SPORE PRINTS

BULLETIN OF THE PUGET SOUND MYCOLOGICAL SOCIETY
Number 419 February 2006

AFLATOXIN KILLS

Dick Sieger

Pet food contaminated with aflatoxin killed approximately 100 dogs during the recent holiday season. The product, since recalled, was manufactured by Diamond Pet Food and sold in 22 eastern states (see http://www.diamondpetrecall.com). The poisonous aflatoxin came from corn infected by the mold *Aspergillus flavus*. The deaths resulted from liver failure. Symptoms included lethargy, poor appetite, yellowish eyes or gums, internal bleeding, and severe, perhaps bloody, diarrhea.

Cornell University

Scanning electron microscope photo of Aspergillus flavus *conidiophore.*

Diamond tests each load of corn for aflatoxin and usually rejects a shipment weekly. *Aspergillus* infections, however, are spotty, and a sample from one part of a truckload may not reveal contamination elsewhere.

Aflatoxin is produced by some strains of *Aspergillus flavus* as well as the closely related *A. parasiticus*. *Aspergillus flavus* survives in the soil as a mat of mycelium (chains of cells) or a hard mass of tissue (sclerotium) which produce spore-bearing structures called conidiophores. Carried by moving air and insects, the asexual spores (conidia) infect plants before they are harvested and while they are in storage. Plants stressed by drought and high temperatures are particularly vulnerable. The fungus grows best on warm, dry substrates which may appear and smell wholesome.

Aflatoxins have been found in many farm products but are especially troublesome in ubiquitous foods and feeds such as peanuts and peanut butter, cottonseed, and corn. Meat, milk, and cheese may contain aflatoxins when animals eat tainted feed. The toxins can cause severe liver, kidney, and heart damage. There is no ethical way to measure the effect of aflatoxins on people, but for some animals they are the most powerful carcinogen known. Because of circumstantial evidence, the most common aflatoxin (B_1) is listed as a human carcinogen. It appears that long-term exposure to even small amounts can endanger people and animals.

Aflatoxins are remarkably resistant to high temperatures. Once in food, they persist. Fortunately, alkaline processing of the corn used in tortillas does degrade them.

The FDA considers aflatoxins unavoidable food contaminants and allows our food to contain as much as 20 parts per billion (0.5 ppb for milk). Canada has a limit of 15 ppb and Germany 10 ppb. Dr. Bryce Kendrick, FRSC, a mycologist noted for his work with molds, writes in the CD-ROM version of his book *The Fifth Kingdom* (see http://www.mycolog.com/fifthtoc.html), "…my own feeling is that no detectable aflatoxin should be permitted. If proper attention was paid to storage and selection of peanuts for human consumption, and to appropriate dilution of mildly contaminated nuts, this standard could be easily attained."

PRESIDENT'S MESSAGE

Ron Post

As the annual flower show and the time for our Survivor's Banquet (March 11) approach, it's good to remember why we joined the club and why we stay attached to it. I'm almost finished with my term as president, so here's my two cents' worth.

Mainly, the people in the club are some of the most gracious and intelligent I have ever met. But there are also some very worthy traditions that somehow are carried on: amateur science that really works; the values of conservation and preservation; a spirit of intellectual cooperation, from the committee level in the club to the international level of our membership and participants; and a way for us to mark the seasons together.

If you have not already done so, make sure you renew your membership this month so that your next newsletter arrives in time for the spring mushroom season!

ELECTION ALERT

You won't see a ballot in this issue of *Spore Prints* (as usually happens in February) since we needed more time to recruit candidates. However, a special ballot will be mailed to you around February 22, and you'll have until March 9 to get it back to the PSMS office. Ballots received after that deadline won't be counted.

Interested in running for the board? Contact Election Committee members Ron Post (206) 527-2996, Tony Tschanz (206) 933-8357, or Brett Vielbig, (206) 932-1703.

Nominations will be taken from the floor at the February meeting or by calling one of the three Election Committee members listed above before February 21.

Here is a list of the open positions.

President
Treasurer
Trustees (five plus alternates to fill in for resignations)

Come one, come all!

DUES ARE (PAST) DUE

If you have an asterisk (*) by your name on the mailing label, your membership has lapsed. Please renew as soon as possible to continue to receive *Spore Prints*. (If you are paid up but still have an asterisk by your name, your dues may have not been received in time for this printing.)

Nature-Oriented Book Sale: Center for Urban Horticulture, February 25, between 10 AM and 2 PM. Hundreds of used books in all natural history disciplines. Proceeds to benefit the Washington Butterfly Association and Seattle Audubon Society.

