Newsletter of the FRIENDS OF THE FARLOW

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Fungi in the Fossil Record of the Rhynie, Scotland

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Near a spring next to a volcano, a fungus managed to get itself into a chamber below the stomata of *Asteroxylon*, a tiny plant, one that doesn't make seeds, just spores. Life went on and sexual structures developed from that fungus. Those structures matured and proceeded to release spores that, if all had been right with their world, would have had the chance to grow and live and reproduce again. However, silica-rich water soon surrounded the plant and its fungal visitor, encasing them in glassy stone - plant, fungal parent, and fungal progeny - beautifully preserved like a spider in lucite.

Four hundred million years later the area around that hot spring has come to be called Rhynie, Scotland, and it's a paleobotanical site like no other. In addition to the plant and fungus I've already described, other plants and fungi (and also animals) are preserved with exquisite detail down to the cellular level. The location and arrangement of fungi within, on, and around plant cells is plain to see. Delicate fungal filaments branch repeatedly within cortical cells of *Aglaophyton*, another non-seed plant. We can see a chytrid, a kind of fungus, growing parasitically on an alga called *Paleonitella*. Another chytrid grows on another *Aglaophyton*. (That *Aglaophyton* was pretty well-liked by the fungi, it seems).

The Rhynie represents a snapshot of an ecosystem that thrived and survived in the early days of the terrestrial world we now live in, and through it we see that the intensive and extensive interactions between fungi and plants, interactions that are so common today, are nothing new. For hundreds of millions of years fungi and plants have lived together, sometimes helping each other, while at other times one of them (usually the fungus) benefits at the expense of the other.

These interactions most likely existed long before the Rhynie came to be, and mutually beneficial relationships between plants and fungi played an integral part in the evolution of terrestrial ecosystems, making possible the rich variety of plants and animals that fill the land today.

Before there were plants, there were algae, some probably making filaments, while others perhaps made more complex 2- or 3-dimen-

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sional structures. All were, most likely, pretty small. As they moved onto land and were no longer surrounded on all sides by water and nutrients, they would have needed a way of getting food from their dry, harsh environment. That's where mycorrhizae came in. Mycorrhizae are fungi that form mutually beneficial symbiotic relationships with plants, growing in and among cells in the roots of plants. The fungus supplies nutrients such as phosphorus to the plant, and it gains carbohydrates that the plant produces via photosynthesis. Mycorrhizae are ubiquitous in modern ecosystems, and, because mycorrhizal relationships are so common in modern plants, it is likely that their ancestors also had these relationships. The fossil record supports this hypothesis.

The earliest fossil record for Glomalean fungi, a kind of mycorrhizal fungus with distinctive spores, pre-dates the Rhynie by over 50 million years. While there is no direct evidence that those fossil fungi were growing symbiotically with plants, all the fungi in this group (and there are many alive today) that have been studied so far are obligate symbiotes with plants, and the assumption is that this was the case for their ancestors, too.

Direct evidence for mycorrhizae doesn't come until the Rhynie. Earlier I mentioned the branching fungal filaments found in *Aglaophyton*. These structures are amazingly reminiscent of the arbuscular mycorrhizae found in extant plants (and also, for that matter, found in fossil roots younger than those of the Rhynie), and it is presumed that they fulfilled a similar function in the Paleozoic.

Fungi are, of course, important as degraders of the dead. The world would be stacked high with dead trees and bodies if it weren't for the organisms that eat them, and, as a look in the leaf litter of any forest will show, fungi play a large role in this cycle. From the fossil record it's pretty clear that this has been the case for a long time.

My dissertation research includes studies of the fossil record of fungi. While my research focuses on the developmental biology of ascomycete fruiting bodies, I've been amazed by how many fungi are out there in and on the fossil plants. Nearly every paleobotanist I've spoken to has told me that they have collections of fossil plants with fungus-looking filaments growing on and in them. These materials potentially contain a great deal of information about the role of fungi in their ecosystems, about their effect on other organisms, and about the evolutionary history of the fungi themselves.

However, it's difficult to identify these filaments to any group more specific than "Fungi." Often even that may be doubtful. Thus, working on these fossils is no easy task, even though they are plentiful and easy to find. But even without identifying these fungi to a particular group, it should be possible to answer questions about how their part of the world worked. For example, what is the relationship between fungal biomass and atmospheric CO_2? There are estimates of atmospheric CO_2 throughout the geologic record. It would be interesting to look at records of fossil fungi, estimate what proportions of ecosystems were made up of fungi, and then see if those proportions increased, decreased, or stayed the same as atmospheric CO_2 changed.

There would be, clearly, many implications with respect to the current increase in atmospheric CO_2 due to anthropogenic input. It would be interesting to see if, in the deep past, fungi acted as a carbon sink, eating up the carbohydrates ultimately derived from atmospheric CO_2.

