4: Try to find a suitable mentor.

The Mycology community isn't very large, but the local foods/farm to table/foraging movements have prompted a lot of growth recently. I watched mycology experts online and tried to find someone with a cohesive personality to befriend, who I could message or call quickly for advice on random issues that might arise. I needed some encouragement to really stick with the process, and I also wanted someone to whom I could present my progress (or lack thereof), and keep myself focused. I learn best kinesthetically; by going out and doing the thing I want to master, so I decided a distance mentor would work. Luckily a brilliant, patient, encouraging, and kind person filled this position even though I never actually asked him or told him he was selected. It went exactly as described and he was available to me from time to time for questions, complaints, direction, and lots of positive reinforcement. He's still an invaluable resource and also a cherished friend. Just in case I haven't thanked him enough, he will undoubtedly read it here again.I'm a bit of a handful sometimes and he deserves the gratitude. Additionally, if someone reading this is in need of encouragement or light mentoring, you may feel free to contact me via email: Lschuler@ymail.com. I'd be willing to try my best to help you along.

The Joy of Black Trumpets

by Joe and Kathy Brandt

Swoon: The mind/body reaction to sticking your face into a bag of fresh-picked black trumpets, and inhaling deeply. Anyone who has ever found these in any quantity will know what we're talking about. Fresh *Craterellus cornucopioides* elicit a sensory (visceral?) reaction that defies description. These beautiful, delicate, flower-like mushrooms are among our all-time favorites, and have no parallel in the mushroom world. Certainly, there are other types of chanterelles, but nothing that compares with black trumpets (a/k/a horn of plenty, a/k/a trumpet of death).

From most of the reports we've received, 2018 was a banner year for these, surpassing most mycophile's wildest dreams – and definitely the best we've seen in 30 years or more. In the northeast, climatic conditions seemed to have created the "perfect storm", and people were finding them in places where they had never seen them before. We're sure that unofficial records were set for both size and quantity – never mind the diversification of locations!

So you're meandering happily through the woods, and suddenly "...what, to my wondering eyes should appear, but a...." (Hint: it's not a miniature sleigh and eight tiny reindeer!) Be still my beating heart! It's a virtual carpet of the damn things! Pulse racing – OMG! Do I have enough bags? Oh – there are more over there! And over there! By the time you get back, you're absolutely giddy – but now the work begins, unless you need to store them in the 'fridge for a day or so, until you have adequate time to devote.

When you've found only a few "Blacks", it's easy enough to clean them, more often than not without the use of water at all – just a superficial brushing, or it you want to be really thorough, opening each one to be sure there are no spiders, slugs, or other surprises hiding inside – but when you have any real quantity of these, this is simply impractical. The first decision that needs to be made is whether to dehydrate, cook & freeze, or do some of both.

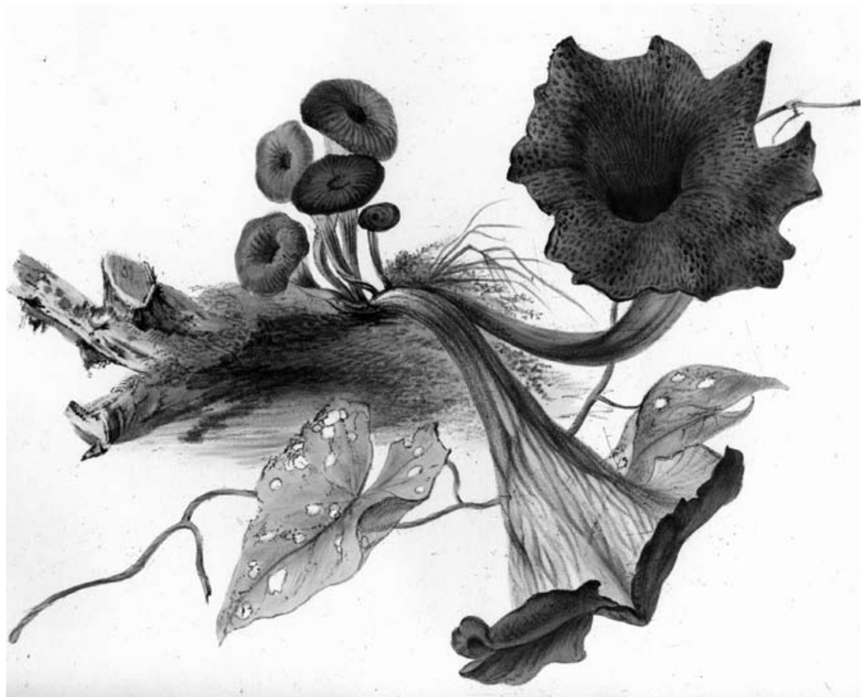
For drying, we recommend cleaning first, since dehydrated dirt or insects are not any more appealing than they are in a "natural" form. The method of choice for cleaning is a (deep) water bath, employing the use of the largest bowl or pot you can lay your hands on. Fill your bowl, and dump in your chanterelles (which hopefully, you have remembered to cut the bottoms off of when you were harvesting), then agitate them gently with your fingers. Dirt will sink, insects and twigs will usually float. Using a sieve, skim off any floating insects or debris, then using your hands or a wide-wired strainer, carefully scoop out the chanterelles, transferring to a colander to drain. (If possible, pour out the water onto a suitable substrate – it will contain spores!) Repeat the process if necessary – but only if the mushrooms are very dirty. Gently towel-dry as best as possible. Now for the fun stuff.

Black trumpets cry for butter (or a butter substitute), as do chanterelles in general. You can certainly cook them in a neutral-flavored oil if you have the mind to, but we can assure you that they're "better in butter". Do you need anything else? No, but some minced fresh garlic (added halfway through cooking) is highly recommended.

Cooking time for these can be a bit tricky. Conventional wisdom says that you should sauté chanterelles for 2-3 minutes, which is fine if you only have a few in your pan, but any quantity at all requires a longer cooking time, and under-cooking these results in a leathery texture and a decidedly "under-cooked" flavor. As a rule of thumb, you want to cook them long enough to have at least most of the released liquid evaporate, keeping them stirred every so often. A little salt is OK, but not necessary.

"That's it??" Yes, it's that simple. From there, you are limited only by your imagination. Black trumpets have an affinity for dairy. Once cooked, they may be combined with scrambled eggs, or incorporated into a cream sauce. Use them as a pizza topping. Chop them well, and mix them into softened cream cheese for a cracker spread that's super easy, and sure to please every time. Dried, re-hydrated Black trumpets are also good, but we find that dehydration sacrifices something in both texture and flavor – although there are differences of opinion as to whether the flavor actually becomes muted or intensified as the result of drying. When dried and ground, these may be used as a seasoning in certain applications.

For preservation, we much prefer cooking and freezing. When properly frozen (air removed as best as possible), these will keep for at least two years, while retaining much of their original flavor. Always remember to date-mark your containers, and use in chronological order. (For most applications, we recommend chopping them up a little before adding them into a recipe.)



Black Trumpet Stuffed Swiss Chard

20 fresh chard leaves, stems removed

Filling:

2 cups cooked yellow saffron rice
1/2 cup cooked black trumpets (sauteed in butter & garlic)
1 onion, chopped fine & sauteed
1/8 cup olive oil
1 egg, beaten (or egg substitute)
1/2 cup toasted pine nuts, lightly chopped
1 tsp chopped dill
1/2 cup chopped parsley
1 cup shredded low-fat mozzarella (or cheese alternative)
1/4 cup shredded Manchego cheese (or cheese alternative)
1/8 cup grated Parmesan cheese (or cheese alternative)

Mix filling ingredients. Roll into chard leaves. Grease casserole dish, stacking rolls tightly, seam side down.

Oil top surface, cover tightly (aluminum foil). Bake for 30 minutes at 350 degrees.

Black Trumpets with Ravioli

1 package filled ravioli, your choice (not mushroom filled!)
3/4 cup chopped cooked Black trumpets (cooked in butter with garlic)
1/2 package low fat (Neufchatel) cream cheese (or low fat cream cheese alternative)
3 Tbsp. tomato sauce
2 Tbsp. milk – low fat OK (or milk alternative)
Salt & fresh ground pepper to taste
chopped parsley or cilantro for garnish
Shredded Parmesan cheese (or cheese alternative)

Cook ravioli according to package directions. Meanwhile, soften cream cheese in microwave, 30 seconds. Mix in tomato sauce and milk.

Add salt & pepper to taste. Lay out cooked raviolis on serving dish, spoon cream cheese & warmed tomato sauce mixture over top, distribute black trumpets over everything. Garnish lightly with chopped parsley or cilantro, serve with shredded Parmesan cheese on the side.

Mushroom

Seeing the Songs

a review of David Haskell's *The Forest Unseen* and *The Songs of Trees*, by Ron Tracy

The Forest Unseen: A Year's Watch in Nature
David George Haskell
Penguin Books: 2012
170 pages

The Songs of Trees: Stories From Nature's Great Connectors
David George Haskell
Viking Press: 2017
292 pages

Some years ago I attempted to pursue my mycological interests with a closer focus. For my first attempt in that venture I selected a pile of logs and other woody debris I had dumped along the drive on our northern Wisconsin lake property. All summer I monitored the pile and photographed any signs of fungal activity, which turned out to be considerable. A highlight of that experience was my first view of *Pezizas* puffing out a cloud of spores.

My second close focus experiment was to mark off a square of two yards on a side in the woods and attempt to pay attention to any visible fungal activity in the square. It was less successful than my experience with the wood pile, yielding only a couple of *Russulas*. In light of those somewhat feeble efforts it was a pleasant surprise to read the first pages of David Haskell's *The Forest Unseen* and find that he was using a similar approach.

Haskell is a biology professor at the University of the South in Tennessee. He begins his preface with an explanation of Tibetan mandalas, which he describes as "a re-creation of the path of life, the cosmos, and the enlightenment of Buddha. The whole universe is seen through this small circle of sand." He then tells how a group of ecology students made their own instant mandalas by throwing plastic hoops on the forest floor and spending an entire afternoon just examining what is inside each of their individual plastic circles. That provides the structure for the book in which Haskell examines the life of a one-square meter patch of old-growth Tennessee forest for one year and uses that patch – which he refers to as his mandala – to ruminate on almost all aspects of the natural world. He ranges beyond his mandala to refer to overhanging trees and other features that pass through or surround the square. He becomes a sort of square-meter Thoreauvian who sees the world, indeed the universe, through his little square. The insights he presents are not little; they are grand and beautifully presented.

The chapters in *The Forest Unseen* consist of short detailed entries with descriptive titles such as "January 30th – Winter Plants" and "March 13th – Snails." The very first chapter, "January 1st – Partnerships," immediately captured this reader's interest for it deals with lichens, the partnerships between fungi and algae or cyanobacteria which covered all the rocks in Haskell's mandala.

He writes that on their own, lichen-forming fungi, algae and bacteria don't do well and are severely restricted, but by "stripping off the bonds of individuality the lichens have produced a world-conquering union" that covers nearly 10% of the land's surface. The chapter includes a well-written explanation of lichen relationships and how they function, the origins of lichen colors and then goes beyond the science to discuss the claim that "the fungi are exploiters, ensnaring their algal victims," a claim Haskell disputes. The chapter includes a section on the mating strategies of horsehair worms, an entirely different realm of partnerships and an example how the author includes very different realms and strategies in short chapters. This is not a science book as such; it is a series of insights and speculations based on science, on what is observed in the square mandala and they make compelling reading.

The second chapter, "January 17th – Kepler's Gift." Is a good example of how the book starts with science and then goes into more subjective considerations. On that day the mandala is covered with snow. Haskell examines some snowflakes, explains how they are formed, and refers back to the 17th century astronomer Kepler's attempts to explain their shapes without any knowledge of atoms and atomic structures. After this straightforward scientific and historical discussion Haskell concludes:

> I examine again the glassy stars on my fingertip. Thanks to Kepler and those who followed him, I see not just snowflakes but sculptures of atoms. Nowhere else in the mandala is the relationship between the infinitesimally small atomic world and the larger realm of my senses so simple. Other surfaces here – rocks, bark, my skin and clothes – are made from complicated tangles of many molecules, so my view of them tells me nothing straightforward about their minute structure. But the form of the six-sided ice crystals gives a direct view of what should be invisible, the geometry of atoms. I let them fall from my hand, and they return to the oblivion of massed white.

At nine pages "January 21st – The Experiment" is one of the book's longer chapters. Its subject is the physiology and behavior of Carolina chickadees as they relate to the bird's winter survival. The experiment referred to in the chapter title is that Haskell goes to the mandala and strips to face the twenty degrees below freezing weather that the forest creatures have to deal with. His personal experiment lasts for one minute but leads into his discussion of the chickadees and their survival or non-survival under such extreme conditions.

The following chapter is a similarly detailed exposition on the techniques employed by plants to survive freezing temperatures – clear, factual biology for the general reader along with phrasing that keeps one engaged: "Plants survive in the same way that a sword swallower survives – with careful preparation and meticulous attention to sharp edges."

Another example of what I term his engaging writing style is the first two lines of "March 13th – Snails": "The mandala is a molluskan Serengeti. Herds of coiled grazers move across the open savanna of lichens and mosses."

Describing the early spring flowers he terms ephemerals Haskell writes: "Once the ephemerals have unfurled their leaves, they reap sunlight and carbon dioxide at a furious rate. The breathing holes in their leaves, the stomata, are thrown wide open. Leaves are stuffed with enzymes ready to convert nutritious molecules out of air. These plants are the fast-food junkies of the forest: they eat rapidly, rushing to get through the meal before the trees block out the light." It is not scientific writing in a strict academic sense but it is delightful writing based on science and a deep appreciation of the wonders of ordinary, everyday nature in North America.

The mycological information in *The Forest Unseen* is presented as part of the larger web of life. "July 2nd – Fungi" begins with the appearances of cup fungi on twigs in the mandala which leads into a detailed introduction to the mysteries of fungal reproduction. The science is well-explained at an introductory level but Haskell writes that "The reproductive life of sac fungi and mushrooms is without parallel in the living world. They stretch the meaning of 'sex' beyond anything animals have achieved even in our most innovative moments." Several pages are devoted to hyphal fusions and the role of mitochondria making the entire subject "a refreshing counterpart to the rather uniform adherence to the roles of male and female in animals and plants."

"December 3rd – Litter" is also largely devoted to fungi and includes an explanation of mycorrhizal relationships and how they are vital to almost all plant life. Other mycological references are spread through the book in relation to other subjects. For instance, in "December 6th – Underground Bestiary" Haskell writes that springtails are some of the most abundant inhabitants of the forest floor and that there is some evidence that "springtails seem to enhance the mycorrhizal association between fungi and plant roots. They graze on fungal strands and thereby stimulate some fungi and suppress others. Springtails are like cows on a pasture, regulating the growth of their food by continuous clipping and by fertilizing the ground with their droppings."

A chapter on ferns explains that the common rattlesnake fern depends on a fungus for food for several years after germination of the spores. A chapter focused on deer explains fungi as an important component of the ecosystem in a deer's rumen and a chapter on vultures includes fungi in a digression on the disposers and decomposers in nature.

There is a wealth of scientific detail in *The Forest Unseen* but at the end of the book Haskell reiterates his more subjective approach: "This year I have tried to put down scientific tools and to listen: to come to nature without a hypothesis, without a scheme for data extraction, without a lesson plan to convey answers to students, without machines and probes." Furthermore, he writes, "there is a danger in an exclusive scientific way of thinking. The forest is turned into a diagram; animals become mere mechanisms; nature's workings become clever graphs." Overall the book contains considerable scientific information and some interesting speculations about what it all means, presented in a lively and personable format, pleasurable reading for outdoor enthusiasts.