Spore Prints

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PUGET SOUND MYCOLOGICAL SOCIETY

Center for Urban Horticulture, Box 354115
University of Washington, Seattle, Washington 98195
(206) 522-6031 http://www.psms.org
User name: Password:

Annual dues $25; full-time students $15

CALENDAR

Feb. 14	Membership Meeting, 7:30 PM, CUH
Feb. 20	Board Meeting, 7:30 PM, CUH Board Room
Feb. 21	*Spore Prints* deadline
Feb. 25	Nature-Oriented Book Sale, CUH, 10 AM–5 PM
Mar. 9	Deadline for election ballots
Mar. 11	PSMS Survivor's Banquet and Annual Meeting, CUH

BOARD NEWS

Dennis Oliver

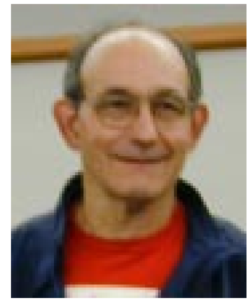
The board meeting was well attended, with nearly all the board members being present. John Goldman presented the annual treasurer's report. The club's finances are in fine shape, but the club lost money in 2005 owing to less income from the annual mushroom show and a drop in book sales. The book sales and income will increase as 2006 progresses and attendance at the show will always be in flux. Colleen Compton and Younghee Lee are co-chairs for the annual survivor's banquet; more details are in this issue. The election search committee is still looking for a few "good people."

You'll have lots of fun at board meetings
With the feudin' and fussin' and fumin'.
You may not learn much
About fungus and such,
But, boy, what you'll learn about humans.

—Ralph Nolan

MEMBERSHIP MEETING

Tuesday, February 14, at 7:30 PM at the Center for Urban Horticulture, 3501 NE 41st Street, Seattle



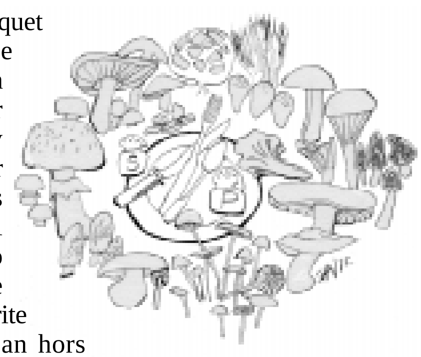
Our featured speaker this month will be our scientific advisor, Dr. Joseph Ammirati, who will enlighten us on fungi of the Puget Sound region and invasive species.

Dr. Ammirati is a mushroom taxonomist, working primarily on *Cortinarius*, but has broad interests in Agaricology. He is respected for his work with *Cortinarius*, toxicology, and forest ecology. His revision of *The New Savory Wild Mushroom* earned him a certificate of achievement from the Society for Technical Communication, and he is co-author of *Poisonous Mushrooms of the Northern United States and Canada*. Dr Ammirati is a constant supporter of mushroom hobbyists, speaking at numerous meetings, banquets, and forays. He was the advisor for our Barlow Pass study, the Oregon chanterelle project, and the Pacific Northwest Key Council. He has been foray mycologist for several North American Mycological Association forays, has been foray mycologist for amateur societies innumerable times, and has spoken at their meetings, classes, forays, and banquets. Now, once again, he will address our society.

Would persons with last names beginning with the letters A–L please bring refreshments for the social hour?

2006 SURVIVOR'S BANQUET

Colleen Compton



The PSMS Survivor's Banquet and annual meeting will be held on Saturday, March 11, 2006, at the Center for Urban Horticulture. By popular request, the dinner will be a potluck again this year. The social hour will begin at 6:30 PM, dinner to follow at 7:30 PM. Please join us and bring your favorite dish to share. It can be an hors d'oeuvre, entrée, or dessert. Be sure to label any wild mushrooms included in your dish. We will secure a liquor permit so attendees can bring wine, etc., to enjoy with their food. The entertainment will include at least two humorous skits written and performed by members. We will also announce names of newly elected or appointed trustees and officers. Especially exciting will be disclosure of the recipient of our 2006 Golden Mushroom Award.

Sign up by sending your reservation for yourself and any guests, along with $7.00 each, to

PSMS Banquet
c/o Younghee Lee
2416 N. 43rd St.
Seattle, WA 98103

You may also register and pay for the banquet at the February membership meeting. Make checks payable to PSMS Banquet.

If you have questions, e-mail colleen.compton@att.net or phone (206) 417-4540. There will be no regular membership meeting in March.

HUNGARY'S TOKAY ASZÚ WINE **Monroe Baisden**

The Sporeprint, L.A. Myco. Soc., Jan. 2006

One of the most incredibly decadent wines in the world is produced in Hungary. Its production is complicated and labor intensive, which makes it one of the most expensive wines as well.

The wine is a dessert wine known as Tokay Aszú, and it has only relatively recently returned to its place of prominence as one of the world's greatest sweet wines.

