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THE FASCINATING WORLD OF LICHENS

by Robert Dirig*

Lichens are among the world's most widespread and least appreciated life forms. Dispersed by wind, they settle on rocks, branches, and other surfaces where we are likely to see them as flaky or crusty growths. Lichens color rocks and tree trunks, mingle with mosses, attach to tortoise shells, and profoundly influence the structure of certain soils. Every country-dweller, naturalist, and environmentalist should learn about lichens.

--EK

Fruticose lichens, which resemble tiny shrubs, are often found on soil. This lovely coralline species is Alpine Reindeer Lichen *(Cladina stellaris)* at the Saratoga County Airport, New York. This lichen extends about 15 cm from left to right. Photograph by John F. Cryan.

"Lichens, though humble plants, engage like other humble of this world, in mighty tasks," wrote G. G. Nearing at the beginning of his classic *Lichen Book* (1947). "Their part is to cover the arctic and alpine wastes, to clothe desert rocks and bare cliffs everywhere, as pioneers carrying life where before no life could exist. Themselves needing no soil, but a foothold merely, they create soil for plants which do need it. With powerful acids they etch the rock, loosening its particles to let in the frost which will disintegrate it further. Though surviving for centuries, their minute creeping ceases at last, and in death, they give their decaying substance to the smaller and larger things, bacteria, moss, ferns, and flowers. Thus they lay down the beginnings of what may one day be fertile ground."

In these few colorful sentences, Nearing summarized the habitats, growth, lifespan, and role in plant succession of these sometimes bizarre and often beautiful organisms that remain so difficult to know.

Lichens are the crusty, scaly, or leaf-like growths -- often grayish-green, or brown -- that we are accustomed to seeing on rocks, logs, and tree trunks. Lichens are unusual in

*Assistant Curator/Curator of Lichens, L.H. Bailey Hortorium, 462 Mann Library, Cornell University, Ithaca, NY 14853-4301.

their biological makeup (see below), and can have far-reaching effects on their local environments. Although lichens enrich the visual landscape, they are often overlooked by casual observers and biologists alike. This article describes some aspects of lichen biology and ecology and some of the traditional and contemporary uses of lichens by the human community.

Human Interactions With Lichens

Most of us are probably unaware of the many uses humans have found for lichens throughout history. Lichens are important sources of dyes, medicines, perfumes, and indicators. Harris tweeds are dyed with lichens, and a wide spectrum of natural dyes (purples, reds, magentas, yellows, browns, oranges, greens, and grays) can be obtained from different lichens using various mordants. Usnic acid, found in the Old Man's Beard group (genus *Usnea*) and in some other lichens, is used in antibiotic salves. Lichens have also been used in Chinese medicine. Essential oils from Oakmoss (genus *Evernia*) produce perfume bases and fixatives. Litmus paper (used in high school labs for pH tests) is made from the lichen genus *Roccella*. Because lichens are sensitive to air pollution, records of their disappearance or reappearance in a given area over time have been used to monitor environmental air quality.

Iceland "Moss" (*Cetraria islandica*), actually a lichen, is used to enrich soups, desserts, and breads. The manna of the Bible may have been the nomadic, wind-blown lichen *Lecanora esculenta*, which is still used for making bread in Israel. Rock Tripes (Umbilicariaceae) can be used to thicken soups. Reindeer Lichens (genus *Cladina*) are fed to domestic reindeer in Lapland. Especially pretty species like Alpine Reindeer Lichen (*Cladina stellaris*) make exquisite tiny "trees" in architectural or railroad models, and are also used to decorate Christmas wreaths and centerpieces.

Iceland "Moss" (*Cetraria arenaria*) grows on sands of eastern Long Island and rarely inland on rocky, windswept ledges in New York. The lichen illustrated here is about 7 cm high. Illustration © 1998 Robert Dirig.

Foliose lichens look like leafy doilies or rosettes on rocks and tree trunks. This Boulder Lichen (*Xanthoparmelia* sp.), growing on sandstone in the Catskills, has the brown reproductive organs of its fungal partner crowded in the middle of the body. The larger circular patch of lichen, at the right of the photograph, is about 12 cm in diameter. Photograph © 1998 Robert Dirig.

Lichens are important sources of dyes, medicines, and perfumes.