Haskell's most recent book, *The Songs of Trees*, is a far more philosophical approach, a treatise on the inter-connectiveness of all living things rather than the romp through natural history presented in *The Forest Unseen*. Terms such as "network," "connections" and "relationship" occur frequently in the book reaching their apogee in a passage near the end of the book that states "human lives and tree lives are made, always, from relationship. For many trees it is nonhuman species – bacteria, fungi, insects, birds – that are primary constituents of the network. Olive and bonsai trees bring humans to the center, giving us direct experiences of the importance of sustained connection."

In other words, this is a book with an agenda but not necessarily an unusual agenda to those with some level of mycological expertise who have been dealing with the concept of fungal mycelia as the first internet for many years now. Other threads of concern running throughout the book include climate change, sounds related to trees and human interactions and impacts on trees.

The Songs of Trees has an interesting structure in which ten trees around the world (two more are included in Interludes) are repeatedly visited by the author and discussed biologically and then more subjectively in terms of relationships with the human environment. Thus we learn that the ceibo tree of Amazonian Ecuador and Peru sacrifices wood strength for speed of growth so it can quickly tower above other trees in its rainforest. Haskell discusses the considerable plant and animal life that inhabits the ceibo's branches and leaves and, after suffering a bad insect bite and worrying about a possible infection, notes that "for a virus the treetops are examples of primate blood, joined by mosquito rivulets," an example of the author's gift for phrasing.

He explains that many tropical plants have to invest much of their energy and leaf weight to chemical defenses against attacks by the wide variety of predators abounding in the tropical environment. The terrible sting of a bullet ant leads to a description of the Ophiocordyceps fungus that attacks ant brains and, later, to the fungal farming activities of leaf-cutter ants. The leaf-cutter relationships has been described many times but it was new to this reviewer to read how Pseudonocardia, "a genus of bacteria that live among the ant's body hairs, keeps the fungus healthy by oozing chemicals that suppress interloper fungus species." Then Haskell continues on to his underlying theme: "The ant/fungus/bacteria convergence of lives has produced an entity whose essence is relationship. Any simple part of this entity falls out of existence without interplay with the 'others.'" Continuing on with another of the book's underlying themes, the discussion of the ceibo ends with the possible results of encroaching oil exploration on the tree's future, referring to one of the book's underlying themes.

There is much more biological information in the Ceibo chapter than can be summarized in this review. One aspect of this chapter that exemplifies a difference between *The Songs of Trees* and *The Forest Unseen* is the use of tools and technology. A magnifying lens was the only tool utilized for observations in the mandala in *The Forest Unseen* but climbing harnesses and ladders were used to examine life on the ceibo tree and in later chapters different electronic devices were used to record sounds, water pressure and movement within trees, vibrations and other aspects of the trees' lives.

Mycorrhizal relationships get a full description in relation to a balsam fir in Ontario. Haskell states that "nearly 90 percent of all plant species form belowground unions with fungi…. For many trees, especially those like the balsam fir that grow in cold, acidic soils, the fungus/root relationship is particularly well developed, comprising a sheath of fungal tissue around every root. Working together, both fungus and plant can thrive in the challenging physical environment of boreal forest soils."

Above ground, balsam fir needles are host to endophytic (leaf-dwelling) fungi and the book claims that there might be as many as one million species of such fungi "making them one of the world's most diverse groups of living creatures." The chapter includes several pages on Carolina chickadees and needle-eating caterpillars in a broader perspective of the fir's ecological relationships, a pattern followed in most of the book's chapters. The underlying themes of the book come forth again in the ending of the balsam fir section which includes discussion of genetic engineering and the significance of the boreal forest as a carbon reserve in relation to climate change.

The last two trees included in the first part of *The Songs of Trees* are a sabal palm in Georgia and a green ash in Tennessee. They include the usual mixture of biology and other considerations. The palm grows on a Georgia island that is being slowly eroded away by changing ocean levels and polluted by ocean-borne plastic. The green ash is a fallen tree and a year's worth of monthly records of life on and around the fallen trunk is given. It is explained, for example, how the fallen tree made an opening in the forest which provided a basking area for wildlife such as rattlesnakes. This is used to inform the reader that while a lot of attention was given to fungus infected amphibians the past few years, little was noted about the fungal problems of rattlesnakes. Haskell writes that "in the last five years, fungal communities on the skins of rattlesnakes across the eastern and Midwestern United States have changed. One fungus species has overwhelmed the others, sickening or killing the snakes. The cause of this change is, for now, obscure. Warmer winters may make one fungus dominate the others, or trade in foreign pet snakes may have imported a new, more aggressive fungal strain." He continues on to wonder if fewer snakes could mean more rodents and possibly, for humans, more disease.

The first four trees in the book are trees that, to some extent (it is not entirely convincing) live apart from humans in relatively remote areas. The second part of the book takes a historical approach dealing with archaeological remains and fossils. The trees in this second section are the European hazel (Scotland) and ponderosa pine (Colorado). Analysis of charcoal remains reveal that the hazel was the dominant tree species in northern Europe for thousands of years, a staple food for hunters and gatherers. Many uses of the hazel are discussed and includes an interesting note on mining. Hazel was used for supports in mines for many years and miners told how they could depend on those wood supports as an early warning system, knowing when the creaking and groaning sounds of the wood signaled an impending collapse. That led some miners to protest when iron was brought in to replace the wood supports.

The ponderosa pine chapter was to this reader one of the most interesting in the book. It includes a discussion of the redwood tree fossils found in ponderosa areas tying it loosely together with the historical hazel chapter. The ponderosa chapter includes considerable information about water supply problems for mountain trees and how the mycorrhizal relationship helps the trees to overcome those problems. There is an interesting discussion of the sound of moving water in the trees which is often interrupted by air pockets: "Water pipes in trees are therefore like those in old houses, knocking and groaning as water moves…"

The final section of the book deals with trees with close human relationships such as in olive cultivation and bonsai production. Cottonwoods, Japanese white pine and the Callery pear complete the chapter. This city-dwelling reviewer enjoyed the chapter on a Callery pear tree in Manhattan growing in its own little square plot of soil (its mandala?) surrounded by cement and people. City trees do not generally get a second glance from most people but they might after more people read this chapter. One might think about things such as the city tree's water supply and the effects of pollution such as road salt and dogs, but Haskell introduces the vibratory world of the tree as being a key influence.

The vibrations are measured using technical devices attached to the tree's limbs and trunk (his earphones and wires attached to the tree attracted some interesting attention). He explains how vibrations such as cars, trucks, subways and pedestrians can impact a tree's growth. The vibrations stimulate more and stiffer root growth. "Tree trunks respond to movement by thickening girth. Inside, the cells that compose wood grow more densely, with stouter walls." The conclusion is that "a city tree therefore clings more tightly to the earth than its countryside cousins."

After reading both of Haskell's books this reviewer's first impression was that *The Forest Unseen* was the more enjoyable and informative book; it just seemed to be a more traditional natural history with the insightful bent of the mandala concept. The short chapter vignettes help move the reader along. Yet, going back through my notes I found myself surprised at the amount of new information I had acquired from *The Songs of Trees*. Yes, it almost gets preachy or mystical at times with all the references to relationships and networks but I have to admit it is a message many people have yet to acknowledge; nature is not something "out there" but right here wherever we are; we humans are part of the natural world ,we are nature, nature is us. Perhaps in mycological terms an alien viewer might see the entire Earth as one big mycorrhizal relationship.

The Forest Unseen and *The Songs of Trees* are both good reads and give some different and interesting perspectives on the natural world we enjoy as we engage in our various mycological pursuits. *The Forest Unseen* might be the more accessible of the two books but *The Songs of Trees* is also full of information and ecological insight.

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A Visual Feast, but Hungry for More

Review of *The Magic of Mushrooms*, by Sarah Prentice

This BBC documentary takes a broad, if not especially deep, view of how fungi shape the world, with dramatic images compensating for a lack of scientific heft.

Note: we ran the wrong version of this review last issue, and are here correcting that mistake by bringing you the correct one.

The Magic of Mushrooms, a 2014 BBC documentary, experienced a recent surge in viewership and interest after its addition to Netflix in November 2017. "Not merely a pizza topping," reads the Netflix summary, "mushrooms play a vital role in the world, which is revealed in this nature program hosted by professor Richard Fortey."

From veteran TV documentary producer Russell Leven, "The Magic of Mushrooms" is a mixed bag best suited for the curious layperson or casual hobbyist. The easy-to-watch film touches upon varied and substantive topics in mycology during its 50 minutes: plant pathology, toxicology, and reproductive biology, as well as culinary, industrial, and medical uses. However, the film contains a bit of erroneous material that detracts from its overall quality.

From the very beginning, the film ventures more widely across Kingdom Fungi than its title suggests. The host, Dr. Fortey, is introduced at a grocery store display of the ubiquitous button mushroom. He fills his cart with familiar fungal foods like cheese, bread, soy sauce, mycoprotein-based Quorn, and wine. His shopping trip extends to unexpected fungal products such as the protein in pet foods, red color of salmon, and citric acid in soft drinks and detergent. Next stop is the forest, where Dr. Fortey, basket in hand, highlights diverse macromorphology as he encounters coral, jelly, and bracket fungi.

Dr. Fortey, a regular voice in British science documentaries, is an amiable, Cambridge-educated paleontologist. He is the picture of a gentleman scientist with his tweed coat, charming accent, and contagious enthusiasm. While not a professional mycologist, he self-identifies as a decades-long fungi enthusiast whose favorite pastime is mushroom hunting.

Sights to Behold

The documentary is split into an introduction followed by three chapters: Birth (spore production and dispersal), Life (fungal trophic modes), and Death (toxic and entomopathogenic fungi). The film is visually striking throughout, with liberal use of time-lapse and slow-motion video. Colorful fungal montages also are a favored creative element. The film's soundtrack skews toward atmospheric art rock, including music by Chvrches, Radiohead, and Sigur Rós.

Visual highlights include microscopic footage of oyster mushroom hyphae trapping and consuming nematodes; the geyser-like spore dispersal of the orange peel fungus slowed down 600 times; and time-lapse footage of parasitic *Cordyceps* overtaking its insect hosts. At a Scottish mushroom farm, a laser beam in the dark reveals waves of spores wafting through the air – one of the film's most stunning scenes.

The movie maintains an engaging pace by switching between outdoor walks, lessons in the lab, animated segments, and interviews with expert guests. During lab segments, Dr. Fortey is joined by mycologist Patrick

Hickey for a variety of experiments and demonstrations. Dr. Hickey illustrates the significance of spore color in identification with two seemingly similar white mushroom caps: One produces a white spore print, the other brown. Separately, a time lapse of kitchen scraps decomposing in a large glass tube shows the crucial role of fungi in breaking down waste. Drs. Fortey and Hickey later challenge the notion that mushroom toxins exist to deter predators with an experiment: A slug is given the choice of five different mushrooms, ultimately feasting on poisonous *Hypholoma fasciculare*.

The film reviews several new and exciting applications of fungi. Eben Bayer, of New York-based biomaterials maker Ecovative, uses mycelium to bind shredded corn stalks in molds, creating an eco-friendly packaging alternative to Styrofoam. Medical researcher Dr. Cornelia De Moor studies cordycepin, produced by the entomopathogenic *Cordyceps* fungus. This compound shows promise for creating a new class of drugs to treat cancer and inflammatory diseases.

Several important figures in the history of British mycology are featured, including Alexander Fleming, whose contaminated petri dishes led to the development of penicillin; Beatrix Potter, well known as a children's author-illustrator but less known for her contributions to mycology; and A.H. Reginald Buller, discoverer of the spore-dispersal mechanism known as Buller's drop.

Short on Science

The sparsity of technical terms may frustrate the more advanced viewer. During his woodland tours, Dr. Fortey avoids scientific binomials in favor of common names: fly agaric, penny bun, sulphur tuft, poison pie. Kew Gardens mycologist Bryn Dentinger describes symbiotic relationships between fungi and plant roots at length without uttering "mycorrhiza" at all. A handful of other terms – spores on the sterigmata of basidia, hyphae, mycelium, saprotrophy – mark the extent of the film's infrequent uses of scientific language.

Trivia buffs will appreciate the film's fungal superlatives: the fastest (the hat-thrower fungus, with ballistospore dispersal reaching 40 mph) as well as the largest (a honey fungus in Oregon, whose mycelium spans nearly 2,400 acres) – of the genera *Pilobolus* and *Armillaria* respectively, although the film again hews to common names. The *Pilobolus* sequence is punctuated by the sound of champagne pops, an amusing but distracting touch.

During one of the animated segments, we encounter the documentary's most egregious mistake: an illustration labeled "a typical ascomycete," with a diagram depicting basidia! In mushroom biology, fungal phyla are defined by their sexual spores. The Ascomycota produce ascospores inside a sac called an ascus, while the Basidiomycota develop basidiospores atop club-like structures known as basidia. Representing an ascomycete with basidia is the mycological equivalent of saying dogs lay eggs.

Lesser offenses involve a few questionable choices in the film's many montages. The film opens with a series of fungi that dubiously includes a non-fungal myxomycete, or slime mold, resembling *Physarum polycephalum*. Later, chanterelles are interspersed in a display of poisonous fungi.

Mystic Pizza Topping

I question the film's effort to make mushrooms seem unnecessarily esoteric, with its claims of "unlocking the secrets" of organisms variously described as hidden, secretive, mysterious, "so strange it seems almost alien," and, of course, magical. Despite the tendency to ascribe near-mystical properties, the film omits any discussion of psychoactive fungi. There are legitimate topics on the subject, from the use of *Amanita muscaria* in Siberian shamanism to ergot poisoning as explanation for historical accusations of bewitchment, but the film remains conspicuously silent.

Overall, the film takes an anthropocentric approach to mycology, centered on fungi's relevance to humans. The narrator provides numerous comparisons to both plants and animals, but states fungi are "neither plant nor animal," while evolutionarily "more animal than plant." Spores are compared to seeds and mycelium to roots, and the fungal digestive process likened to that of humans. Yet Kingdom Fungi is never formally defined, perhaps to spare the viewer a tedious biology lesson.

The Magic of Mushrooms, despite its occasional shortcomings, manages to cover an impressively broad amount of material in less than an hour. Fun, fast-paced, and visually rich, it offers an intriguing introduction for the myco-curious and will be appreciated by lovers of nature documentaries. Even mushroom aficionados should take away something new or novel from the film. It is worth your time on an afternoon too rainy for mushroom hunting.

Mushroom

A Life Full of Mushrooming

Chuck Barrows speaks with *Mushroom the Journal*

Some of you may have heard of (or known) Chuck Barrows, one of our old, bold mushroom hunters. A tireless forager (and a sampler of everything) he would be best known to most readers as the namesake of Boletus barrowsii. *Barrows, born in 1903, wrote this piece for* Mushroom the Journal *in 1987, two years before he died. It is fascinating to see how much has changed – and stayed the same – about the field: foragaing, cooking techniques, and of course names.*

Many are beautiful, many are delicious, and some are both beautiful and delicious. I became interested in mushrooms when I was an art student living in Greenwich Village. I collected many species in Central Park and ate some of each.

The first one I found was the well known "chicken mushroom," *Laetiporus sulphureus*.[1] It really does have the consistency of the breast of chicken. It generally grows in clusters from a wound in a tree, most frequently an oak tree. One day as I was walking through the park, I came upon the most beautiful specimen I have ever laid eyes on. It was growing out of the black earth of the path, undoubtedly from buried wood.

It was a round cluster of eight or more banded vermillion caps overlapping like the petals of a flower, but more beautiful than any flower I have ever seen. I left it where I found it. It would have been a sacrilege to have disturbed it.

I have also collected it in Arizona and Mexico. In California it grows in quantity on eucalyptus trees but it is not as good to eat as those which grow on oak, and they even make some people sick. I ate some, however, without harm. It is interesting that the taste of a species of mushroom can differ when growing on a different tree.[2]

But to get back to my days in New York City: I also found the oyster mushroom and the little puffball (*Lycoperdon pyriforme*), and *Coprinus micaceus*. The puffball is good in soups and casseroles, and the *Coprinus micaceus* fried in butter goes great with your eggs for breakfast. They complement each other. Fry some onions and celery in butter until golden, chop up some *C. comatus*, add all to some chicken broth, butter and fine herbs, and stew a few minutes. It makes a great stew or soup.