Though there are references to the Aszú wine even from earlier times, the origin of Tokay Aszú is traditionally dated in the year 1630, when, according to legend, fear of a Turkish raid delayed the vintage several weeks in mid-November, and the fruit of the Oremus strip shrivelled and became dry. Adding choice grapes dried on the vine, Máté Szepsi Laczkó, court chaplain of Zsuzsanna Lorántffy, produced an unequalled wine from this vintage, which he offered to Lorántffy at Easter. This wine became famous all over Europe, being known by Louis XIV's description as "the wine of kings and the king of wines."

The *Phylloxera* infestation of the late 1800s, however, began its demise. World Wars I and II devastated the reviving vineyards, and when the Communists took over in 1949, the wineries and vineyards were confiscated and nationalized. By the mid-1980s the innocuous wine called Tokay bore no resemblance to the once awesomely delicious sweet wine.

When Communist rule ended in 1989, winemakers, consultants, and investors began the revitalization of the wine industry in Hungary, resurrecting Tokay Aszú to its former glory within five years.

As I mentioned, the wine is not an easy wine to make. It is made with the help of *Botrytis cinerea*, the fungus also known as "noble rot." In order for the fungus to do its job, climatic conditions must be perfect. There are four primary grapes that may be used—furmint, hárslevelu, yellow muscatel, and oremus—the most important being furmint.

The infected grapes are literally harvested one by one and are crushed into a sweet paste. The non-infected grapes are harvested separately and made into a base wine.

The aszú paste is then added in various proportions to the base wine of the same year. The proportions are measured in "puttonyos," one of which is equal to about 20 liters (5.2 gallons) of aszú paste.

After eight to 72 hours, the sweetened wine will be drawn off of the paste and allowed to ferment again. Sometimes this fermentation takes years owing to the high sugar content and the cold temperatures.

Tokay Aszú must be aged for at least two years in oak and one year in the bottle before release. The wine label will indicate the number of puttonyos added, indicating the sweetness of the wine. A 4-Puttonyos wine will be less sweet than a 6-Puttonyos one, with prices running from about $40 for a 500 ml bottle to $100 or more. Even more exceptional is the exceedingly rare Tokay Eszencia, the cost of which can top $200 for a half-bottle.

While Tokay Aszú is quite sweet, it is balanced with natural acidity, allowing rich flavors of honey, dried apricots, peaches, and crème brûleé to "dance in your mouth with a refinement that is breathtaking."

You owe it to yourself to experience a Tokay Aszú, or if you give one as a gift, make sure there is a "for sharing" clause on the card.

Blessed Tokaj wine, how good you are,
your mere fragrance is enough to send death running;
for many ill people have been cured by drinking you,
though they were about to be taken away.
Drink of the gods, immortal nectar,
the land is blest where you grow!

—Miklós Szemere

TRUFFLES: LOVE THEM OR LEAVE THEM?

NJMA news, New Jersey Myco. Assoc., Jan./Feb. 2006

In an article by Katy McLaughlin in *The Wall Street Journal*, she states that the reason that people either enjoy the taste of truffles or detest them depends on their sensitivity to a chemical component called androstenone. Twenty-five percent of the population have no reaction at all to this chemical, which contributes to the fungus' signature musky aroma—the aroma that makes female pigs go into the mating stance. Another 40% are keenly sensitive to it. They say it smells like rotten wood or sweat. That leaves 35% of the population that likes the smell—and makes them willing to pay to have it added to their food for as much as $110 for a plate of spaghetti with white truffle shavings (at Cafe Boulud in New York). Restaurants serving truffles may be paying up to $1,600 per pound for this most-expensive fungus, yet some diners may be so turned off by the "overpowering woodsy taste" that they want to make sure that truffles are not in any of the food that they order. Research is "still out" as to whether perception of the compound is due to differences in individuals' noses or in the way the brain processes aroma messages.

If you are tempted to spend several hundred dollars on a truffle dinner, ask a specialty food store to let you take a whiff of a truffle or a high quality truffle oil made with genuine truffles. [NJMA Editor's note: I have learned through trade publications that there is no such thing as a white truffle oil that is made with anything but manufactured flavors.] If you smell nothing or, worse, you smell overpowering notes of rotten wood, urine, or sweat, you might want to save your money for another "delicacy."

COMPANIES SEEK OUT MICROBES TO FIGHT CROP PESTS **Joel Millman**

The Sporeprint, L.A. Myco. Soc., Jan. 2006

Davis, CA - The autopsy began. "See?" Pamela Marrone said, nudging another scientist closer to the blackened corpse. "The white thing—it's growing out of the right side of his head." Wrinkling her nose at the aroma of decay, cadaver specialist Sherry Heins leaned in. "But how do we know it's the cause of death?" she asked.