The fossil record of fungi is quite extensive. By investigating how ancient systems worked and how their organisms interacted with each other, we can gain new insights into today's ecosystems.

There is much more to Dr. Siver's research, however, than alpha taxonomy. He has observed that the relative proportions of different species of diatoms and golden algae vary according to the concentrations of nutrients in aquatic ecosystems. And, because the organisms he studies have decay-resistant glass cell walls, they are beautifully preserved in lake sediments. They, therefore, provide clues to the nutrient status of lakes in years gone by.

In Dr. Siver's research, cores are carefully removed from lake bottoms, sectioned, and dated. The numbers and species of algal microfossils are then recorded from each section. Following this labor-intensive process, statistical analyses are used to track shifts in nutrient levels in New England lakes — shifts which are correlated with the development of housing, industrialization, and other changes in land use. Thus, Dr. Siver's research on diatoms and golden algae provides insight into the ways that humans have altered their environment.

News from Members

Vernon Amadjian reports that a new edition of *Symbiosis:An Introduction to Biological Associations* (by S. Paracer and V. Ahmadjian) has been published by Oxford University Press in both paperback and hardcover versions. The book has two chapters on fungal associations and an essay on Anton DeBary. According to this essay, William Gilson Farlow was asked by his Professor, the Harvard botanist Asa Gray, to go to Germany and study the new experimental approaches to morphology and development of plants under DeBary. On his return from Germany, Farlow established a research laboratory at Harvard and trained a generation of mycologists in the United States. (Farlowia 1945, (2) 1:9-27. "The correspondence of William G. Farlow during his student days at Strasbourg," Hilda F. Harris.)

Robert Edgar is preparing an exhibit for the State of Ohio Bicentennial in 2003 with Joy Kiser, Librarian at the National Endowment for the Arts (Washington, DC), on Hamilton Lanphere Smith, an important nineteenth-century American diatomist and a co-founder of the Cleveland Museum of Natural History.

Elio Schaechter writes that one of the first fungi to merit a specific publication was the stinkhorn. Hadrianus (Adrian DeJonghe), after whom *Phallus hadriani* was named, wrote his treatise *Phalli* in 1564. The original, a translation, commentary, and other material can be found on at: http://www.collectivespource.com/hadrianus/index.shtml.

A Scholar's Visit

Elizabeth Kneiper

The FOF Harvey Pofcher Visiting Scholars Program will enable Larry St. Clair, Professor of Botany and Curator of Nonvascular Cryptogams at Brigham Young University in Provo, Utah, to work at the Farlow from June 22 to July 6, 2001. The Farlow collections and library resources will be used by Dr. St. Clair to prepare descriptions and commentary on the genus *Lobothallia*, a lobate crustose lichen genus common to rocks in the western intermountain regions.

Dr. St. Clair has done extensive floristic work to document western intermountain lichens. Please come in and brouse through Dr. St. Clair's *A Color Guidebook to Common Rocky Mountain Lichens* and meet the author, our first Harvey Pofcher Visting Scholar. FOF members are always encouraged to visit the Farlow to use the resources.

News of the Farlow

Scott LaGreca

Last fall (2000) the Farlow hosted four distinguished speakers in mycology or lichenology. In October **Diane and Bob Peabody** of Bridgewater State and Stonehill Colleges talked about genetic mosaics in *Armillaria*. In November, **Paula DePriest** of the Smithsonian Institution talked about using molecular tools to examine lichen symbioses; and in December **Rick Kerrigan** of Sylvan, Inc., a commercial supplier of *Agaricus* spawn, spoke on *Agaricus* systematics.

More recently in March, **Mary Berbee** of the University of British Columbia visited and gave a seminar entitled "Molecular Phylogenetics and Life History Strategies in the Ascomycete Fungi."

Sam Hammer has made recent trips to New Zealand, where he has been collecting new and interesting species of Cladoniaceae (lichens). In the past few months he has given the Farlow almost 900 specimens from both New Zealand and California. These include many duplicates for exchange with other herbaria. Thanks, Sam!

Greg Valiant, a high school student at Milton Academy, has been doing culture and microscope work with graduate student **Brian Perry** to delimit intersterility groups within the *Mycena epipterygia* species complex (mushrooms). Brian, who has his qualifying exam in May, has started working on the molecular systematics of this and other *Mycena* species.

Toby Feibelman has donated her large personal collection of Gulf Coast fungi to the Farlow. These specimens were collected from Louisiana and nearby states as part of her graduate work at Tulane University. Toby has been spending many quiet Sunday mornings at the Farlow to organize and process her material.

Graduate student **Zhihong Zhong** has described a new species of discomycete from herbaceous plants in China: *Pezicula magnispora*. The paper, submitted to *Mycotaxon*, is co-authored with **Zheng Wang** of Clark University and **Don Pfister**.