The oyster mushroom is best dipped in egg batter, cracker crumbs and fried in butter. These are great for a light lunch. Beer goes well with oyster mushrooms.

The puffballs must be used at once or they will go on maturing and end up a slimy mess. This is true of all puffballs. Puffballs cannot be air dried in a humid climate, but in our arid southwest they may be cut like shoestring potatoes and dried on screens in the sun. Dried, they will keep for years. Puffballs, particularly, as well as many other mushrooms, have better flavor when dried.

Another beautiful and edible mushroom is *Hypomyces lactifluorum*, which is a mushroom parasite on *Russula brevipes* and on some *Lactarii*. It is lobster red and looks like an aborted mushroom. Most people like it better than the original mushroom, but it's still not a great treat.

We in New Mexico and Arizona had been eating a large white bolete for many years, thinking of it as a variety of *Boletus edulis*. I sent a collection of it to Dr. Alexander Smith at the University of Michigan, and he recognized it as a new species and named it – what else? – *Boletus barrowsii*. It is found in the whole southwest wherever there is Ponderosa pine. David Arora finds it with oak in California.

One day I was slicing up some of it to dry. It was lunchtime and I had nothing prepared so I fried some of the mushrooms in butter, put a lot of them on a slice of bread topped with mayonnaise and another slice of bread, and presto, a new sandwich! It was surprisingly good.

Beauty in a mushroom is not, of course, evidence of edibility. There are some beautiful poisonous ones. One that comes to mind is *Boletus pulcherrimus*, in Latin "most beautiful

[1] Chuck calls this Polyporus sulphureus. I've updated this name and a couple of others, but left the controversies that he reports unchanged, because I'd just be marking things up all over the place.
[2] These have actually turned out to be different species, which is currently considered more of a component of their different toxicity than the tree host.

bolete." It is a bolete that was first named *B. eastwoodii*, but later another mycologist discovered that the type specimen was *B. satanus* and so "*eastwoodii*" had to be discarded as a name.

It is a large bolete with a cap up to ten inches in diameter. The cap is tan with pink blushes on the margin. The tubes are yellow, turning blue when cut; the pores are a deep red; the flesh is yellow and turns blue when cut. I have two friends who ate a half of one between them and were very ill all night with vomiting and pain in the belly.

Another beautiful but disappointing one is *Leucopaxillus amarus*. It looks like a cookie just out of the oven. It just begs to be eaten. I tasted it, and it was the bitterest thing I have ever tasted. Still I taste it every time I find it, hoping that someday I will find one that is not bitter.

That is not as ridiculous as it might seem. *Hypholoma fasciculare* is a very bitter mushroom that I have tasted many times. When one day I found a log covered with this pretty little mushroom, I tasted it as usual and was both surprised and delighted to find it was not at all bitter. I sent a collection of it to Dr. Smith and he said it was *H. fasciculare* all right, and that variation in taste like that sometimes happens. *H. capnoides*, however, is an edible mushroom.

I have tasted many species of *Cortinarii*. Most of them taste like rotten wood. However I once found a group with tannish yellow caps and sulphur yellow gills that had a pleasant taste. I never saw them again, so I never had a chance to try them for edibility.

The worst mushroom of all that I have tasted is our western *Russula foetens*. It is worse than the eastern one. I tasted it as I always do by taking a small bit (about the size of a pea) and then spitting it out. It was the most remarkable experience I have ever had in tasting mushrooms. As I bit down on it, before I could get a taste, I became so nauseated that I almost vomited before I could get it off my tongue. I don't think anybody could possibly eat enough to get sick. I can't tell you what it tasted like, for I never had a chance to taste it.

But let me get back to a pleasanter experience. There is a small *Agaricus* that grows in our conifer forest: *Agaricus semotus*. It is between one and two inches in diameter, with pinkish brown gills and the most delightful sweet anise flavor, almost like candy. On one occasion I was collecting with Bill Isaacs and Jim Gilbert, another friend. We had found a good collection of it, and on the way home we had stopped to have some ice cream.

We each had a dish and Jim and I got the idea of trying some of the little *A. semotus* on our ice cream. So chopped some up and scattered it over our ice cream, and believe it or not it was great. A new taste sensation! Bill did not try it, but he got a big kick out of our waitress, who was watching us in astonishment.

We have a lot of *Leccinum aurantiacum* in our mountains, and also a few *L. insigne*, but once in the Jemez Mountains I found a group of three with caps of a beautiful rose pink. I sent them all to Dr. Smith. It was a new species. I have never seen it again. Dr. Smith named it *Leccinum barrowsii*.

Another feature of mushrooms that intrigues me is fragrance. One such mushroom is *Hydnum suaveolens*. It's not very beautiful; it has a white cap with a very purple stem. Its fragrance is unlike anything else that I have ever smelled, like an exotic French perfume. Each year I find a few of them and take them home with me and leave them around on the coffee table. They retain the fragrance until next year, so I always have some around just for their fragrance.

There are mushrooms with odors like almost any odor you are familiar with. Several smell like garlic, for instance, and coconut, and carrion. *Phallus impucidus* grows from an underground pink egg. The egg is edible, according to the great mycophagist Charles McIlvaine. I have not heard of anyone else who has tried it. I will have to try it sooner or later.

In running down the origins of the names of colors I came upon a most interesting story. The name I was looking up was isabelline. It was named after a popular queen of Spain, three or four hundred years ago, whose name was Isabelle. Her beloved husband was riding away to the wars, and she vowed to not change her underwear until he returned. It turned out to be a rather long war. The color isabelline is a dingy ochre yellow.

Most of the eight mushrooms that Dr. Smith named after me were very rare and I have never seen them again. *Lactarius barrowsii* I've found in several locations and I generally see some of it every year. Its most remarkable feature is that bright Paris green which it becomes when it is broken; but it rapidly fades to a duller color.

The *Pholiota barrowsii* is very close to *P. squarrosa*. There are also a pure white *Amanita barrowsii*, a *Psathyrella*, and a white *Hebeloma*.

The Siberians have been eating the *Amanita muscaria* for its psychedelic effects for hundreds of years. In parts of Siberia where it did not grow they were so fond of it that they would trade a reindeer for one mushroom. Incidentally, it is said that reindeer ate it and also became intoxicated.

A. muscaria has intrigued me for many years. It has probably had more written about it than all the rest of the mushrooms put together. It has been eaten in most of the countries of Europe for many years after being treated in some way or other. In many of these countries all mushrooms were boiled before cooking or were soaked in salt water for twenty minutes to drive out worms. This would also destroy some of the acrid flavor and some lesser poisons.

About the turn of the century Ford and Clark claimed, after laboratory experiments, that soaking *A. muscaria* ten minutes in salt water and then ten minutes in vinegar removed all the poisons. I also did some experimenting with *A. muscaria* after I read that the Siberians soaked them in the juice of the whortleberry and then drank the juice. This indicated to me that whatever caused the psychedelic effect was soluble in the juice of the whortleberry.

One of the best genera for eating is the genus *Agaricus*. *A. bitorquis* is a very common mushroom in New Mexico. It likes hard-packed earth along sidewalks and paths. I have found it frequently on the Plaza in Santa Fe, but just out of town about a mile there is an old landfill where it grows in great quantity, both in the spring and in the fall if it rains. I can pick five pounds in an hour or so.

However, the very best of the *Agaricus* is *A. campestris*. It grows only in pastures. It is dependent on dung for it sustenance. It has a really delicious flavor. It has been cultivated in France, but it is too fragile to pack and ship, so other varieties are produced for the market. Taste is sacrificed for firmness, so very few people other than mycologists have ever tasted A. campestris.

There are three or four species of *Agaricus* that are called poisonous. One is *A. xanthodermus*; *xanthodermus* in Latin means "yellow skin." There are many varieties of this species, but they all smell like creosote.

We have a lot of one of them here in New Mexico that has no yellow on the cap but the base of the stem is bright yellow inside when cut. This is the sure sign that it is *A. xanthodermus*. It also has a strong smell of creosote, and does not taste very good. It gives some people gastrointestinal disturbance. I have eaten five or six of them several times, without harm, but the flavor is not good enough to bother with them when there are so many better ones to be had.

With the help of Dr. Smith and all the forays I have participated in all over the country and along the Amazon River and in Peru, I have learned to identify maybe two or three hundred species, and am learning some new ones each year. Bill Isaacs and I have been teaching a class in mushroom identification for ten years in Santa Fe and are still getting good attendance.

The North American Mycological Association is doing a great job nationally in getting more and more people interested in mycology. Mushroom clubs are being formed in many states. Pat Brannen of Albuquerque initiated the first club in New Mexico a couple of years ago. If you want to get more fun out of mushrooming, that's the way to go: join a club!

The great value of a club is that with more people collecting, and displaying their ollections, you have the opportunity to see more mushrooms than you could possibly find yourself. And many of them will be known to somebody in the group, so you will learn to identify many more.

It's a great hobby and becomes more exciting all the time. Go to it – good collecting!

Mushroom

Old and Bold

by Kevin Wald

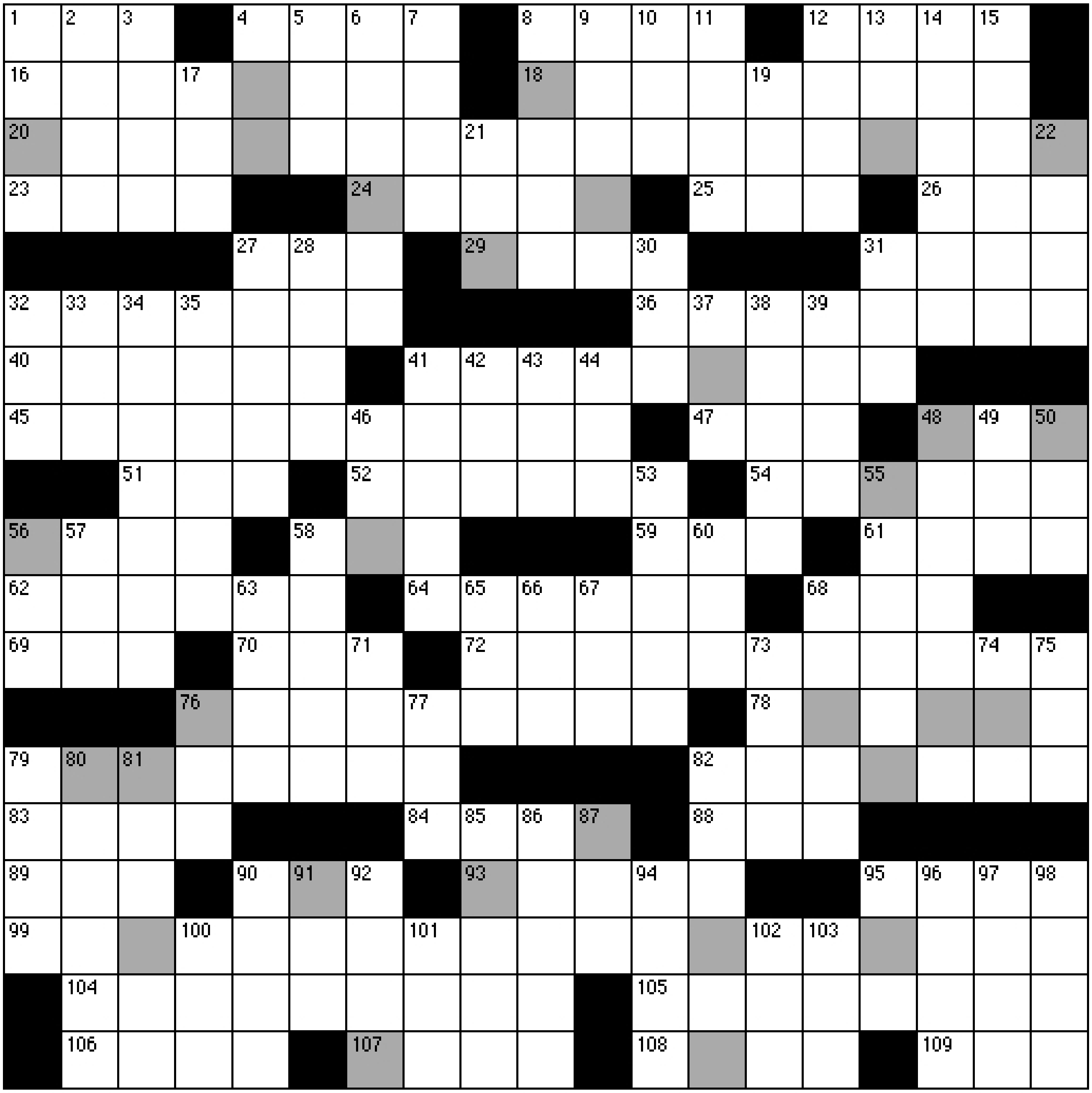
What distinguishes the old and the bold is, of course, the letter B. Once the grid is filled, one third of its 30 shaded squares will contain a B; from each, you must make a short foray to another square. Specifically, numbering these squares 1-10 in usual reading order (left to right, top to bottom) you must go (1) two south, (2) one southeast, (3) one southwest, (4) one south, (5) two east, (6) two north, (7) one west, (8) two southwest, (9) two south, and (10) one northwest. Read the letters you get to, in the order (10)(1)(2)(3)(9)(4)(6)(7)(8)(5), to see how you might indicate these journeys on the grid. Then read the 20 other shaded squares to see where you can find the exciting sequel to this.