The two women stuffed the victim—all two centimeters of a recently deceased corn-ear worm—into a glass chamber filled with cornstarch and molasses. If the bacteria that killed the worm were still alive, they would gorge on the sweet sludge and swell up into something big enough for Dr. Marrone and her team to study.

Corn-ear worms destroy corn crops. Dr. Marrone's biotech company, AgraQuest Inc., hunts for worm-killing germs. It also seeks fungi, parasites, spores, and anything else that kills crop-eaters in the wild.

The Davis, California, company is one of a new generation of "biopesticide" makers that search for innovative ways to kill crop

cont. on page 4

Micro-organisms Fight Pests, *cont. from page 3*

pests without using synthetic chemicals. Though the science of biopesticides is decades old, it's rather new in commercial enterprises, with a slew of products just coming to market. Some of the companies breed insects and other bugs to eat the pests. Others develop carriers of deadly microbes to poison the pests. Still others search for the specific germs that kill pests and mass produce the microscopic assassins. Most of these companies are small start-ups, few of whom have yet to show a profit. Their business plans read like part science fiction, part "CSI: Fruit Orchard."

Take Pasteuria Biosciences LLC, a Gainesville, Florida, start-up that is raising capital to kill nematodes, worms that attack plant roots. Pasteuria uses a fermentation process to reproduce a killer microbe called *Pasteuria penetrans*, which burrows into nematodes and prevents them from producing eggs. Soybean plantations and golf courses, both veritable salad bowls for nematodes, could be huge markets, says Tom Hewlett, a nematologist who launched Pasteuria in 2003.

Then there's *Trichoderma harzianum*, a fungus discovered at Cornell University, which is how marketed by BioWorks Inc. of Fairport, New York. *Trichoderma* grows a shield around a plant's roots and secretes an enzyme that destroys invading fungi. Another firm, Certis USA, a unit of Japan's Mitsui & Co., produces a bug killer, called Azadirachtin, from the sap of Asia's neem tree, which poisons aphids and whiteflies.

Overall, biopesticide sales are expected to reach $340 million in 2005, up 20% from 2004, according to the Biopesticide Industry Alliance. That's small change compared with some $30 billion in chemical pesticide sales, but that market is barely growing. Thus far, biopesticide companies' products are sold mainly in the U.S., usually to greenhouses and horticulture farmers.

Biopesticide customers include not only organic farmers but conventional farmers who worry that heavy reliance on chemical pesticides will poison their fields and water sources, especially in the tropics where a lush climate produces a host of crop-eating pests.

In Costa Rica, which last year imported about $100 million in chemical pesticides, biopesticide vendors are making inroads, in part, because the government wants to market the country as an ecological haven. Ball Horticultural Co. of West Chicago, Illinois, is busily replacing toxic pesticides with bio-killers at its Costa Rican nurseries. AgraQuest sells Ball a fungicide, called Serenade, which kills molds by eating their cell walls.

Dr. Marrone, AgraQuest's 49-year-old founder, grew up in a family of organic gardeners in New England. After getting a Ph. D. at North Carolina State University, she worked at Monsanto Co., where synthetic chemical pesticides were the norm, and she was encouraged to seek biological substitutes. But when Monsanto shifted its focus to genetically engineering crops. Dr. Marrone decided to search for venture capital instead. Today privately owned AgraQuest has 72 employees and expects sales of $10 million this year.

While many biopesticide makers tinker with microbes discovered on university campuses, AgraQuest is unusual because it searches fields and jungles for new compounds, often finding them in dead bugs. It's painstaking work. Of the billions of bugs that inhabit the planet at any given moment, fewer than 1% die of infection.

Over the past decade, Dr. Marrone estimates she's screened some 23,000 suspects. Tanks and storage boxes filled with rotting vermin line the hallways at AgraQuest's headquarters. Besides bugs, there are growing collections of ocean sponges and bird feathers. Sponges harbor microbes yet to be exposed to garden pests, Dr. Marrone explains. Feather shafts are breeding grounds for microbes that kill lice, and perhaps crop-devouring bugs, too.

Putah Creek, a nature reserve near Davis, is one of Dr. Marrone's favorite hunting spots. A former walnut grove, the area swarms with fruit-eating bugs, especially after spring floods. This summer, on ground still slick with runoff, she walked along a brackish stream examining rotting walnuts, tree bark, and spider webs for specimens. "Oh, my God!" she exclaimed, chancing on a cache of aphid husks on a blade of wild millet. Within hours they were bagged and tagged in her laboratory's microbe morgue.

Other times, Dr. Marrone relies on professional microbe hunters, mainly academics who prowl wilderness areas. In Honduras, Gary Strobel, a Montana State University researcher, found a fungus called *Muscodor albus* nestled in the bark of a mutant cinnamon tree. When dropped into water, it releases a mixture of gases that asphyxiate insects. Dr. Strobel licensed the microbe for around $100,000, plus royalties, to AgraQuest. The company hopes to turn it into a replacement for methyl bromide, a chemical pesticide that is being phased out by the Environmental Protection Agency because of its alleged hazard to the ozone layer.