Lichens add a dimension of subtle beauty to the landscape. Lichen-covered boulders, sometimes transplanted from distant locations, have become popular in landscaping. This practice is inadvisable, however, because of the potential for ecological disruption by introduction of non-native lichens to inappropriate habitats or regions. Also, lichens often die quickly when removed from their native habitats.

Because lichens are sensitive to air pollution, they are used to monitor environmental air quality.

Due in part to our ignorance, humans often unwittingly destroy habitats of sensitive lichen species. Lichen abundance and diversity has suffered from loss and degradation of habitat, and some species approach extirpation. These losses may become more dramatic in coming decades due to development sprawl and worsening air pollution. Fortunately, state conservation agencies and privately-funded conservation groups are becoming more aware of the ecological importance of lichen diversity.

What is a Lichen?

A lichen is "an association of a fungus and a photosynthesizing symbiont (partner) resulting in a stable thallus of specific structure," according to the International Association for

Lichenology. Neil A. Campbell, in *Biology*, his 1990 college textbook, restated this in a much prettier way: "Lichens are not plants at all, nor are they technically even individual organisms. Lichens are highly integrated symbiotic associations of millions of algal cells tangled in a lattice of fungal hyphae." There are about 17,000 known lichen species worldwide, 98% of which belong to the Ascomycetes, the subset of fungi that also includes the morels and the cup fungi.

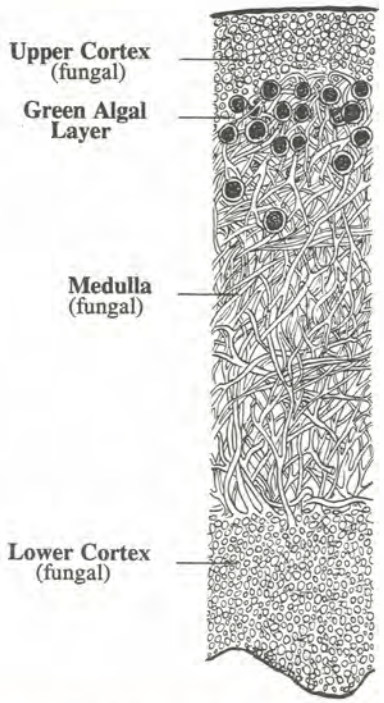
The symbiotic partnership between a fungus and a photosynthesizing alga enables lichens to colonize otherwise inaccessible habitats.

In this context, symbiosis is the regular association or "partnership" between a fungus and a photosynthesizing organism, sometimes exclusive of an independent existence. The photosynthesizing partner is usually either a green alga (*e.g.*, the genus *Trebouxia*) or a cyanobacterium (blue-green "alga," *e.g.*, the nitrogen-fixing genus *Nostoc*). The fungus, because it is unable to manufacture its own food, benefits nutritionally, penetrating the algal cells to receive nourishment. The photosynthesizing partner derives various benefits from the partnership, including removal from competition in a free-living state, living within a stable thallus (the physical body of the lichen, made of fungal threads, or hyphae), ability to colonize otherwise inaccessible habitats, and having a hyphal shield from wilting sunlight.

Lichens are not a systematic group, but a subset of the fungi defined by their biology rather than their taxonomic identity. The scientific name of a lichen is tied to the fungal partner, although it also refers to the symbiotic association with the algal partner. The algal partner has its own taxonomic identity as genus and species as well.

Most lichens have a distinctly layered body, often with a densely interwoven fungal upper cortex and lower cortex, and a much more loosely organized fungal medulla containing the algal layer in between. Colors and shape, almost always derived from the fungal partner, may be very beautiful.

The same photosynthesizing alga may live within a number of different fungi, thus being a partner in different lichen species. In some lichens where a fungus lives with two different photosynthesizing partners, segregated bumps (called cephalodia) may occur because the fungus has a different growth form when associated with a green alga than with a cyanobacterium. An example is the Studded Leather Lichen (*Peltigera leucophlebia*), in which members of these three biotic kingdoms live together symbiotically! Sometimes lichens live on or within other lichen species. For example, in the Northeast, the Rugged Crater Lichen (*Diposchistes muscorum*) can occasionally be found growing over *Cladonia*.



Layering in a foliose lichen, showing the densely fungal upper cortex and lower cortex and much more loosely organized fungal medulla with a band of green algae at the top. The lichen section illustrated here would be about 1 mm from left to right. Illustration by Carolina Biological Supply Company, © 1967.