Across

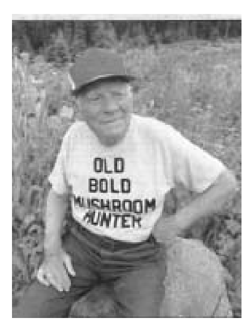
1. Vichy water
4. City in the Book of Esther
8. Mail-order company in cartoons
12. Black-and-white seabirds
16. Bolete with scabers
18. Named after Chuck
20. The most beautiful pored mushroom (*2 wds.*)
23. Very picky
24. Owned item
25. Freezing cold
26. United
27. Vase
29. Idle of Monty Python
31. Piqued state
32. Shaggy (mushroom)
36. Genus that is often yellow and slimy
40. Unconcerned with ethics
41. Edible species of 76 Across
45. Genus known for being fragile
47. Tartish dessert
48. Supplicate
51. Diarist Anais
52. Flavored with a leek relative
54. Sister city of Champaign, IL
56. Harry's First Lady
58. *Angie Tribeca* network (*abbr.*)
59. Einstein's birthplace
61. Request on an invitation (*abbr.*)
62. James Cameron film with blue people
64. Lure
68. Actor Hanks
69. As of this time
70. Bossy remark?
72. Poisonous species of 76 Across
76. Black-spored genus
78. _____ *dictum* (judge's incidental opinion)
79. Poison Pie genus
82. Genus for flies and flying
83. Siouan tribe
84. "Behold this remarkable feat!" (*hyph.*)
88. "Mayday!"
89. To what end
90. Prez on the fin
93. Oxidized
95. Annoyance
99. Wood-inhabiting puffball (*2 wds.*)
104. Bossy genus of mushroom?
105. Genus for 32 Across
106. Norms (*abbr.*)
107. Badger burrow
108. Actor Morales of *Ozark*
109. Slugger Mel

Down

1. Isle in a palindrome containing 11 Down
2. Ten myriad myriad years
3. Coll. near Tinseltown (*abbr.*)
4. Employ a chair
5. Palindromic Burmese statesman (*2 wds.*)
6. Lazy _____ (turntables)
7. Stereo components
8. Less inept
9. Spiny plants
10. "And _____ will demonstrate . . ." (Beatles lyric; *2 wds., abbr.*)
11. ". . . speak a prophecy _____ go . . ." (*King Lear*; *2 wds.*)
12. Cockeyed
13. Highway paralleled by I-95 (*hyph., abbr.*)
14. Robe with an obi
15. Meter or kilogram, e.g. (*2 wds., abbr.*)
17. Animator's sheet
19. Tolkien villain
21. Employ
22. Bristly body part
27. Beehive State resident
28. Well-ordered
30. _____ Sharkey (Don Rickles sitcom; *abbr.*)
31. Female sib
32. Visored headgear
33. Some mantras
34. Laments because of (*2 wds.*)
35. Brush user, perhaps
37. Pelvis
38. Contempt
39. Ogle
41. Use smoke to perfume
42. "The Greatest"
43. Arafat's org. (*abbr.*)
44. A Bobbsey twin
46. Steal from
48. Rice variety
49. Ltr. container (*abbr.*)
50. Discontinuity
53. Joshua tree or its kin
55. Thanos portrayer Josh
56. Reddish-brown horse
57. The first lady
58. Prefix for "sphere" or "pause"
60. Garland on Oahu
63. _____ nitrite (inhalational drug)
65. Gridiron org. (*abbr.*)
66. The Way
67. Doctrine
68. Heavy metal instruments
71. 15 Down measuring resistance



73. Singer Perry
74. Out of the rat race, perh. (*abbr.*)
75. Period
76. Giggly syllable
77. Morsel for a 56 Down
79. Wail wolfishly
80. CH_3CH_2-groups
81. Childish term for a 68 Across (*2 wds.*)
82. Texan diamond workers
85. Approximately
86. Kirsten of *Bring It On*
87. Dadaist Jean or Hans
90. What UK flats are (*abbr.*)
91. Arthur on *The Golden Girls*
92. Blunders
94. Widespread ATM network (*2 wds.*)
95. Food with roots in Hawaii
96. Cube designer Rubik
97. Parasitic fungus
98. Exam
100. Condition of Monk on *Monk* (*abbr.*)
101. Spotted cube
102. Hoppy beer style (*abbr.*)
103. Day named for a fem. deity (*abbr.*)



Mushroom

From Long Island to North Carolina

an interview with Rytas Vylgalys

Leon: So… I don't remember if it was you who told me or not, but….

Why don't you tell me how you got started in mycology.

Rytas: (laughs) Well, I probably got started when I was a little kid, because my grandmother and other Lithuanian relatives were pretty avid mushroom pickers. For the extended summers, we'd do a lot of hunting around our summer place up in the Laurentian mountains in Canada. And so a lot of the immigrants, Lithuanian immigrants were pretty fond of mushrooms, but I didn't take a mushroom class until I was in high school. I took a course with Marge Morris – you might remember her.

Leon: Yes!

Rytas: from the COMA club [this is the club where Leon got his start in mushrooming] and Marge was also a member of the original New York Mycological Society.

She taught an adult ed course, an introduction to mushrooming, using Orson Miller's field guide, which she was a big fan of.

So that was how I was first introduced to mushroom systematics. Later in college I actually had a mycologist for my advisor! That was at Geneseo – SUNY Geneseo. His name was John Clouse, and he had been a student of John Couch at UNC; he was my microbiology professor.

I did an independent study with him on the mushrooms of Livingston County, up in upstate New York. John was also the person who gave me a piece of paper and said, "You need to join the Mycological Society of America. It's only five bucks." (Leon laughs) Yeah. [It turns out that a student membership is currently $50 a year] And it was great. So I actually started getting the journal [Mycologia] while I was still in college and I came to appreciate what was being published back then.

That was a very good introduction, because when I applied to grad schools, I ended up at Virginia Tech and worked with Orson Miller.

So that's how I got interested in fungi.

Leon: So you grew up in New York?

Rytas: I grew up in Great Neck, New York. So that's how I came to know Marge: because also was from Great Neck. She of course spent most of her active mycology years with the COMA club. But Marge was a wonderful person, and we remained friends with her for many years after that.

Leon: Yeah… I remember her as… very helpful, but also sort of a humorously grumpy person?

Rytas: Maybe so! I don't really remember her personality-wise other than she appreciated really…

▲ Rytas in younger years

good mycology. And that was my introduction; she was my first person to really learn from. I didn't even have a good sense of what true wilderness was, because we lived on Long Island; but she was good: she suggested places to go hunting for mushrooms, and pretty soon I was the same. You know, you start out collecting in public cemeteries and parks, and you start to learn what might be out there.

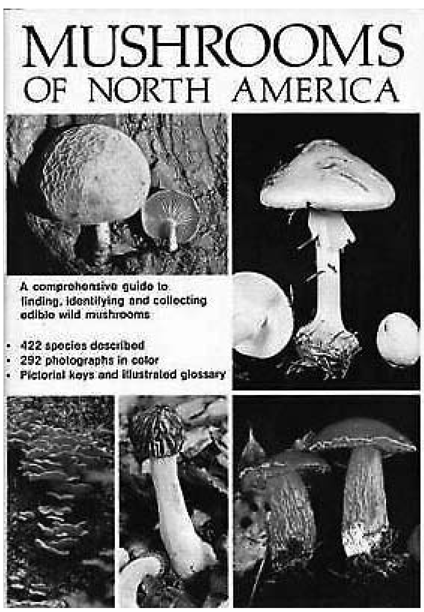
I didn't have anybody to teach me in college. John, my advisor, wasn't a mushroom expert. But he was very helpful. And of course Orson was the person who really drummed in a very strong foundation of systematic mycology into me –for all of his students.

Leon: and when you spoke of using his book, was that that BIG hardcover book?[1]

Rytas: It was a big hardcover book, but it had just come out in a plastic cover – Mushrooms of North America?

Leon: Yeah, that's the one I was thinking of. (Rytas laughs) That was one of the first ones I ever saw, also.

Rytas: That was, back then, already recognized as a ground-breaking field guide for mushrooms: it had color photographs, it had natural habitat backgrounds that would provide you with clues about where these mushrooms were growing. And although Orson… I wouldn't say he was a *great* photographer, but he had a great eye for photographs that showed you something about the ecology of the species. And I still teach his basic system of learning the mushroom families; I'm sure we all do.



▲ Orson Miller's big field guide

We really learned our ecology; I think ecology became a big part of learning the taxonomy of different mushroom families.

Leon: Neat! So what sort of work did you do with Orson?

Rytas: Well, I did both a masters and PhD with Orson. You know, back then I couldn't believe that you could actually get paid to study fungi. It was just amazing.

I worked on the *Gymnopus dryophilus* species complex. Back then it was called the *Collybia dryophila* group.

Anyway, these were a very common group of litter-decomposing agarics, and I worked on mating compatibility. I was already interested in genetics, and so we started doing single-spore – single basidiospore – isolates, working out the mating compatibility systems, and using crossing studies to define biological species. At that time, that was the big thing.

Leon: Is this the sort of thing that later Roy Halling did with *Rhodocollybia* and the rest of the collybioid species?

Rytas: What's amazing is that… well, the concept of what *Collybia* was at the time was not clear. But Roy was just finishing his dissertation, which was a monograph of *Collybia* in the northeast. So he had developed a very clear idea of what the characters were for… what became *Gymnopus*, and for *Marasmius*, and for other collybioids. And so when I started grad school, I actually went and visited Roy – for several summers, Orson sent me up to New England and he said "Talk to Howard Bigelow." I met Howard and the Bigelows, and I met Roy Halling and Tim Baroni. And Roy very kindly gave me a copy of his thesis, even before it was published, and showed me how to recognize the micromorphology of these fungi.

That was very helpful, because after I learned that I started collecting more. I actually had a lot of people helping me get spore prints for growing. Orson of course would go off in various places out west and overseas, and he would collect some of these common species complexes like the *Collybia dryophila* group, and he would save genetic material – in the form of spore prints at the time – and then later I would germinate them and do the crosses. He also set me up with a network of European collaborators who provided material for my PhD which was basically crossing the European and North American counterparts of the group. So I got the benefit of many excellent mycologists who all were familiar with the species complex.

Leon: So you say "species complex." Did it get resolved into a bunch of different species?

Rytas: Exactly. So back then, the *Collybia dryophila* group I identified four intersterility groups from North America; and there turned out to be four in Europe as well; and three pairs of those were mutually compatible. If I recall, none of them were cross-compatible. But what was striking back then was that each of these eight groups also formed a morpho-group – that is, once you knew what to look

[1] @ "big": it was large-format. It usually printed its color photos three to a page, and each of them was a bit larger than an entire page of the Audubon guide.

for, you could distinguish them via physical features – *but* the groups in Europe did not necessarily have the same morphological features as their biologically compatible North American counterpart.

Leon: So you're saying that there were three European biological species that were each compatible with one of the North American ones.

Rytas: Correct.

Leon: But they didn't necessarily look alike.

Rytas: They were not necessarily the same morpho-species.

It was sort of mutual illumination: you do the crosses and then you go back and look at the specimens some more, and what we found was that sure enough you could develop a set of criteria for recognizing each species within its native range, but you couldn't map those same sets of characters to the same species on the other continent. I think that people were already realizing that, and nowadays we know almost always it's because there's no gene flow between these continents, so you end up with very different species groups.

So in North America we found that there's a variety of *dryophila* with yellow lamellae, that had been described from Europe; and sure enough, there's a group in North America that had yellow lamellae, but not always. It's one of the key characters that's been used in that group – there have been many varieties and subspecies that have been described over the years – but it's a polymorphic trait. So we sorted that out and we found that that had previously described from North America as *Collybia subsulphurea*. Peck had described it as a form of *Collybia dryophila* with yellow gills; but it turns out the gills can be yellow or white. And the same thing: Fries had recognized a yellow-gilled form of the dryophila group from Europe, and sure enough that one was also polymorphic – it could have yellow gills or white gills. And it was a different biological species group from the one in North America.

So this work required a reassessment of the morph-taxonomy. Now of course this was all based on the mating types, but DNA came on the scene then as well, so we could also identify which of these mating groups were closely related or not. So the compatible pairs from Europe and North America did end up being each other's closest relatives, but they were genetically distinct even back then.

Leon: So is this part of the motivation that got you deeper into DNA?

Rytas: Yeah. I think what got me back then, and what still is really exciting about species complexes is that those are the groups of fungi where you can get insight into the factors that drive speciation in fungi. The evidence of genetic local adaptation, the evidence for mating compatibility, and especially mating compatibility – and the associated intersterility – as a reinforcement that maintains species differences.

Leon: So I'm wondering, "What kinds of insights does this give us?" My understanding is that for animals there's geographic separation, and you end up with groups that look different, and then *after* that they end up becoming intersterile because they use visual cues to signal mating compatibility – looking different erects another barrier to gene flow. But mushrooms don't use looks in choosing a mating partner, so they tend to drift apart genetically first and only later end up looking different.

Rytas: Yeah, I think… the fungal species complexes where you can do the crosses are especially valuable, because there you can actually assess different criteria for speciation genetics. So for example in the case of fungi, I could actually do *all* the crosses in all combinations, in the laboratory. You can do it in vitro, and that's something you can't do with animals – you know, even if you have a huge zoo, you can't cross *every* animal with every other animal. It's just impossible.

I think those studies at that time were the first insight that the fungal kingdom is really full of cryptic sibling species – that almost every morpho-group that we were recognizing as a species at the time… we knew that there were cryptic species within those groups, but the study of the intersterility barriers really drove home the idea that, first of all, that once they've speciated, they really usually don't go back; and it also demonstrated the importance of geographic isolation as a factor in eventually leading to those intersterility barriers to evolve.

But you know, intersterility is a funny trait to measure because there's a process of reinforcement. Once species diverge – or populations diverge – there's subsequent evolution that reinforces the genetic differences, and that's what we see as an absolute intersterility in mushrooms. That's why it's a really useful technique. You know Ron Petersen made a whole career – his later career – out of studying those interactions. And those still require the fungi: you have to grow them, you have to be able to let them do their thing and tell you what the patterns are. Nowadays, we use DNA sequencing and population genetics to *infer* the same things – the same processes, but the advantage of being able to work with cultures like this is you can still study these processes at the level of the fungi themselves.

Leon: Do you get any insights into what's driving the divergence? – what these microadaptations *are* that start them off on their different paths?

Rytas: Well, that's something we think about all the time. It seems that the evidence is that fungi are capable – all fungi seem to be capable to some extent – of long-distance dispersal. And in the face of that – in spite of that – what we see is more and more overwhelming evidence that there have been long periods of local adaptation which results in these morphologically distinct – sometimes very subtly distinctive – local populations and species groups of different fungi. It doesn't mean that they don't occasionally mate with their cross-continental, or cross-oceanic partners. But I think it suggests that primary unit is this sort of local geographic population – meta-populations, people sometimes call them – that show a strong signature of genetic identity where they occur.

Of course, nowadays you can also find evidence of the opposite. I think we've gone further now, right? We can actually find evidence now that fungi actually *are* hybridizing. Karen Hughes has done some really beautiful work showing evidence of rare – but sometimes not so rare – hybridization events that occur between closely related mushroom species.

Leon: That's really cool. Now besides geography… you mentioned *subsulphurea* and around here we get that in the very early spring – it's one of our first mushrooms.

Rytas: That's right.

Leon: So is this separation something that happens seasonally as well as geographically?

Rytas: Absolutely. I think especially in the *Gymnopus dryophilus* group, there are some early season fruiters, so here in North America *subsulphurea* is early in the spring, early summer, and then by late summer *Gymnopus dryophilus* takes over, and that has a darker cap and it doesn't have the pinkish rhizomorphs of *subsulphurea*; it has white rhizomorphs. So there are some ways to recognize these.

There's also – I don't know if you've ever picked it – *Gymnopus earleae*, which Murrill also described. That's also one that fruits very early in the spring – around here you'll find it in March and April – and it's fruiting on bare soil.[2] So it's an early season member of that species complex.

And there must be quite a bit of seasonal variation – seasonal differences as phonological difference – in Europe as well. I know they have at least – I'm trying to remember the name now – gosh, it was so long ago – but there's another member of that group that fruits in areas where the snow has *just* disappeared.

I think a lot of these litter decomposers probably do split up the season, and that probably does provide some manner of isolation, although the *subsulphurea* and the common *dryophilus* form that we see later in the year – those two are *rigorously* intersterile. They don't cross. So even if… you *can* find them fruiting at the same time; but they're not interbreeding.

Leon: I see. This is all very cool. So what have you been working on lately?

Rytas (laughs): Unfortunately, I don't get to work on speciation and genetics much anymore. But what we've been doing… I'd say for the last twenty years, we've done a lot of work on the fungal Tree of Life, and elucidating that – so the big-picture phylogeny of the fungal kingdom. But in the course of that, I've become more interested in the use of these molecular techniques to study fungi in their native habitats – in the environment – and particularly looking at different ways which fungi interact with each other and also with plants. So for the last twenty years or so, we've been working increasingly on how forest fungi interact with their forest tree species, either as mycorrhizae or as endophytes.

Currently I'm working on genetics of host compatibility between Suillus and different species of Pinaceae. As you know, different pines – white pines, yellow pines, two-needle, three-needle, five-needle pines – all these different groups and the larches, doug fir… these are all members of the Pinaceae and they all have very strong patterns of host specificity with different groups of *Suillus*.

We've been working on that quite a bit for the last ten years, getting genomes of different species of Suillus, so we can understand what genes they use to interact with their different hosts.

Leon: So to do the census, you're sampling root tips?

Rytas: We do. We sample root tips, but one reason we're working with *Suillus* is because first of all, we can collect the actual mushrooms in

[2] It also often has a cap with a really dark brown center, rusty orange rhizomorphs, and this is one that can have yellow gills.

the field. We can collect them as root tips as well. *Suillus* is one of the groups of fungi that we've looked at using sort of environmental metagenomic types of approaches where we look at the whole community of fungi associated with a particular host.