In the lab, Dr. Marrone isolates microbes from the plant pests they kill and tries to figure out which specific microbe did the deed. "You can squash the guts on a glass slide and look under a microscope for spores or something that might have caused an infection," she says with a knowing grin. "Or you can put the corpse into a Clorox solution, put it on a Petri plate, and see what crawls out."

Eventually, proven killers are released for further testing in bug colonies, usually fruit flies or mosquitoes. Next, AgraQuest determines how well a killer can survive storage. The hardiest germs are reproduced by fermentation in a plant outside Tlaxcala, Mexico, and then dehydrated for shipment. Farmers add water to the microbes and then spray them on crops with hand pumps or crop-dusting aircraft.

Most of AgraQuest's sales are from its best-selling product, Serenade, derived from *Bacillus subtilis*, a microbe Dr. Marrone found in a Fresno, California, peach orchard. During her recent trip to Culiacan, Mexico, a local tomato farmer, Juan Jose Ley, told her he's such a Serenade fan he used it in his greenhouses even before the Mexican government gave it regulatory approval. "We imported it from the states, illegally," he said.

Back at home, Dr. Marrone said she's toying to clear her kitchen of specimens, especially the ones she keeps among the ice-cube trays. "My husband has been bugging me to get these things out of the freezer," she said with a smile, reaching for an open jug of Clorox.

DEAD SEA FUNGUS MAY HELP CROPS

Kurt Kleiner, *The Sporeprint*, L.A. Myco. Soc., Jan. 2006

An extraordinary fungus that manages to thrive in the super-salty Dead Sea could one day open up new genetic approaches to creating crops that can tolerate saline soils.

The fungus, *Eurotium herbariorum*, is able to tolerate the Dead Sea's incredible salt content of 340 grams per liter—about 10 times saltier than ocean water. Most of the Earth's organisms are far less tolerant of salt and will dehydrate and die if exposed to too much of it. Researchers are interested in developing salt-tolerant food crops because soil salinity is increasing in some parts of the world.

Land that needs to be constantly irrigated gradually becomes more saline, and crop yields go down.

One way that cells respond to stress from salt is by manufacturing glycerol, which helps keep water from migrating out of a cell. So researchers from the University of Haifa in Israel isolated a gene called EhHOG associated with glycerol production in the fungus and inserted it into brewer's yeast, *Saccharomyces cerevisiae*.

They found the transgenic yeast was able to tolerate more salt than normal, and that it had more tolerance for high and low temperatures and for hydrogen peroxide. The researchers say if the gene could be inserted into a plant, it might eventually be used to increase stress tolerance in crops. They add that other genes from Dead Sea organisms might also be promising.

But Tim Flowers, a plant physiologist at the University of Sussex, UK, says that fungi are so different from crop plants that there is no reason to think the gene will be useful. He says salt tolerance is probably a trait involving multiple genes, and it that it is unlikely that transplanting one or two genes will result in crops with increased salt tolerance.

SHIITAKE'S SECRET MAY BENEFIT EARTH-FRIENDLY FUELS

Marcie Wood

Mushroomers, Ore. Myco. Soc., Jan./Feb. 2006

Fallen logs on the forest floor make a perfect home for shiitake mushrooms. These fungi—sold as a delicacy in the produce section of your local supermarket—thrive on the downed wood, turning it into sugars that they use for food.

Now, Agricultural Research Service (ARS) scientists in California are looking at bringing the gourmet mushroom's mostly unstudied talent indoors. And, as a first step toward doing that, they've found and copied a shiitake gene that's key to the mushroom's ability to dissolve wood. Called Xyn11A, the gene carries the instructions that the mushroom uses to make an enzyme known as xylanase. The researchers want to see if a ramped-up version of the gene could be put to work digesting rice hulls or other harvest leftovers.

If enzymes can do that quickly and efficiently in huge vats, or fermenters, at biorefineries, they could help make ethanol and other products a practical alternative to today's petroleum-based fuels, for example. That's according to Charles C. Lee, an ARS research chemist.

With colleagues, Lee isolated and tested the Xyn11A gene, the first of its kind to be discovered in Shiitake mushrooms, *Lentinula edodes*. Lee did the work with research chemist Dominic W. S. Wong and chemical engineer George H. Robertson. The scientists are based at the ARS Western Regional Research Center in Albany, California.

In laboratory experiments, they transferred the Xyn11A gene into yeast. Equipped with the gene, the yeast was able to produce xylanase. In nature, the yeast normally can't do that.

The researchers described their work in *Protein Journal*.