Lichens are often perennials, which grow slowly and live in the same place through several years at least, or even decades, centuries, or millenia in some species. Thus they contrast with the evanescent fruiting of most fungi, such as mushrooms.

Lichen Habitats

Lichens can survive in severe environmental situations, and are found in varied habitats -- deserts, beaches, bedrock outcrops, prairies, mountain tops, forests, tundra, wetlands, and even on living leaves of green plants in warmer climates -- from the tropics to the Arctic, and in the Antarctic (where the lichen *Verrucaria serpuloides* grows permanently submerged in sea water). Lichens may be largely absent near big cities due to polluted air, and are especially intolerant of sulphur dioxide and fluorine.

Lichens can survive in severe environmental situations, including frigid waters of the Antarctic.

Lichen substrates include soil, sand, rocks, tree bark, twigs, dead wood, animal skeletons, roof shingles, bricks, cement, stone walls, and other stable structures. Wind-, water-, and animal-dispersed propagules make lichens excellent colonizers, and allowed enough time, lichens will find the places they prefer to grow, and be luxuriantly established there.

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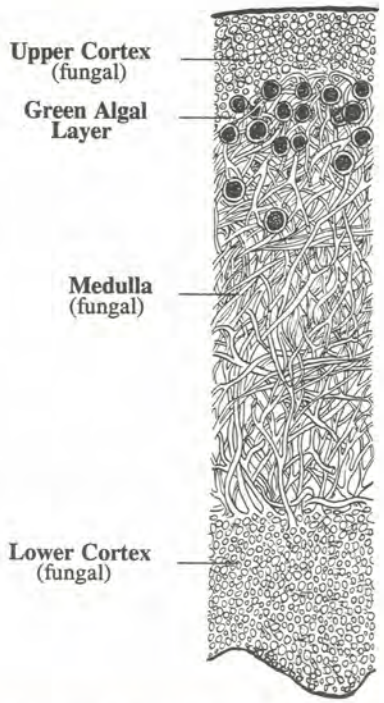

Layering in a foliose lichen, showing the densely fungal upper cortex and lower cortex and much more loosely organized fungal medulla with a band of green algae at the top. The lichen section illustrated here would be about 1 mm from left to right. Illustration by Carolina Biological Supply Company, © 1967.

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Although sometimes mistakenly thought to be a disease, lichens do not harm living substrates in any way. On the other hand, lichens that grow on ancient sculptures and centuries-old tombstones and stained glass occasionally may contribute to biodeterioration via acids they produce.

A well developed lichen found in New York may be decades or even centuries old.

Optimal conditions for lichen growth include clean air, high humidity, cool temperatures, and moderate to high light intensity. Water availability is critical. Lichens have no special mechanisms for uptake or conservation of water, but rapidly absorb it from rain, fog, or dew. Respiration and photosynthesis are favored by optimum water content; photosynthesis occurs in early morning and early evening.

Lichens provide food for insects and other animals, nest material for birds, and models for protective coloration of insects and some amphibians.

Sphagnum-heath bogs, swamps, and fog zones along beaches and on mountain tops are often filled with lichens because such places foster maximal growth and have remained largely undisturbed. Old growth woodlands and other pristine habitats may likewise abound with lichens, which grow very slowly and respond poorly to disturbance by humans. Some northern lichens grow less than 1 mm per year, and individual thalli may be hundreds or thousands of years old, up to 4500 years. The average age of a well developed lichen thallus found in New York may be decades or even centuries.

Ecological Associations

Invertebrates (*e.g.*, springtails, mites, and slugs) may live on lichen thalli and eat the cortex and algal layer, leaving the medulla. Some temperate-zone tiger moth larvae (Arciidae) feed on lichens; the adults are warningly-colored, perhaps because the lichen acids ingested during the larval stage may make them distasteful. Local examples include the Painted Lichen Moth (*Hypoprepia fucosa*), Scarlet-winged Lichen Moth (*H. miniata*) and the Black-and-Yellow Lichen Moth (*Lycomorpha pholus*).

Umbilicate lichens are held to their stony substrate by a central point beneath, called the umbilicus (southwest corner of white triangle). This is Smooth Rock Tripe (*Umbilicaria mammulata*) on Camel's Hump sandstone in the Catskills. The lichen in this photograph is about 9 cm from left to right. Photograph © 1998 Robert Dirig.