But the other reason we work with *Suillus* is because we can take it into the greenhouse and the laboratory. Using cultures and spore prints, we can experimentally inoculate different *Suillus* species onto different Pinaceous hosts, and by doing that we can (again) experimentally validate whether or not a given strain is compatible with one pine host, or does it have a preference for white pines or larches and so forth.

We can confirm the patterns that have been reported based on field taxonomy, and go further. We can actually begin to look at the genetic systems that these fungi use to recognize their hosts. How do they communicate with different pine trees? And what is the language? – the alphabet, as it were.

Nowadays, I think mycology has become a genomic science. We can do an awful lot with just sequencing the genomes. But we can do even more with some of these fungi, like *Suillus* – we can actually do experimental work, and use the genomics to really get some insight.

So let's see: three years ago we published a paper describing the metatranscriptome – using RNA as the sequencing technique – we were actually able to identify which genes are used by different *Suillus* species to recognize their pine host. And conversely we can also – since we're working with mycorrhizae in the laboratory – we can also identify which pine genes are also activated in response to either a compatible or incompatible mycorrhizal partner.

So that's the new frontier… it's *almost* the holy grail, but it's not quite there yet. It's this idea that fungi and plants… fungi sense their environment and they interact with it. In the case of a symbiotic interaction, it's at least two partners involved, and they actually do communicate with each other, and they actually use that communication to go to the next level which might either be synthesizing mycorrhizas, or trying to make a connection with the host.

Suillus absolutely requires mycorrhizae to survive. They can live as spores for a long time, but I think at one point or another their spores are going to try to establish an interaction with the host. So right now we're really excited about using genomic approaches to identify what are the suites of genes involved in host recognition, and then subsequently – once the mycorrhizas are established, what is the role of these different mycorrhiza types in the nutrition of the host and the fungus.

That's what we've been working on more lately: a community-drive approach to understanding how *Suillus* and other fungi interact with different tree hosts. That seems to be a very nice system for looking at how fungi are functioning in the forest.

And of course you've got your saprophytes as well. They're doing similar things, except they're interacting with all of their different substrates that they grow in.

Leon: But presumably they don't need to establish the same kind of connection.

Rytas: They don't, but… symbiotic interactions are one type of interaction; but you also have… not surprisingly, the symbiotic fungi are using a lot of the same sort of interactions that the plant pathogens use. So that's a useful framework for understanding them and there's been tremendous progress in understanding how pathogens interact with their hosts at the molecular level.

Our lab has always been field-oriented, so we're trying to take it all outside more and so the focus has been on meta-genomics: can you understand these community interactions as a whole, more than species by species – although we do species by species interactions as well.

Leon: Now, you speak of identifying the genes that are activated for these interactions, and you've spoke of trying to figure out what the language is; so I'm thinking that the genes are kind of like the transmitters, but what is the actual language?

Rytas: Yes! There's an entire huge field that has developed focused on how plants interact with microbes: plant-fungal interactions, plant-bacterial interactions… and we know that plants in some ways are like animals: they have an immune system – they have a way of preventing infection by unwanted microbes – and it turns out that the mutualistic, mycorrhizal fungi utilize the same mechanisms to gain entry into a plant host as the pathogenic fungi do. The main difference is that the mutualists can't kill their host! They actually help their host; so they establish these long-term, stable interactions that we call mycorrhizas.

There's different types of mycorrhizal interactions. The arbuscular mycorrhizae utilize similar mechanisms; some of them are maybe even identical. But they also perform different functions and provide different services to their hosts. We're trying to use the same approaches to also study what they

▲ A more contemporary photo of Rytas in action

do. Nowadays that's all incredibly inter-disciplinary, and it's not just DNA and RNA – it's also the ability for people to study the proteins that are involved, to study the metabolites – metabolomics-based approaches – it's really integrating all of these that has really become a very hot… hotbed of research in many labs, actually.

Leon: So these services that the fungi provide: are you seeing how these get modulated and changed depending on what other organisms are in the system?

Rytas: Yes. And of course ecology – and ecological theory – provides additional context for interpreting all of these kinds of findings. I think that there's huge potential right now for synthesis between molecular-based studies, and people who study biogeochemistry – somebody looking with sensors from space might be able to tell you exactly how this fungal community is affecting changes in soil and soil respiration et cetera. And at the same time, there are these general ecological insights coming from all the other metagenomics work that people are doing – looking at how fungal communities vary in space and time, especially in the forest environments.

It's not just mushrooms anymore!

Leon: Going back a moment to speciation and smaller-scale issues: do you see evidence for the sort of speciation we were talking about being driven by horizontal gene transfer?

Rytas: No. I don't see horizontal gene transfer being as important or prevalent in these fungal systems as it is in bacteria. But you have to qualify that – we probably don't even know just how much a role horizontal gene transfer has had on the fungal kingdom. We know that some kinds of genes – especially genes that are involved in secondary metabolism – and of course certain other types of genes that (for instance) confer antibiotic resistance (that's more in bacteria) but I think the fungal ability to produce a lot of metabolites is almost certainly the result of them acquiring those genes from bacteria, because certain gene families are exactly the same.

We often know – now, through genomics – that fungi actually harbor their own endosymbiotic bacteria, and it's probably both a historical and an active process, whereby fungi take up certain bacteria that eventually become symbiotic with the fungal mycelium.

I don't know if you've picked up any of the reports on that, but the very first fungal genome that our lab sequenced (through the Joint Genome Institute) the first report came back with "We've got the genome, but there's also a bacterium living inside your fungus. We've reconstructed the fungal genome of Mortierella.[3]

"But there's also a fully assembled bacterial chromosome present," and sure enough, we were able to confirm that there was a fungal endosymbiont living inside the cells of the fungus.

I think it's these kinds of situations that are the for horizontal gene transfer to contribute. We know that a lot of fungi have these secondary metabolite gene clusters. Not all fungi have them! A lot of ascomycetes are loaded with them;

there are a few boletes that have very unique sets of those – probably almost all acquired from some sort of bacterial endosymbiosis.

Leon: Cool! So they have them, but you don't see it as a big driver of speciation.

Rytas: I don't see it as a driver of speciation as much as… it's definitely a factor in the evolution of certain groups. But what really drives speciation, based on what we know about it, you have opportunities or scenarios by which populations can rapidly diverge, and I think from my thesis work and since then, it's always been very clear that allopatry is a major driver. Even widespread species of fungi, like Schizophyllum commune, or *Trametes versicolor*, almost all of these ubiquitous fungi, if you look at their genomic variation, what you find is that they still form very genetically distinct populations in different parts of the world. Together with evidence of periodic gene flow between the continents, which suggests that there's something else – that there's an ecology that helps reinforce that process of local adaptation that gives rise to these geographic variants.

So we know that geography is an important driver. At the same time, there's always been controversy about whether species can evolve in situ – in the same area – like on different hosts or something – and I think there's evidence in fungi that that also occurs. Pretty much everything that occurs in plants and animals also occurs in fungi. (Leon laughs) We find evidence of local adaptation leading to rapid speciation; you can also find evidence more and more nowadays of hybrid origins of certain groups of fungi. And again, a lot of that has come through the analysis of fungal genomes more so than through observation.

You're familiar with grasses and grass endophytes, right? – the fact that all of our common turf grasses that we value and that we use for forage and so forth – those are all colonized by ascomycetes, clavicepitaceous fungi[4] that are *hybrids* in the genus *Epichloe*. Essentially, these are asexual fungi that have a hybrid ancestry. They evolved from the hybridization of pathogenic fungi on grasses; but the hybrids are sterile, and they produce loads of secondary metabolites that are beneficial to the grasses and which hopefully don't harm the sheep and cattle that graze on them – sometimes they do!

Nowadays we manage the endophyte communities so that they're good for animal foraging.

Karen Hughes and her crew have done some very detailed work on the fungi of the Smokies, and she's got some great examples of potential hybrids and examples where some of the agarics have probably gone hybridization as well. But I, we don't know how common that is.

Leon: It's not a broadly sampled thing?

Rytas: It's not broadly sampled, but… it's probably much more common than we thought. And especially now since we kind of have the genetic tools to figure it out.

Leon: Was it her and Ron who did the work on *Flammulina*?

Rytas: Yes, that was one of the first examples.

Leon (laughing): And we found out that there's more there than we thought.

Rytas: There's *always* more there than you thought. That's almost axiomatic.

Leon: So where do you think this is all going? Where would you like to see people… attack the field?

Rytas: Where's the field going? Gosh. This sort of work is going in *many* good directions. From the standpoint of fungal systematics and mushrooms and mushroom diversity, I think we are entering a… two thoughts come to mind. One is that we're clearly in a molecular era. Molecular systematics and genomics have caught up with what we do. So we're starting to get that next level of understanding of not just what the species groups are, but we also have the ability to identify them… sort of in any kind of context and also understand on a genetic level what different groups of fungi might be doing. I think that's really exciting.

And it's also, I think, because of the focus on DNA barcoding, this is sort of the next level that's accessible to the average person. When I first started doing DNA work, there was a lot of resistance to molecular techniques as a solution; and I think there's been a change: we've overcome that initial resistance. A lot of mushroom clubs and a lot of individuals – especially the new generation of field mycologists who are coming along – have a lot more… *facility* with using that ITS barcoding or whatever to get a handle on fungal diversity. Right now we're a little behind, but we're actually sequencing lots of field-collected mushrooms for different club groups as part of that MycoFlora project that Bill Sheehan and others have been promoting.

It's wonderful! It's great. As a

[3] a common soil Zygomycete fungus

[4] your ergots and so on

molecular mycologist, I still get excited when I look at the list of sequenced types and what species they represent, because that really is… empowering a lot of amateur mycologists to get into that game, and of course they're finding new things all the time.

Leon: You spoke about molecular work being more accepted, and actually what I hear a bit nowadays is… from people in clubs, is sometimes you'll get graduate students who have never seen a fruiting body.

Rytas: That's right! And yet they probably know everything there is to be known about the phylogeny of a group! (Leon laughs) Certainly, in every generation, we lose a tremendous amount of first-hand knowledge of fungi – and the natural world in general. It's unavoidable. But my feeling is that there's plenty of people coming along who are out there collecting mushrooms, and I think amateur mycologists – *field* mycologists, let's say – are greatly empowered nowadays because they have all these additional ways of integrating what they see.

But of course, yeah! Everybody's got a list of fungi that they've never found: that they've read about, or they've studied… that they've only seen in the laboratory or on a computer. I don't think it lessens the joy of discovering something that you haven't seen before – it might just increase the value. But yeah, you're absolutely right, and it's not just our field: there are people who study *Drosophila* and yeast who have never seen them out in the wild. I think that there have been in the past some people who didn't have enough training in basic field mycology; but that's sort of where we live. We are moving more and more into bioinformatic approaches.

Artificial intelligence is not the solution, right? But it's a good way to get people interested in some of these questions. We don't have a Google app that identifies mushrooms yet. But the only way we're gonna get there is by people doing that sort of interfacing and making these sort of tools work better and better. I think with molecular systematics, mycology has definitely made quantum leaps in the last… generation. For sure! And I think that now, there's just so many directions left to go, and I think students – new students – they're not intimidated by… a lot of the things that might have intimidated us in the past: the challenges of molecular work or integrating fields – taxonomy with whatever's the next thing – anyway, who knows? The future looks pretty promising, as long as there's support for mycologists to do what they wish. To do what we do.

What is *your* thought? I think mushroom clubs and… amateur mycology in the broad sense is actually kind of renaissancing right now. There's a lot of young folks out there!

Leon: I'm seeing… you know, I do these interviews, and every time I do an interview I find out all these new things about where the field is going. So I don't… have that perspective myself. I was just at NAMA, and I remember late at night Tom Bruns and Joey Spatafora saying "Yeah… we've just gotta train people to work better with data." (Rytas laughs)

I do see a lot more of the clubs, like you said, getting on board with the sequencing, and that just being a legit area of operation for clubs nowadays. I mean, I remember when I first came to Chicago, trying to explain at a club meeting different kinds of blackening Russulas that we had in the area, and I had one guy stand up and yell at me that if we can't eat them then why was I talking about them. *That's* not happening anymore. There's just a lot more… respect and interest for the scientific questions – and that includes sequencing and finding out what we really have.

I think there was this real trauma when sequencing first came on the scene, and it was "Agh! Everything's getting shaken up and what do I do now? I thought I knew things and now I know I don't."

Rytas: Well, that's something we all learn as we get older, isn't it? Everything you learned in life is wrong! I certainly feel that way. On some level, everything I learned in grad school is wrong. But you end up with a perspective that's much broader. You can explain… you know, we had a lot of really crazy ideas in fungal biology twenty or thirty years ago. A lot of them just wouldn't die at first: questions about the origins of fungi, things like that – the Floridian Hypothesis of the red algal ancestry of certain fungal groups. There was just any number of those, and of course taxonomic ideas were just all over the place.

So I think that a huge amount of consensus has emerged, and of course it's just so much more complex than we had imagined.

Leon: And it's made it less personal. The DNA is something you can refer to rather than personal judgment, with people getting mad at each other and stuff.

Rytas: Yeah, well people still do that anyway! (both laugh)

There is another photo of Rytas inside the back cover.

Mushroom

Collecting fungi in the Amazonian Cerro de la Neblina, Venezuela

by Amy Y. Rossman[1] and Roy Halling[2]

Introduction

After years of discussion the Smithsonian Institution and the government of Venezuela obtained funding to explore the biological diversity of one of the most remote places in South America – Cerro de la Neblina, located in southern Venezuela where it intersects with Colombia and Brazil (Figure 1). Translated as Mountain of the Mist, this mountain is one of several, steep-sided, flat-topped tepuis[3] that are the remains of the ancient Guayana Highland and function as biological islands.

Visited previously by a group of botanists led by Bassett Maguire in 1953, we were invited to participate in the third (and last) trip of this project, which took place from January to February 1985. Other trips had taken place in April and November-December 1984 and included several of our colleagues, mycologist Gary Samuels (April), Venezuelan mycologist Teresa Iturriaga, and lichenologist Lois Brako (Nov-Dec). Although plans were made for another trip after ours, this did not take place and to our knowledge no scientists have visited Cerro de la Neblina since we left, except for a mountain-climbing expedition in 1999 that looked for carnivorous plants.

Our Venezuelan leader was Dr. Charles Brewer-Carías, an ex-dentist and minister of youth, who facilitated the complicated logistics of getting to the high elevations on Cerro de la Neblina. Charles was a knowledgeable amateur naturalist who was dedicated to the success of this project. Many kinds of systematists were invited covering most groups of organisms. Participants in our trip included mycologists Amy Rossman and Roy Halling (the co-authors of this article); entomologists Paul and Phyllis Spangler and their student Warren Steiner; ornithologists David Willard and John O'Neill; herpetologists Roy McDiarmid, Rex Cocroft and Venezuelan Alfredo Paolillo; mammologist Al Gardner; botanists Brian Boom, Anna Weitzman, Mike Nee and Susanne Renner; bryologist Bill Buck; pteridologist Joe Beitel; ecologists David Benzing and Tom Givnish; and journalist Adele Conover. Early on two Smithsonian writers and a photographer joined us but left after only a few days. This trip was written up in *Smithsonian Magazine* (May 1985) and *Natural History Science* (July-August 1985).

▲ Figure 1
Location of Cerro de la Neblina: the extreme south of Venezuela, at the star. Mountain heights are given in meters.

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[3] Tepuis are mesas, known by the local word "tepui," which means "house of the gods" in the language of the Pemon indigenous people.