Next, the scientists will work on engineering the mushroom gene so that it enables yeast or some other organism to produce greater amounts of the xylanase enzyme in less time. Gains in efficiency could help make biorefining of plant-based fuels and other products a practical alternative to petroleum refining.

FUNGUS BREAKTHROUGH RAISES LEUKEMIA TREATMENT HOPES

The Sporeprint, L.A. Myco. Soc., Jan. 2006

New research into the gene code of a family of fungi could hold the key to tackling the leading cause of death in leukemia and bone marrow transplant patients.

The study by international scientists into the genome sequences (genetic maps) for the fungi *Aspergillus fumigafus*, *Aspergillus nidulans*, and *Aspergillus oryzae* has produced some important results.

The three species of fungus are genetically very different. *Aspergillus* is a very common airborne fungus and, though usually harmless, the species *Aspergillus fumigafus* has been identified as a leading infectious cause of death in vulnerable leukemia and bone marrow transplant patients.

Aspergillus nidulans has been a leading experimental system helping to unravel many fundamental cellular processes for the last 50 years, while *Aspergillus oryzae* has been used in the Far East for 2000 years to produce sake (rice wine), miso (soybean paste), and shoyu (soy sauce).

Led by the University of Manchester, the researchers discovered that the three species of fungus only shared around 68% of the same proteins, making them as different from one another as humans and fish. Almost a third (30%) of the 9,500–14,000 genes identified are new to science and of completely new function and structure.

Published in *Nature* magazine, the research indicates that the species of fungi also differ considerably in genome size, with *Aspergillus oryzae* around 31% bigger than *Aspergillus fumigatus* and 24% bigger than *Aspergillus nidulans*.

University of Manchester Professor David Denning, who co-ordinated the project, said: "Identifying these genome sequences will transform scientific understanding of why this group of fungi is so lethal and allergenic."

"The importance of the project in helping develop new drugs and diagnostic tests and understand and prevent allergies and diseases like pneumonia and sinusitis cannot be overestimated. The information revealed will also develop our understanding of the biology of composting and mycotoxin production and provide benefits for many other areas of science and medicine."

HOW MICE HELP MUSHROOMS GROW

Arturo Estrada Torres

The Mycophile, North Amer. Myco. Assoc., Sept./Oct. 2005

When we look at how forests develop and grow in both cold and warm areas of the world, we almost never think about what factors actually help in that development. Perhaps we think that all that is required is water, salt, minerals, and some light. Generally, we tend to think that plants are quite independent of other life forms. It seems that isn't the case, however. Forests in the northern hemisphere tend to be populated with pines, firs, beech trees, and oaks, while eucalyptus and other tropical trees are found in the southern hemisphere. We now know that the roots of all of these trees have formed associations with various mushrooms, which technically are called ectomycorrhizal associations.

The mushrooms involved in these associations form reproductive structures, part of the fruiting mushrooms we see and collect in

cont. on page 6

Mice, *cont. from page 5*

our forests during the rainy season. Many of these mushrooms are edible, such as boletes and *Amanita caesaria*. Others are poisonous, such as *Amanita muscaria*, known as the "fly agaric." In all cases, though, these mushrooms play an important role in the maintenance of our forests.

The type of ectomycorrhizal association I've been talking about is mutual: both organisms involved receive benefits. The tree gives mushrooms the carbohydrates and vitamins they need for their development, while the mushrooms provide the tree with salt, minerals, and antibiotics that help prevent damage, as well as hormones that help them grow better.

Mushrooms reproduce through spore dispersal, and many mushroom species depend on the wind for this dispersal. There are, however, some mushroom groups that develop their reproductive structures under the ground. These mushrooms cannot disperse their spores through the air and need animals to do the job for them. Such animals need to uncover the mushrooms, eat them, and pass them through their digestive tracts. Once deposited in the animal's feces, the spores are liberated and are ready to germinate. Bears, deer, rabbits, pigs, and mice are just some of the animals that eat a lot of mushrooms as part of their diet because they are rich in nutrients.

But is there also a relationship between animals and mushrooms that do not grow underground? The answer almost certainly is yes, because of the great abundance of mushrooms that grow in our forests and are a sure source of food for the animals that live there. To verify this, we chose three different environments in La Malinche National Park [near Puebla, Mexico], where we studied mushrooms for evidence of animals eating them. As well, we collected the droppings of rodents in the same locations to see if their feces contained any evidence that they had been eating mushrooms.

Why rodents? Rats, mice, and squirrels comprise a group of mammals that are well represented in the forests of La Malinche. Generally, they are considered a nuisance because not only do they eat cultivated plants such as corn, but they also eat a lot of the seeds of interesting forest species, inhibiting new growth. Many of these animals tend to store much of the food they gather in their burrows and later abandon it.