Graduate student **Kris Peterson** recently published part of her master's thesis in the journal *Sydowia* (52[2]:204-257, 2001): "Agaricales of the Hawaiian Islands. 6. Agaricaceae I. Agariceae: *Agaricus* and *Melanophyllum*."

Herbaria employee **Mary Lincoln** has databased the Clark University bryophyte specimens which were donated to the Farlow late in the last century. In doing so, she has updated their names and has checked the identifications on many of them as well. Mary has also been compiling a list of liverworts for Massachusetts, using both herbarium specimens and published accounts. Most recently she has taken over the New England Botanical Club cryptogam integration project, in which NEBC cryptogams (mostly mosses) are being inserted into the general Farlow collections. This project is being overseen by NEBC Cryptogam Curator **Nancy Reid**.

Curatorial/Research Associate **Scott LaGreca** was awarded a two-year Massachusetts Natural Heritage and Endangered Species Program grant for "A Bryophyte and Lichen Survey of the Boston Harbor Islands National Recreation Area." His crack team of cryptogamic investigators includes **Doug Greene**, **Elizabeth Kneiper**, **Elisabeth Lay**, **Mary Lincoln**, and **Phil May**. The project, which will begin this spring, involves collecting expeditions to a number of the more remote island localities in Boston Harbor.

In March, **Don Pfister** attended "Linnaean Taxonomy in the 21st Century", a botanical symposium held at the Smithsonian Institution, Washington, DC.

an image of one or more flowering plants and some contain small insects as well. The exhibit focuses in on the plant that is used to make pith paper, *Tetrapanax papyriferum* (Hook.). This plant remained a mystery to Western botanists for many years. Explorers brought back tales of the plant and samples of the pith paper to England where it was studied by botanists such as Sir William J. Hooker. The paper was followed by dried specimens, leaves, and stems of the plant itself, and finally a living plant arrived in England in the 1850s. Included in the exhibit are some of the earliest renderings of this plant that were seen in the west, images of how the paper was made, and information regarding the uses of this plant throughout history. This exhibit also includes thumbnails and quarter-sized images of all 27 plates.

The last exhibit ***In the Field: Botany in the Wild*** contains materials from the Archives of the Gray Herbarium and the Farlow Herbarium. This exhibit, using photographs, letters, diaries, manuscript materials, and maps from our archival collections attempts to illustrate the dangers and rewards faced on different collecting trips. These journeys date from 1853 through 1963 and take place in various locations from mountaintops to under the Atlantic Ocean. This exhibit finishes with a section titled *Pictures from the Field* which is a selection of images of botanists in the field dating from the 1860s through the 2000s.

The first journey highlighted in this exhibit is that of Charles Wright (1811-1885) and his time with the *U.S. North Pacific Exploring Expedition, 1853-1856.* This expedition required Wright to be on board ship for months where he found no one who was interested in scientific matters and suffered a great sense of isolation. Wright also dealt with climates he described as "most villainous," and, because of political unrest in Nicaragua, many of his letters never made their way out of the country.

The second section deals with the difficult time that Roland Thaxter (1858-1932) had on his much anticipated *Voyage to South America, 1905-1906.* Thaxter had been curious about the area of Tierra del Fuego from a very young age, and finally, during his Harvard sabbatical year of 1905-1906, he made arrangements to study and collect in this region. A boyhood dream was about to come true. Unfortunately the trip was plagued with bad luck. An outbreak of small pox, severe personal illness, and a discovery of a dead body were among the problems that found Thaxter during this yearlong voyage.

The third collecting trip discussed took place in Canada and involved many Harvard scientists including Merritt Lyndon Fernald (1873-1950), James Franklin Collins (1863-1940), Carroll William Dodge (1895-1988), and Arthur Stanley Pease (1881-1964). In 1923 they explored the Gaspe Peninsula and were so successful that their collecting areas were renamed for them. The Great Basin was renamed Pease Basin, and the names Fernald Basin and Fernald Pass were given to two other areas in Gaspe. Botanist's Dome was the name given to the flat area at the top of Tabletop Mountain, the highest point of land in eastern Quebec, and lastly, in April of 1926, the Canadian Geological Survey named the 3,500 foot mountain near Mt Logan, Mt Collins.

The last example of fieldwork showcased here is Ivan MacKensie Lamb's (1911-1990) *Botany Under Water, 1962-1963.* Lamb went as far as Antarctica to dive for algae, but a series of well-documented dives was made much closer to home. In 1962 and 1963, Lamb and a changing cast of characters (including Richard E. Waterhouse, R.A. Fralick, Martin Zimmermann, and Bob Knowles) made numerous dives off the coasts of Massachusetts, New Hampshire, and Maine. These dives are recorded in a fabulously funny journal located in the Farlow archives.

All of these exhibits can be found at: http://www.huh.harvard.edu/libraries/Exhibits.htm. We also hope to add a fifth exhibit this fall, one dealing with the history of women in botany.