Getting to Base Camp

We arrived in Caracas a day or two before leaving for Neblina with a brief stay at a hotel and local collecting. Amy found her first fungus on the plants in the window boxes outside the hotel—a rust on *Plumeria* (sometimes called frangipani), ubiquitous throughout the tropics, and some ascomycetes in the mountains known as L'Avila behind the city. From Caracas we flew on a commercial airplane to Puerto Ayacucho, the capital and only city in the territory of Amazonas, located on the banks of the Orinoco River, which traverses most of Venezuela and finally empties into the Caribbean. We stayed at a used-to-be-grand hotel (Figure 2) with an unfilled swimming pool and delicious hot ant sauce (Figure 3, back cover – it looks so much better in color!) to liven up the bland morning arepas (the iconic Venezuelan corn cake).

▲ Figure 2 The formerly grand hotel

For the next leg of the trip, we helped to fill the cavernous hind end of a large military transport plane – probably a C-27 Spartan, a smaller version of Lockheed's Hercules. Into this we pushed at least a dozen 50-gallon steel drums of helicopter fuel, quite a few pallets of beer, and other essentials such as our baggage. Finally loaded, we strapped in to the optional side seats for the two-hour ride to the village of San Carlos on the banks of the Río Negro, a river that flows south eventually into the Amazon River.

Eager for excitement, the villagers greeted us when we landed on the red soil airstrip. We stayed overnight in their small houses – each with a television and announcements blasting over the town loud speakers. Here we did some last-minute shopping for chocolate and became acquainted with little Alfredo and his pet river otter (Figure 4) as well as penned tapirs and pigs. We gathered that evening for instructions from leaders Charles Brewer and Roy McDiarmid, although we truly had no idea what lay ahead for us.

The next morning we were guided into either motorized dugout canoes to travel downstream in the Río Negro that eventually joins the Amazon River in Brazil, or a helicopter for travel to our next stop. Sadly, Amy went by helicopter instead of canoe to the small military outpost guarding the border with Colombia. The view was spectacular as we cruised over the flat, almost featureless Amazon jungle with meandering rivers and widely spaced flowering trees. Much of the beer was consumed at the military base during this very early stage in the trip.

▲ Figure 4
Just a boy and his otter

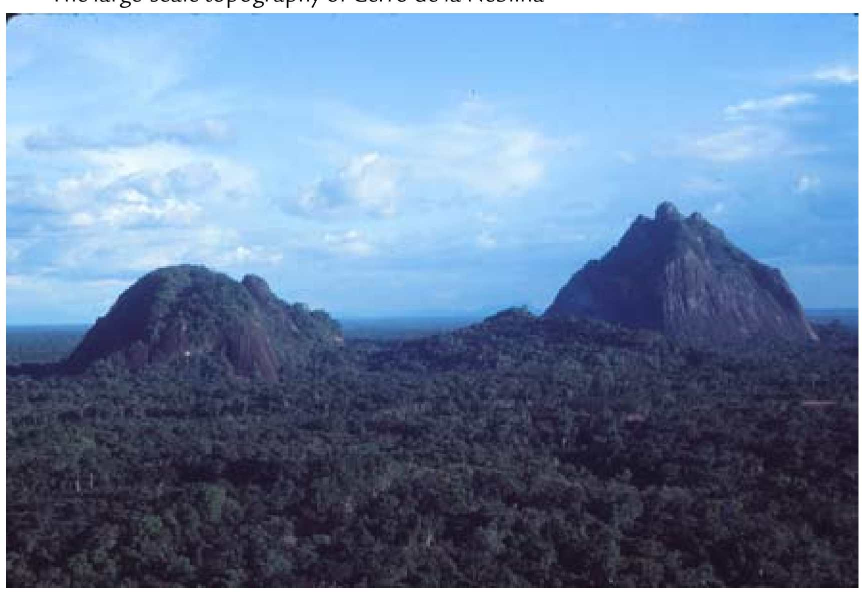
Roy demonstrates the ability of mycologists to remember essential information many years later by recalling that the small border outpost was named "either Cucui or Cocuy". Cucui is indeed the name of the border town (and the district in Brazil on the other side of the border); cocuy is the locally-made agave liquor, named after the region. Roy did not actually stay over at Cucui, however. Instead he flew via a Bell-Jet helicopter directly to Neblina base camp from San Carlos; a half hour direct flight. That same helicopter also had a cargo hook (and net) underneath – that's how the barrels of fuel and some baggage got transported from San Carlos to Base Camp.

Conditions at Base Camp

At last we were helicoptered to our base camp that workers had built for the previous trips in 1984. A couple of months had passed since the last group was at the base camp, and it appeared to be untouched, suggesting that no humans lived in this part of the world. However, the tin roofing initially flown in to make the base camp had disappeared, indicating that people at least passed through this area occasionally. All the necessary structures there were made primarily from a local small tree. The open-air sleeping quarters had low sides and a roof from which to hang our hammocks. (Figure 5) They were easy to clean by simply sweeping extra debris through the gaps between the logs in the floor. The open wash room included a large sink (not local) with flowing cold water and a moderately enclosed shower although some of us preferred the river for bathing until a large electric eel and anaconda were sampled from it (The river and showers are among the color photos on p. 53; a photogenic anaconda is shown on p. 50).

▲ Figure 5
Field accommodations

Figure 6
▼ The large-scale topography of Cerro de la Neblina



Food was basic and mostly starch, i.e., arepas for breakfast, rice or spaghetti for lunch and the same for dinner – no sauce (except catsup). The clever one, Bill Buck, who had been on a previous trip, brought curry powder which he often shared. This trip was proof that you do not need fruits and vegetables to survive.

On one occasion we had meat that had been procured locally by the workers and was incredibly scrumptious. Paca is a large rodent that tasted deliciously like ham. Someone should go into commercial production of that most delectable product.[4] Or maybe it was just the circumstances. Other meats included guan (a group of ground foraging birds in the Cracidae) and wild peccary. We also sometimes had tamarind-like fruit juice made from a local species of *Inga*.

The scientific laboratory was a basic structure made of small logs with roof, floor, tables and benches. Electricity was generated for a few hours every evening so it was possible to work at night. We had brought a propane stove for drying fungi but

[4] Actually, wikipedia reports that "The Smithsonian Tropical Research Institute in Panama has studied the possibilities of developing the paca as a viable high-priced food supply for the tropics," and cites a publication by the Food and Agriculture Organization of the United Nations. Sadly, that publication cites the old scientific name of the animal (*Agouti paca*) instead of its new genus name of *Cuniculus*. This doesn't only happen in mycology! – LS

mostly the weather was sunny and we laid the paper bags with microfungal specimens out to dry in the air. Because some specimens are relatively small, the essentials for collecting are a hand lens, a good sheath knife, kraft paper bags for individual specimens, and a large plastic bag for the day's haul. Amy also kept insect repellent in her belt pouch to ward off those primary competitors – ants.

▲ Figure 7
Al Gardner with specimen

Trips to High Camps

Although Cerro de la Neblina is a tepui, it is greatly eroded with a central canyon surrounded by flattened areas (Figure 6 here and 6a on the back cover). Travelling via helicopter we visited three high camps. Initially the helicopters were commercial ones contracted for this expedition. However, after a few trips the commercial helicopter pilots were frightened by the narrow valleys and steep slopes and were replaced by larger military helicopters (see photo next page). In spite of her fear of flying on commercial airplanes, Amy was never afraid in the helicopter because the views were always so amazing.

The first trip was to Camp 3 located at the highest, wettest elevation ca. 3045 m (9000 ft) and in fact we may have been in Brazil. The soil was more than soggy and yielded almost no fungi perhaps because of the anaerobic conditions but we did encounter the largest earthworms we have ever seen—about 20 cm long and three cm in diameter! After one day there, we were ready to move on and did.

▲ Figure 8
The tents of the high camp

Returning to base camp, we had to wait a few days but then went to the fungus-rich but ill-fated Camp 7. We landed on the flattened and recently cleared top of the mountain. The camp was established down the hill near a stream where we set up our small tents not far from the laboratory tent and cooking area. The fungi were fantastic with diverse tropical vegetation and plenty of debris.

However, after about four days, we found out that the helicopter had run out of fuel and could not come back to pick us up. By that time, we had limited food, and would have to just wait an unknown number of days while the helicopter returned to the Maracaibo military base to fill up. Although we were in touch with the outside world by radio and knew that they would come back eventually, this was alarming because we had no food left – only coffee – to feed about ten field scientists. We tried cutting down the palm trees for their hearts but it was difficult with only a machete. We wasted energy not knowing which palm species would yield edible hearts and, even then, palm hearts have few calories. We tried roasting the small birds that we could catch in the ornithologists' mist nets. That too proved unsatisfactory as the birds were very small with not much left after skinning and cooking them. It was easiest to just quietly starve and laugh about our situation. We called it the Neblina Quick Weight Loss Diet and it worked although left some feeling crazy. Amy lost about ten pounds in five days and dreamed of chocolate almost every night, regretting every dessert she had ever passed up. This experience did leave one with the ability to design an ideal meal anytime.

One incident during this time involved blueberries from true *Vaccinium* bushes that were fairly abundant. That seemed like a partial answer to our food scarcity except for one problem – those who ate the blueberries went unconscious with a very slow pulse about 30 minutes after ingesting them. The blueberries did not taste good to Amy and thus she did not eat more than a few so was left to care for those who went under. This was a frightening half-day especially when the very tall mammologist Al Gardner (Figure 7) started to faint and staggered toward his hammock. Fortunately he made it on his own, as none of us could have carried him there. The effect wore off after about three hours but for a while we were all very frightened. After five days the blessed helicopter dropped off some food and we all survived.

▲ The military helicopters that came to replace the Bell-Jets were Bell UH-1 (affectionately called "Hueys") helicopters, which established a reputation for being reliable modes of transport during the Vietnam conflict. Here is one of them, landed on a field of shattered vegetation.

Staying at this camp was heavenly, with plenty of amazing fungi, so we just kept collecting in spite of the lack of food. Because the camp was located down the hill from the "heliport", every evening we would climb to the top and watch the sun go down at the end of the grand canyon, then descend in the dusk down the adventureland-like trail with a rope ladder on the slippery rock wall and traverse through the bamboo grove back to our camp.

The last trip was to Camp 11 (Figure 8) and it truly was the last high camp. To get there, a place to land had to be hacked out on the flattened part of the mountain that was covered with a a member of the Theaceae, *Neblinaria celiae* (see photo back cover). Several workers were literally dropped off from the hovering helicopter. Once there was evidence of flat ground, the helicopter landed and let the scientists and their supplies off. We put up tents and a shelter in which to work and cook – by now we knew the routine. Collecting was great at this camp with varied vegetation in both wet and dry areas. We had plenty of food including one rare commodity – a large bar of chocolate, which was divided into 17 equal pieces! Everyone did their thing collecting all kinds of organisms for about four days.

▲ One of the local anacondas that made bathing in the stream a more exciting experience.

Early one afternoon the word came down that we had to leave right away meaning we had to pack up immediately. This was quite a surprise and shock as this had come with no warning. Given the circumstances, we did what we were told and soon we were all loaded into a helicopter and transported back to base camp. After we arrived and settled in, Bill Buck told us why we had to leave so suddenly. Apparently one of the blades on the helicopter was cracked and, although they had mended it with epoxy glue, it was unclear how long that would last. Wow, what a surprise!

▲ Figure 9
Paul Spangler and Mike Nee holding a bromeliad in the genus *Brocchinia* cut down to make the "heliport"

Events at Base Camp

Back at base camp collecting fungi was good, yielding an unusual species, *Entonaema pallida*, in the Xylariaceae. These appear on large dead woody trunks as rounded balls filled with gelatinous material but having a whitish surface in which black perithecia are immersed (Figure 10, next page).

The weeks at base camp provided the opportunity to see how other scientists did their work. The ornithologists were dedicated to their mist nets, checking them often for unusual birds (see color photos, p. 53). The herpetologists worked day and night to sample the caiman in the river and snakes wherever they were found.

Although we were expected to collect other scientists' organisms, when a snake came toward Amy one afternoon, she did not respond appropriately. We had been instructed to grab the snake behind its head and whip it between our legs. Being in base camp, she simply yelled for a herpetologist to come quickly. Collecting frogs required great patience because they are very small, almost invisible, and thus they must be found by their call made only at night. Given their shy nature, one must sit quietly until the frogs thought you were not there and started calling. Then with his musical training, Rex Cocroft responded appropriately until the small frogs were found.

One major incident in base camp was the overnight loss of Adele Conover. Personally we thought she was a goner, but no, Adele lived to tell her story and can even laugh about it now. Adele was recording bird songs when she stepped off the narrow, recently made-with-machete path and could not find her way back.

In general, the Amazon jungle appears completely homogeneous and it is easy to get lost because everywhere looks alike. As evening approached in camp, word went out that Adele was not back – yikes, this was serious. A few folks went out looking that evening but mostly there was nothing to do until daylight the next morning. Then we formed search lines so as not to lose anyone else and combed the area near camp with the understanding that a gunshot would signal that she was found.

After about three hours, a shot was heard – she had been located. The workers walked through the jungle hooting and Adele, surprisingly, realized that she had to hoot back in order to be heard. She had spent the night huddled on a log waiting, terrified by the night sounds. To save her voice she had cleverly recorded herself yelling for help using the same tape recorder she used for bird calls. What a relief! After that we carried a compass so at least we could walk in a straight line.

Return to Civilization

Although Amy's government work papers said she should return some weeks before, she stayed at Neblina as long as possible. But eventually everyone had to leave.

As with the trip out, there was a divergence of route. This time, Roy spent the night at Cocui, along with Dave Willard, Alfredo Paolillo, and some others, then went by outboard powered dugout to San Carlos.

Amy returned "directly" to San Carlos. But this part of the world had not been mapped and the pilots did not seem to know where they were in the vast Amazon basin flat with few landmarks. At one point they looked at the empty map, then looked back at us as if to say did any of us know the way? We shrugged, having no idea. Eventually we found the Río Negro and flew upriver back to San Carlos, then to a military base at Maracay and finally Caracas.

▲ Figure 10
Entonaema pallida. The black, gelatinous interior and black perithecia embedded in the outer surface are most visible in the specimen to the right.

Back in the big city of Caracas we had some of the best food we had ever tasted. Incidentally, no one at her home base ever asked where Amy had been all those extra weeks.

Our Findings

During our six weeks in Venezuela we collected about 1200 fungal specimens. Amy collected primarily hypocrealean and xylariaceous microfungi as well as discomycetes, while Roy concentrated on macrofungi including mushrooms and polypores. We tried to collect all the fungi we saw. These were sent to mycologists throughout the world and are still being described, most recently a Xylaria by Jack Rogers and colleagues (Ju, YM, JD Rogers, HM Hsieh. 2018. "*Xylaria* species associated with fallen fruit and seeds". *Mycologia* 110: 726–749).

Many additional new species of fungi have been described from Neblina in the thirty years since we were there. But, were the fungi unique to Neblina or the tepuis? For at least one species of macrofungus, *Xeromphalina nubium*, this may be the case as this species is known from two tepuis. In microfungi it is difficult to determine if they are endemic to Neblina because microfungi are so poorly collected. However, in mosses at least one species of *Sphagnum* is known only from tepuis (W. Buck, pers. comm.).

In Conclusion

This trip was a biologists' paradise because the landscape and vegetation are totally undisturbed representing nature as it has evolved on its own. In addition to collecting amazing fungi, we could appreciate how other organismal biologists sample their specimens – some with great effort and patience, and others with danger such as floating in the stream observing and then grabbing caiman or electric eels. In 1999 some explorers climbed Pico da Neblina looking for carnivorous plants, but otherwise no sceientists seem to have returned to Cerro de la Neblina. Although rumors exist that gold is to be found there, hopefully this will never happen and its precious biological diversity will be preserved forever.

Acknowledgements: Many thanks to Bill Buck, New York Botanical Garden, for his helpful comments and to Carolyn Peterson, Corvallis, Oregon, for scanning the original Kodachrome slides.