After a year of work, we found that almost all the mushroom species we collected in our study sites showed at least some evidence of rodent bites. Often, their tiny teeth marks were clearly visible. We trapped ten different rodent species, most of which had some mushroom spores or other fungal material in their feces, clearly showing that rats and mice eat mushrooms as part of their diet.

What are the implications? As in other parts of the world, animals, specifically rodents, play an important role in the reproduction of mushrooms, especially those whose reproductive structures are under the ground. Even more important, these animals also eat mushrooms that do not grow underground, providing another means of spore dispersion, one even more powerful than the wind, and one that assures they'll easily find a host to grow on. In this way, rodents are an important element in the forest, connected to all the others and forming a tripartite association that plays an important role in the functioning of our ecosystems.

[Arturo Estrada Torres is the President of the club Myco Aficionados of Mexico. This article was adapted from a talk given February 19, 2005, at a meeting of MAM in Tlaxcala, Mexico. –*Mycophile* Ed.]

ALGAE OF THE WORLD UNITE—YOU HAVE NOTHING TO LOSE BUT YOUR HYPHAE

Else C. Vellinga,
Myco. Soc. San Francisco, May 2003,
via *Mycolog*, Humboldt Bay Myco. Soc., September 2005

An old pickup truck sprouts gray growth on its roof, oaks gently toss pale green threads in the foggy wind, the high-rising cliffs of Pinnacles National Monument are covered in orange and yellow crusts, and the rocks along the coast are painted black: lichens, lichens, lichens everywhere. From the high mountain tops and the snow-covered plains of the Antarctic, from the depths of the tropical rain forest to the immensely hot dry desert sands, on rocks and even inside them, you will find lichens. Within each lichen is a fungus. Indeed, lichens are a combination of a fungus with something else, but the combination is more than the sum of its parts.

A huge variety of fungi, mainly Ascomycetes, can form lichens together with another diverse group of photosynthesizing organisms. While green algae are the partners most commonly encountered, cyanobacteria (formerly called blue algae), or brown or golden algae, can also be encapsulated by fungi to form a different organism than the two parts grown separately. This theme has even more variations: one lichen can be made up of a fungus, a green alga, and a cyanobacterium species, a "menage trois"; or one fungal species can do it with different algal species in different parts of its geographical range; or the same fungus can have either a green alga or a cyanobacterium as partner. There are about 14,000 fungal species involved, and slightly more than 200 photobionts (the general word for the photosynthesizing partner) are known, but this latter number might be enormously underestimated. The fungi cannot maintain a separate existence, but their partners are often found growing on their own.

So, what's the deal? The photobiont makes sugars from carbon dioxide and water, a process for which sunlight delivers the energy and chlorophyll provides the catalyst. The fungus takes these sugars from the photobiont in various ways; it will even send out its hyphae to penetrate the algal cells. The fungus provides the structure in which this happens and the water necessary for the photosynthesis. The photobiont lives inside and gets some protection against predators and UV light. Many lichens look like leaves, with the photobionts in the same sheltered position as the chlorophyll in a leaf. If the photobionts were on the surface, they would easily be damaged by too much light, especially UV light. The fungi are good at making secondary compounds, called lichen substances or lichen acids, which are often the bright pigments we find so characteristic of lichens and provide subtle colors for dyers. The orange parietin and dark melanin are such pigments, which act as sunblock for the photobiont.

Water is an essential for photosynthesis, and can be taken by many fungi from the air, hence the growth of lichens in fog and spray zones. Nevertheless, without water these organisms are able to survive for month after month. High and also low temperatures can be endured in dry conditions, while with water they would either be cooked or frozen to death. However, the lichens that are found in dry hot areas are different from the ones in cold wet or

Lichen

cold dry places, and from the ones on the leaves of trees in the tropical rain forests.

Every generation the symbiosis has to be remade. Lichens often form little packages containing both fungal and algal material; fragmentation is another way of starting a new organism, but these are vegetative ways of reproduction. The fungus does form fruit bodies, just like the free-living Ascomycetes. The fungal spores have to germinate and find photobiontic partners in the wild. Mites may play a role in facilitating this: they crawl over the surface of the lichen, eating their way through it, both spores and algal cells, and everything ends up in their droppings, ready and viable to start a new life together.

The lichen symbiosis was always considered as the ultimate mutualistic way of life: a harmonic and idyllic life style in which both partners profit and none suffers, a welfare state in a nutshell (sometimes literally). Present day lichenologists describe it much more as a capitalistic society, in which the fungus is the only one making a profit and doing it on the backs of the poor algae and cyanobacteria. These cannot escape, their growth and division rates are highly controlled, and they can forget about sex. The fungi, of course, do produce sexually, and they grow as far as they can, albeit often quite slowly.