Mushroom

▲ *Cora pavonia*, a *Stereum*-like lichenized (basidiomycetes) fungus

◀ The river in which baths were taken

◀ Accommodations at Neblina: would you rather bathe in the river along with the electric eels and anacondas, or in the log showers with the red buckets as a water supply?

▼ Dave Willard with oilbird

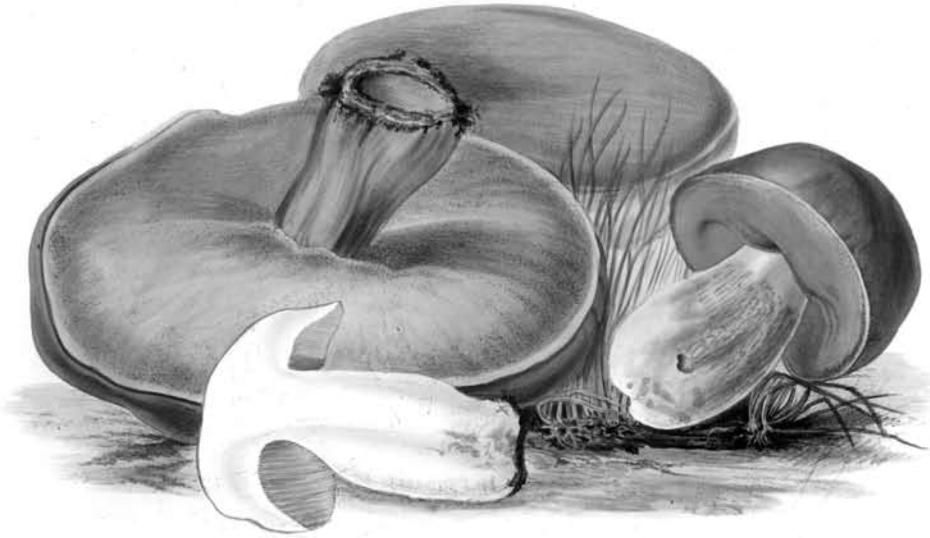
Fungal colors

Fungal photography by Walt Sturgeon

Walt Sturgeon, eminent mycologist and former president of the Ohio Mushroom Society, has shared some of his photos with us.

Top left: *Cortinarius iodes*
Right: *Hygrocybe cuspidata*
Below: *Russula parvovirescens*

continued on pp. 56-7



Mushroom stationery and playing cards from Mushroom the Journal!

Each package of stationery contains seven designs drawn from the watercolors of Mrs. T. J. Hussey's *Illustrations of British Mycology* (1855). The bolete, *Chroogomphus* and *Russula* images at the top shown at actual size; the other four are ca. half-size. Each sheet is 5½ x 8½" (half the size of a regular sheet of paper). Envelopes are not included, but if you're like me you have plenty from other stationery. Printed by *Mushroom the Journal*.

The playing cards, from the Heritage Playing Card Company, are a full deck suitable for actual play, with a different watercolor mushroom on each card. Again, the parasol is illustrated almost at full size, and the two below as miniatures.

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Photo by Walt Sturgeon


Photo by Walt Sturgeon

Opposite page, top: *Flammulina velutipes*

Opposite page, bottom: *Tylopilus alboater* (the black velvet bolete)

Above: *Hydnellum caeruleum*

Left: *Russula ochroleucoides*

(continued from p. 54)

Mushrooms and Microhabitats

by Jack Waytz

▲ *Slide 1*: Jack's initial impression of Washington state

This talk is about discovering engrammatic[1] and habitual markers for specific habitats for the mushrooms you look for. The examples are taken from mushrooms in my area, which is northwest Washington – and will also include both sides of the north Cascades spine and some shots of morels from the Leeward Islands. But you should be able to apply the basic principles throughout the temperate northern hemisphere.

The first slide is what I first saw when I saw when I first arrived in western Washington from Texas – it just was striking how big the country was. Everyone asks "Where do you find chanterelles?" and then you step out into the forest and see this just miles and miles of expanse. So it dawned on me very early that the devil would be in the details – that as many markers that I could learn about for a specific mushroom that I was foraging for, would enable me to develop a framework so that I could find my own spots for chanterelles and other mushrooms.

When I first got to western Washington from Texas, we moved to a place outside of Bellingham proper, a little into the foothills. There was forest all around, and we saw interesting mushrooms everywhere we looked. One day, walking my dogs up the Galbraith

[1] An engram is a characteristic of defining feature or component of a specific memory. For example, the smell of traditional foods cooking could be engrammatic for one's memory of home.

Mountain right outside my door, I discovered a four-inch piece of wood that was about two inches wide and one inch thick, and on this piece of wood was growing a fascinating raspberry-colored slime mold. I took a couple of pictures of it and called Buck McAdoo – who was my mentor for learning about the mushrooms of the northwest – and he came by and identified the mushroom and photographed it. And how does this pertain to my talk? Well, I scoured the entire Galbraith Mountain looking for another piece of wood that would have this mushroom on it and this was 2003 and I've never seen it before or since… and there are lots of pieces of wood that look exactly like it! So there were some specific habitat markers that were hidden to me (and still are!). Today I'm trying to share my template for organizing my mental framework of habitat markers for each of the mushrooms that I forage for. Sometimes it works, and sometimes things remain a mystery.

The second slide (see color photos, p. 61) is a shot, as you can see, of somebody's back yard – of five beefy *Boletus edulis var. grandedulis*. These were almost a pound and a half apiece, and they were growing in a habitat that as far as I knew was not associated with or conducive to Boletus edulis at all. This was just in somebody's grass lawn and the only trees in the yard were a couple of paper birches. What the mycorrhizal partner might have been has remained a mystery to me. I stop by this yard in Mount Vernon, WA every year since, and have never seen this mushroom again.

The next several slides cover the habitat on the San Juan Islands out here in northwest Washington. In the spring there is a fruiting of a particular blond morel which naturally captivates all of us. There's also a picture of this dainty little calypso orchid (again, see color photos p. 61), and this is a habitat marker for these morel mushrooms. These morels are mycorrhizal with the older Pacific madrone (*Arbutus menziesii*), and those trees are in the range of 75 to 100 years old.

The oldest trees are where the morels mostly grow, and as you can see from some of the shots they grow right out of the rocky outcroppings, and just growing out of the *Arbutus* duff. There's one shot standing right near that tree. It's about 20 feet around, that tree. It's huge! It's probably at least 150 years old.

Top: *Leccinum arctostaphylos*, growing with kinnikinnick. Below: *Amanita muscaria*, growing with european beech.

Top left: *Boletus edulis var. grandedulis*, growing in a suburban lawn.
Top right: A variety of *Boletus edulis*, usually found at high elevations, here growing much lower on Mount Baker due to landsclide displacement.
Above left: *Calypso bulbosa* (Calypso orchid) and a troupe of *Clavariadelphus truncatus*
Above right: A white *Boletus barrowsii* lookalike
Right: *Cantharellus formosus*, in its favorite flat-leafed moss
Below: *Cantharellus cascadensis*, on the Galbraith mountain

All photos by Jack Waytz except for the Calypso orchid, which is by Jeremy D. Wade.

The other engrammatic mark for the habitat of these morels is that they were all, without exception, on southwest-facing slopes, so wherever the land was conducive to them, we could have ignored all the rest of the markers in favor of the southwest-facing slopes.

This is one of the points of the talk: the major factor in virtually all of these habitats is weather: temperature, precipitation, ambient humidity and so forth… weather is one of the chief concerns in the microhabitats of each of these mushrooms.

The next three slides are pictures that I myself took in the Sears Creek fire from 2012 and the spring of 2013 of three different species of burn morels.

This was a really fascinating habitat to forage in. There are times that you actually have to collect horizontally, because if you're vertically walking up a draw, you're stomping on all these mushrooms – there's literally a carpet of morel mushrooms. And this is the most fascinating habitat, because apparently the morels are primary fixers after these fires – they start to normalize the pH within the soil of these places and get them ready for the return of plant life. Another interesting factor to note is that although these morels grow in forests that are known to have "natural" morels[2] growing in them, DNA sequencing has recently revealed that none of the burn morels are the same species as that "natural" morels that occur in the same area. And that opens up a variety of questions about microhabitat of the burnt forest.

I've further observed certain types of morels growing specifically with certain types of burned wood, and there's some disagreement even among the experts as to how this works. Another important note about the burn morel habitat is that generally speaking only the first year after a burn will produce the morels. There are some exceptions to that, especially if there's a really poor first year for the burn morels.

There are two factors that they need in the habitat in order to have these really audacious fruitings. Number one: soil temperature contrast. The soil temperature has to come up drastically after the snow melts on some of these areas. And the other factor is moisture. The more rainfall that hits these areas in the early spring, the more extravagant the fruitings will be. In years where there isn't enough of a contrast in the temperature – in other words, if cold temperatures prevail late into the spring – or there's no moisture to accompany the snow melt – a lot of times what'll happen is the winds

[2]Natural morels are the ones that come up pretty much each year in the same spot, rainfall permitting (like regular mushrooms), as opposed to the burn morels which fruit only when there's a forest fire (and then they fruit massively).

will take away the snow, and it'll evaporate quickly, robbing the area of a lot of moisture, and then the morel fruitings will be very poor. If there's a year like this, there is sometimes a secondary fruiting the second year after a burn, and you can look for them there; but they're never as dense as the first year fruiting when conditions are correct.

The next two slides… the first slide is a club fungus called *Clavariadelphus truncatus* (see color photos, p. 61). This is on a particularly interesting part of the north Cascades spine. The next slide is *Polyozellus multiplex*, the

"blue chanterelle." These are both mycorrhizal with spruce, and there are two kinds of spruce that grow in Washington – the coastal range grows Sitka spruce, which is the same one that's seen in Alaska, and this one is Engelmann spruce, which is very limited to this area of the north Cascades spine. It's right at the apex of most of these mountains. This photo was taken near Washington Pass, which is the highest pass in Washington state.

These two mushrooms are mycorrhizal with the spruce, and they are found nowhere else in the western part of Washington, so the habitat marker is of course the Engelmann spruce.

The next slide is a picture of *Cantharellus subalbidus*, the very tasty

and beefy white chanterelle. In my opinion, for the kitchen this is the very best of the group – at least for the Washington chanterelles.

We find these on the west side of the Cascades, but they're much rarer than on the eastern side. The habitat is more conducive on the east side and the fruiting bodies in general are much bigger – I've found a couple up to three pounds. These are mycorrhizal with pacific silver fir and ponderosa pine –both trees in the area – and they share a habitat with white matsutake mushrooms. You generally find them growing adjacent to one another in this particular habitat.

Another important factor in all of these habitats is elevation: these are mountain mushrooms on the east side of Washington, generally found at about 3500-5000 feet. They're found growing in the duff, and their growth patterns are different from the golden chanterelles of our area: they push up from underneath the ground, so they're generally covered with dirt, similar to the growth habit of *Russula brevipes*.

The next slide (top half of p. 60) is that orange *Leccinum*. This is one of the more strange and fascinating habitats that I've found over the years. This is *Leccinum arctostaphylos* and that plant you see in the foreground is *Arctostaphylos*, or kinnikinnick. This *Leccinum* is mycorrhizal with this plant, which is exceedingly unusual – usually *Leccinums* are associated with trees. Because of this association, this mushroom is otherwise only known from Alaska. So it's quite a notable mycological experience to find it by a concrete airstrip in Washington. It's the only sighting of this mushroom in the 48 contiguous states.

The trick is that the airstrip is loaded with kinnikinnick for about 50-75 yards on either side of it as ground cover. This *Leccinum* is quite common in Alaska with kinnikinnick, and this airstrip has had big fruitings of it, along with several other mycorrhizal mushrooms – it's a very interesting site. Because of the kinnikinnick, it has many mushrooms found nowhere else in the state.

The slide is of a mushroom that we were thinking was going to be new to science, but has since been determined to be a form of *Amanita constricta*. It's extremely rare, but not a new species as we had thought. It's only found out here in one little area that I've ever discovered, in the lowland forests of western Washington. It's associated with old-growth forest, rather than older second-growth – which explains its rarity as most of the old-growth forest has not survived to 2019, sadly.

Its shape and coloration make it very distinctive, although it's just an example of a different morphology from the usual *Amanita constrica*.

This (top right, p. 61) is another very fascinating habitat. It is on the southeast face of Mt. Baker. It is the site of the last big lahar[3] eruption, about 6500 years ago.

A lot of the material that was on the mountain was brought down the mountainside. Among the things that survived this lahar were some seeds of silver pacific fir, which managed to germinate at about 3500 feet below their normal elevation. Generations of these firs went by and there was ongoing volcanic activity. Many of the silver firs didn't survive but there were always a few that did, and eventually these pacific silver firs took hold and some of them grew old.

This variation of *Boletus edulis* only officially occurs at 5000 feet, but here we are at 1200 feet and here are these mushrooms and a lot of the associated botany from the alpine zone here in this place right near Sulphur Creek. It isn't found this low anywhere on the mountain except this specific spot. You've got a whole microcosm of that alpine setting here, fitting together perfectly, about 3500 feet below its normal elevation. It's a fascinating site.

The next slide (underneath the previous one, on p. 61) is not overexposed; it's a shockingly snow-white bolete. We originally called this one *Boletus barrowsii* – with the common name of "white king" and you can see why – but the problem with that identification is that this is well up the Scott Paul trail on the northwest face of Mount Baker, at at least 4500 feet. But all the *Boletus barrowsii* out here occur at or about sea level, so there's a suspicion that this mushroom is a species that has not yet been described by science. It grows mycorrhizally with the pacific silver fir, so there's nothing different about that from the regular *Boletus edulis* but it is definitely a different mushroom. It is now being sequenced by David Arora to determine where it belongs.

This one doesn't occur every year – again, the microhabitat is very weather-driven: it needs a lot of moisture at the point where there's still a lot of ambient sun. This one comes out only at this one particular spot if there's a lot of rainfall in the second half of August. It'll come out in September, if there isn't a frost and the rainy conditions persist. Some boletes are a bit resistant to frost; but this one, as soon as you see frost, you've seen the last of that group.

Jumping tracks a little from the alpine, this slide (bottom half of p. 60) is in an urban setting – the Beacon Hill neighborhood of Seattle, Washington. As you can see, there's a rather boisterous fruiting of *Amanita muscaria*. This is in the cultivated area on the side of a major road, and the tree is an English beech tree. I've found a bunch of different *Amanita* mushrooms at different times under these trees, and as you can see it's a forest-like microhabitat right there, against that beech tree. No matter what the larger setting is, I've found that mycorrhizal partners can come up around their favorite trees virtually anywhere that the tree is. The ground, the exposure to the sun, and of course the mycorrhizal partner – the beech tree – all play a role in this habitat.

[3]Lahar is a volcano-triggered mudslide. They often happen when volcanoes melt existing snow or glacial ice, or when the tremors of volcanic activity shake a layer of mud off the mountainside.

Jumping around a little bit, here is another morel. The common name of morels that fruit like this is "landscape morels." Their relationship with ground disturbance can't be overstated. The following spring – and only the following spring, similar to burn morels – you get these boisterous fruitings of morels, and then you won't see them again.

There are two species of landscape morels in the United States: the one in the south is *Morchella rufobrunnea*; and this one, in the north, is *Morchella importuna*.

These were unusually large – about eight inches long. They were found in someone's backyard where they had dredged out a rain garden[4] and put new soil in and topped it off with wood chips.

What's notable if you're foraging for the table is that this is the quintessential sheep in wolf's clothing: although they sure look delicious, they're virtually flavorless. Unless you're a master with seasonings this is a big disappointment once it hits the table. But it is a pretty interesting mushroom.This is an unknown Mycena which is just growing out of a pile of twigs that was left there by birds. The mushrooms are very opportunistic and they'll make a habitat out of what seems to be nothing on the forest floor, as evidenced by this group: they seem to be quite happy with that little microhabitat.

The next slide is the classic golden chanterelle for NW Washington, Cantharellus formosus. This is the predominant chanterelle found on the western side of the cascades, but they are very seldom found on the east side of the crest. And again, this is attributable to a microhabitat. There is a specific type of moss – a flat-leafed moss that is pictured with this group of chanterelles – which (although they're not associated with the mushrooms in a mycorrhizal relationship) the ground cover seems to have a big role in these fruitings, though the mushrooms themselves are mycorrhizal with Douglas fir.

It can be found at many different elevations, but the habitat is always around secondary-growth Douglas fir trees – even more than old-growth, which is interesting. The wheelhouse age for the Douglas fir trees would be between 60 and 80 years, so late secondary growth; the forest floor is relatively free from a lot of plants, although Oregon grapes are often featured with them and sword ferns as well; and of course this particular kind of moss.

Next slide is also found on the Galbraith mountain, but in years where the weather is a bit different. You have a good kickoff of soaking rains in September or even October and then it gets dry again, a lot of times the Cantharellus formosus will get a green mold on them. But the upside is that this mushroom, Cantharellus cascadensis, is often found in those same dry periods. It's a very unusual configuration of weather for out here – usually once the rains come in September or October it stays wet through November; but if it's dry for two weeks or so, there's a possibility this mushroom will turn up.

And again, the main microhabitat marker for this mushroom is a little bit of a dry period, so it's weather-driven once again.

Mushroom

[4] A rain garden is a planting designed to catch rainwater runoff, especially runoff that has been increased by manmade impervious surfaces like roads and sidewalks. Rain gardens are often sunken somewhat to aid in water capture.

Toxic Substances in the Fly Agaric

What About Organometallic Compounds?

by Beowulf Glutzenbaum

I read with interest the article by Kevin Feeney and Tjakko Stijve on the possible contribution of minor muscarine concentrations in cases of fly agaric poisoning (*Mushroom the Journal*, issue 106, pp 32 – 36). It has now generally been accepted that the principal toxic compounds in *Amanita muscaria* are the isoxazole derivatives ibotenic acid and muscimol. To some extent, muscarine could play a role in the poisonings, but what is puzzling me is that, in this context, other ingredients are never mentioned.

Indeed, if we confine ourselves to the chemical elements reported in this beautiful mushroom, we have already quite a field of investigation. The colorful fingerprint after Cocchi, Vescovi and Petrini (2006) presented here shows that the fly agaric is loaded with at least 8 chemical elements of which several are far from harmless. For a better comprehension of this fingerprint, it should be borne in mind that the zero line represents the median value of the elements as found in non-accumulating mushrooms. For example, the median concentration of the metal vanadium (V) in a non-accumulating species is about 0.10 mg/kg on dry matter. The fingerprint indicates that the fly agaric contains 2000 times more, i.e. 2000 x 0,10 = about 200 mg/kg!

Besides vanadium, the fly agaric contains considerable amounts of rubidium (Rb), selenium (Se), chlorine (Cl), cadmium (Cd) and even of zirconium (Zr). If the levels of chlorine, rubidium and selenium are relatively harmless, a toxicologist would frown upon the other metals present at unusually high concentrations.

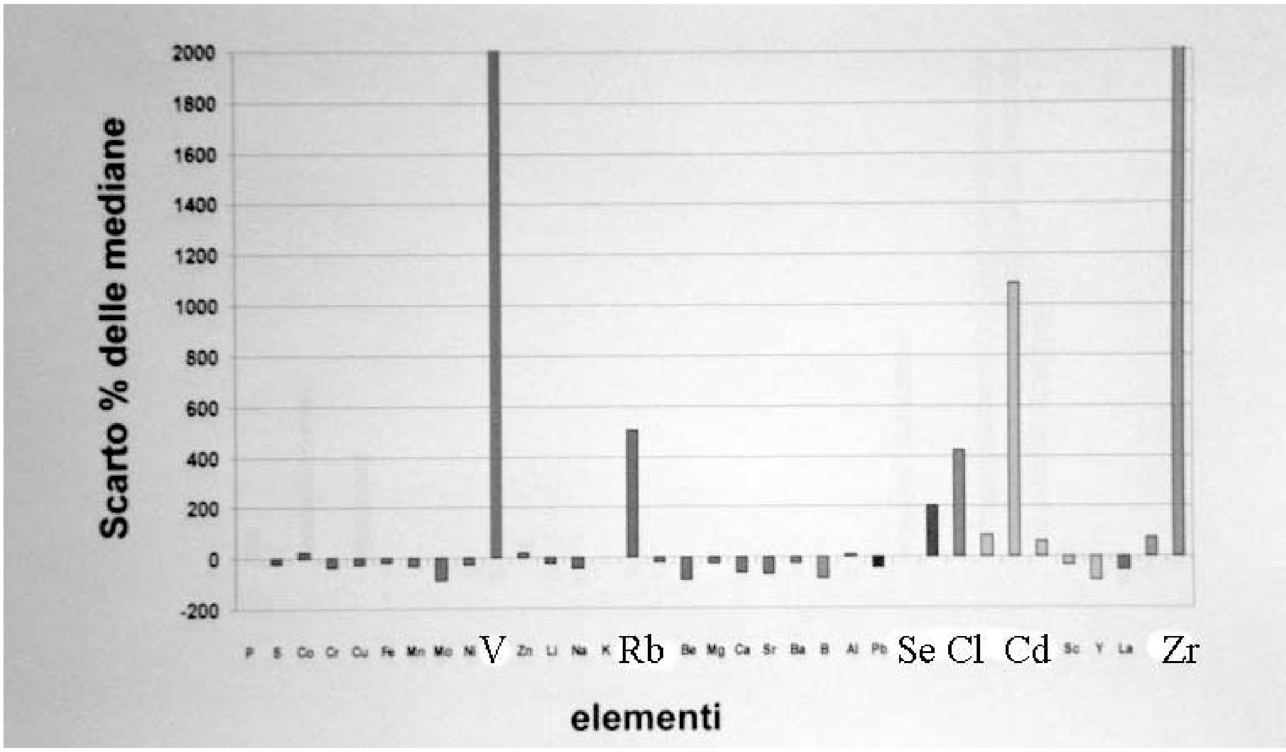
Cadmium is a well-known chronic toxicant that is stored in the kidneys, but there are many edible mushrooms, such as boletes and *Agaricus* species containing much more.

The outliers vanadium and zirconium are far more disturbing. The chemical form in which vanadium is stored in the fly agaric is an eight-coordinate complex called amavadine, which was first isolated and identified by Kneifel and Bayer (1972). Amavadine was soon recognised as a vanadium compound having unusual chemical properties. For example, it was applied as a highly efficient catalyst in organic syntheses. In the last 40 years it has been so thoroughly studied that, when googling for amavadine, you'll find about 8000 results!

The biological role of this compound is still unknown, but it has been suggested that it serves as a toxin for the protection of the mushroom (Garner et al.; 2000). Although its mammalian toxicity has not yet been investigated, the amount present may be as high as 0.15 % on dry matter, a concentration close to that of ibotenic acid!

Even more puzzling is the fly agaric's affinity for zirconium (Petrini et al., 2009). So far, no biological role for this metal has been discovered. Most land plants do not even have detectable amounts of zirconium, and those that do have as little as 0.005 mg/kg. Many mushrooms have 5 – 10 times more, and according to the fingerprint a 2000 times higher concentration was found in the fly agaric. Indeed, the results of my own analyses for Zr in European material fluctuate between 10 and 70 mg/kg dry weight. The chemical form of this tetravalent metal in the fly agaric is still unknown, but it is not unthinkable that Zr forms a complex similar to the above-mentioned amavadine.

Come to think of it, according to our chemistry books, zirconium is always accompanied by small amounts of hafnium, another tetravalent metal, but much more rare. A literature search revealed that the Czech scientist Randa (2002) found 0,052 – 0,31 mg/kg dw in fly agarics. Considering the rarity of hafnium, this concentration range is really enormous. Consequently, Amanita muscaria could well contain the amavadine analogues amazirconine and amahafnine. Whether these compounds would induce copious vomiting remains open to question. Although it has repeatedly been stated that consuming fly agarics is rather harmless (Rubel



▲ The elemental "fingerprint" taken from Cocchi, Vescovi and Petrini (2006). Since the key is illegible at this scale, your editor has enlarged the symbols of the elements of interest.

and Arora, 2008), the average consumer's stomach may not be equal to the amounts of organometallics ingested!

Beowulf Glutzenbaum is a sometime pen name of Tjakko Stijve.

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An Unusual Poison Control Call

by Bill Bakaitis

Well, there are two unusual factors here: First, it wasn't exactly a call from the Poison Control Network but instead one of those calls self-reported from someone who suspected a self-induced toxic ingestion; and who (second factor) following ingestion found my name online and called for help at five in the morning.

Take the first factor first: For a variety of reasons calls previously received from Hospitals and Doctors –Veterinary Medicine excepted – have tapered off to nearly zero. Info from friends and contacts within the medical community suggest that a prime reason for this has to do with HIPPA confidentiality standards which are now widely applied in a fairly narrow fashion. This often leads to a hesitancy to call in a volunteer consultant, particularly if an in-house professional is available. Add to this the dictum that one treats the symptoms, not the mushroom, along with the easy availability of diagnostic and treatment protocol available online, and the hesitancy to call in a mycological consultant becomes even more pronounced.

Within this context, there are also widely available online resources – chat rooms, web sites, credible images and fine grained search engines, all of which result in what amounts to a buyer's market with an easily accessible embarrassment of riches. Anyone, it seems, with a scintilla of interest in searching out an ID from field characteristics can do a quite god job with a few well-placed clicks of the mouse.

Which brings us to the second factor, the case here in point.

It was towards the end of June, a few days past the new moon. The tides in Maine where I summer were running twelve feet or more. Shrimp and silversides were flushing in and out of the salt ponds and estuaries, drawing with them large schools of gamefish, conditions which kept me on the water until well past midnight. I didn't bed down 'till after three.

Waking at nine or so, I checked my cell phone and listened to the barely coherent message…. "*Poison Control…Mushroom… help…*" was what I thought I could decipher. I called back and received an even more incoherent and garbled response. Nothing made any sense. The static and quality of the audio convinced me this was the result of a bad connection, so I pleaded with the garble to call me back. Twice. Three times. Finally an 'OK'.

An hour and half later the call came in and I spoke with a relatively coherent "James" who was calling from a field behind his house where the reception seemed to be better. He would not give me his real name, but we spoke for a half hour or so. Filtered from the wandering and evasive narrative, this is what I believe was the actual chronology of his crisis:

Sometime earlier in the year, perhaps in May, he had picked a large number of mushrooms he thought were *Panaeolus subbalteatus* from dung and old hay in his horse pasture. I think he obtained his ID from internet sources. He described drying the mushrooms well, picking out all of the debris (manure?) and storing them in clean, moisture free packs, perhaps in the fridge or freezer, a process he learned from an online website. He was keeping them for a special event.

That event appeared to come on June 26th when he made and drank a tea prepared from a half cup of dried mushrooms and 'dust'. He said there was some aspect of light from fireflies which he wished to investigate, something about the light at night when there was no moon. The way he described the event seemed to suggest that he might be a visual artist. It turned out he drank the tea about the same time I was turning in – a little after three in the morning. I asked him if the mushroom tea worked and he stated emphatically that it did, although the effect was "subtle". Unfortunately it also gave him a terrible stomachache and he wondered if he had made a mistake and somehow poisoned himself.

Even though he was high he clearly was able to go to his computer, search the web and come up with my telephone number, presumably from the NAMA website or a similar one. My cell phone recorded the call as coming in at 5:24 am, the timing of which indicates that both the visual and the somatic effects (stomachache) happened within the first hour – during which his cognitive functioning nevertheless allowed for a logical computer search.

He asked for advice as to his medical condition. I told him that all we could do was attempt to ID the mushrooms from a photo, habitat information, symptoms, and things like that. He persisted in wanting to know if he had made a mistake and poisoned himself. The fact that I knew nothing about the mushroom he thought he had collected and ingested caused him great anxiety. I explained that toxic gastric effects are usually self-limiting, that the more serious/deadly effects of amatoxins, which might be present in a few non-descript little brown mushrooms (which are sometimes mistaken for the psychoactive ones) take days to fully manifest. I told him that Amanita did not grow on dung and/or hay, and suggested that if he was concerned about the conditions he was experiencing, he should see his doctor or go to the emergency room of a hospital.

He fought that suggestion, implying he had no doctor or medical insurance, and that he was afraid of being arrested. At this point he grew quite agitated. He was unaccepting of the usual set of suggestions and reassurances that it was pretty much a sure bet that he would not be arrested and that public/institutional funds are usually available to help those without health insurance. I braced myself for what I thought might be a long, calm, and rational reiteration of a prudent medical course of action.

Judging from his tone of voice and the fact that he seemed to be acting alone, one could easily assume him to be an impoverished young artist/ college student living alone in a rural location, or a teen- age/ young adult still living with parents. In either case his plight was easy to identify with.

Rather than pressing him into a more strenuous defense of the advice previously suggested, I offered instead a moment of telephonic silence. Supportive understandings, Hmm's and deep breaths followed, and then in a sudden reversal of his previous refusals, he thanked me and said he would seek (unspecified) medical advice if he did not feel better by the late afternoon. I asked him to call back if there was any change in his symptoms or condition. He said he would.

Was his sudden change insightful self-revelation, fear driven rigid refusal, or a calculated cost-benefit rational decision? Dunno.

He never called back, which is not that unusual; but it did leave me wondering as to his physical, social, and mental conditions, and of the effects of the mushrooms consumed which themselves seemed to contribute to the volatility punctuating his life that night-into-morning.

The take-away which fell into my lap was a reflection of the advice from the psychedelic drug-taking '60's: That the general effect of such drugs are framed by the (mental) Set of the drug taker, and (social) Setting of the experience, with the drugs themselves usually magnifying elements already in play. In this case social isolation, unexpected physical symptoms, and fear of an incorrect identification of a collection of dung-inhabiting fungi were what was on his mind and took control of the experience he sought.

I recalled the advice of Tim Leary, psychedelic godfather of the '60s. Raised Catholic, he framed the drug experience as religious, the drug as a 'holy sacrament' and accordingly proscribed rituals necessary for a good trip, most importantly entering the experience in a state of grace having first made both a good confession and act of contrition appropriate to the sins involved. Not bad advice, it seems, even for secular atheists.

The more pointed lesson however might be, "those who live by the internet, may well die by the internet", suggesting that those sweet baby Jameses among us might just as well 'fess up to that sobering fact before concocting some experimental version of tea gleaned from a website and served up at three in the morning.

My contact information may be posted, and the emergency room may be open 24/7, but as for me, when I hit the hay, my phone gets turned off, the better to keep my own demons snug in their dream states where they belong. At three in the morning dreams have a way of becoming nightmares. So, mix your lime with the coconut, drink 'em all up, but call me in the morning.

Mushroom

Solution to last issue's crossword puzzle

The squares along the path, except for the initial X and the final Y, spell out YOU'RE STRANGE, SIR. The shaded squares not on the path spell out TWO ANSWERS CROSSING IT; the answers crossing the final Y square are OH BOY and GROOVY.

Rytas Vilgalys, doing something he does even better than fungal genetics research. The photographer, Francis Martin says that they were "collecting porcini in the Donon forest in the Vosges range, NE France. There was a profusion of mushrooms on this day of October 2017." I don't know about you, but this is how I want to look if I ever get to collect mushrooms in the Donon forest.

For the interview with Rytas, see p. 38.

▲ Hot ant sauce in Venezuela, Figure 3 from "Collecting fungi in the Amazonian Cerro de la Neblina," p. 46.

▼ The genus *Nebilinaria* is named after its location: the Cerro de la Neblina. See article p. 46.