This profit making goes far. Lichens with both a green alga and a cyanobacterium make the most of both. The green algae deliver the sugar, and the cyanobacteria are forced to produce more of their nitrogen-fixing cells to chum out nitrogen for the fungi. Nitrogen is a limiting factor for fungal growth (it is an important substance of fungal cell walls) and also necessary for cell maintenance. It is thought that the above-mentioned lichen substances are formed because the fungus has too much carbon and too little nitrogen, and has to do something creative with the sugars.

This symbiotic relationship originated not just once in the history of life on earth, but several times, in independent events. Recently it has been shown that the relationship has also been lost several times. One way this could have happened is that some of the lichen fungi started to develop as parasites by exploiting their fungal kin while still profiting from the photobionts. As parasites they could now get the benefits more indirectly without the hassle of having to start the symbiosis anew with every generation. Even fungal parasites on humans might have developed their unpleasant habits in an earlier lichenized existence. These discoveries shed a different light on the life styles of fungi; it is not a one-way street from protrophic life to being a parasite or a symbiont. Options remain; everything is possible.

And that seems to be the theme of the lichens: everything is possible, all combinations of players, all kinds of forms and shapes, and an incredibly wide range of habitats and places.

An eye-opening book to get a taste for lichens is:

Broddo, I.M., S.D. Shamof, and S. Shamoff, 2001. *Lichens of North America*. Yale University Press, New Haven & London. 795 pp. See also www.lichen.com.

MUSHROOM OF THE MONTH

Dick Sieger

The mushroom was big and fresh. Its heady aroma of morels was most appetizing. But considering the source of its nourishment …

This was a time when my work as a handyman blended with my hobby, mushrooms. Sodden joists in my customer's cellar were evidence of a persistent leak in her upstairs toilet. Growing on the wet wood was a handsome cup fungus, *Peziza domiciliana.*

"*Domiciliana*" means "around the house," and that's where it is found. It's fond of alkaline materials but expect it on anything that is porous and constantly moist—wood, carpets, wallboard, furniture, fireplaces, clothing, etc., etc., etc. I haven't seen anything damaged by it, but the moisture that attracts it may invite unfriendly invaders such as insects and destructive fungi.

Mature *Peziza domiciliana* is a shiny yellowish tan inside and out. Solitary cups are about 2 in. across, sometimes twice that. Often, one finds a number of smaller, mutually compressed cups. The very edge of the cup is ragged and the rest is smooth or a little bumpy. Its habitat tells the story, although a few other less common *Peziza* species can set up housekeeping.

No one seems to consider *P. domiciliana* edible. Experiment with pezizas only if you can take a day or so off from work.

Eric Strauss

Peziza domiciliana

The Wild Mushroom

Well the sunset rays are shining.
Me and Kai have got our tools,
A basket and a trowel,
And a book with all the rules.

Don't ever eat Boletus
If the tube-mouths they are red.
Stay away from the Amanitas
Or brother you are dead.

Sometimes they're already rotten
Or the stalks are broken off
Where the deer have knocked them over
While turning up the duff.

We set out in the forest
To seek the wild mushroom
In shapes diverse and colorful
Shining through the woodland gloom.

If you look out under oak trees
Or around an old pine stump
You'll know a mushroom's coming
By the way the leaves are humped.

They send out multiple fibers
Through the roots and sod.
Some make you mighty sick they say
Or bring you close to God.

So here's to the mushroom family,
A far-flung friendly clan.
For food, for fun, for poison
They are a help to man.

—Gary Snider

MUSHROOM PATÉ WITH BRANDY **Juergen Kuerten**

Mycofile, Vancouver, B.C., Myco. Soc., Winter 2005

1–2 cups of cooked wild mushrooms
1 envelope unflavored gelatin
1/3 cup Brandy
8 oz (225 g) fine liver sausage
1 teaspoon onion salt

Drain cup of liquid from mushrooms into a small sauce pan; sprinkle gelatin over; stir to soften gelatin; heat slowly, just until gelatin dissolves; stir in Brandy.

Pour ¾ cup of this liquid into a 3-cup metal bowl or mold and place into fridge until gelatin begins to thicken.

Put remaining liquid into a blender; cup liver sausage into it; add mushrooms and onion salt; cover and blend until very smooth.

Swirl thickened gelatin in bowl or mold to coat side; pour paté mixture in; cover with wrap and chill. Paté becomes better after a day or two.

Unmold by warming bowl or mold in hot water for a few seconds. Invert onto serving plate and serve with your favorite crackers.

I know you believe you understood
What you think I said;
However, I'm not sure you realize
That what I think you heard
Is not what I meant.

On the right is one of several mushroom-related drawings that we were fortunate enough to receive from artist and long-time PSMS member Pat Murosako. We will be including others in *Spore Prints* from time to time as space allows.

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