In winter, browsing mammals may eat lichens. Lichens are also used by Ruby-throated Hummingbirds (*Archilochus colubris*), Eastern Wood-pewees (*Contopus virens*), Blue-gray Gnatcatchers (*Polioptila caerulea*), Northern Parulas (*Parula americana*), and several vireos (*Vireo* spp.) for nest material or ornamentation.

Certain members of the Orthoptera (*e.g.*, grasshoppers), Coleoptera (beetles), and Lepidoptera (butterflies and moths) camouflage themselves by mimicking the color patterns of lichens, as do some amphibians (*e.g.*, the Gray Treefrog, *Hyla versicolor*). The Peppered Moth (*Biston betularia*), the British moth world famous as an example of industrial melanism (evolution of mimicry of soot-blackened bark), was a lichen mimic in its pre-industrial, paler color form.

Identifying Lichens

Lichens are beautiful and easy to collect, but identifying them can be quite a challenge. Keys to lichen names rely on overall thallus form, color, fine morphological details, and on their reactions with three caustic chemical reagents: C (calcium hypochlorite = household bleach), K (potassium hydroxide) and PD (paraphenylene-diamine). Common names are rarely used with lichens, field guides are essentially nonexistent, and accurate identifications often require a specialist's help. The lack of pictures and readily accessible

Of all the biological diversity of the Hudson Valley, lichens may be among the most threatened.

In 1974, Dan Smiley and Carl George published a paper documenting the decline of Rock Tripe Lichen cover on conglomerate cliffs at the Mohonk Preserve (*Bryologist* 77:179-187). In 1978, Brooke Feeley Connor, a Bard College student, wrote her senior thesis on bark-inhabiting lichens in northern Dutchess County: she found lower diversity of lichens nearer the Hudson River. Also, in the 1970's, Richard Prince found only 28 species of lichens in a survey of Westchester County, where we would expect well over 100 (*Bulletin of the Torrey Botanical Club* 05:67-69, 1978). This was not a comprehensive survey but it clearly indicated there was something wrong with the lichen flora of Westchester. Air pollution is probably the cause of the loss of abundance and diversity of lichens reported in these three Hudson Valley studies.

Lichen communities tend to rebound when air quality improves. Can the human community of the Hudson Valley (and the pollution source areas of our local cities and the Midwest) reduce air pollution and improve the environment for lichens and for human health?

--Erik Kiviat

descriptions, combined with complicated identification techniques, such as chemical tests and thin-layer chromatography, make lichens difficult to know.

Squamulose lichens are flaky or scale-like. This species is the diminutive Oyster Lichen (*Hypocenomyce scalaris*), which grows in humid edge habitats on tree bark, and charred wood, especially pines. Each squamule, or flake, resembles an oyster's shell, hence the common name. The lichens in this illustration span about 8 mm from left to right. Illustration © 1998 Robert Dirig.

Most of the literature on lichens is in the form of technical monographs in scientific journals such as *Mycotaxon, The Bryologist*, and *The Lichenologist. The Lichen Book* (Nearing 1947) is the only fully illustrated work on the lichen flora of the Northeast. Although many of Nearing's scientific names are outdated, his descriptions, ecological notes, and drawings are as fresh and accurate today as they were 50 years ago.

Lichens are beautiful and easy to collect, but identifying them can be a challenge.

A new color-illustrated field guide to North American lichens is in preparation by one of the world's leading lichenologists, Irwin M. Brodo of the Canadian Museum of Nature. With about 700 color photographs associated with names and ecological/habitat information for the full spectrum of lichens, this book will make information on our lichens accessible to non-specialists for the first time. Other lichen references are listed on the next page (p. 6).

Large herbaria (collections of dried plants and fungi) may have lichen collections to aid in identification. The largest eastern lichen collections are housed at the New York Botanical Garden (Bronx), the New York State Museum (Albany), the Farlow Herbarium at Harvard University (Cambridge), the U.S. National Herbarium, Smithsonian Institution (Washington), the University of Michigan Herbarium (Ann Arbor), Duke University Herbarium (Durham, NC), and the Canadian Museum of Nature (Ottawa). Index Herbariorum Part I, The Herbaria of the World, a global directory, can point you to the nearest lichen collection. Consulting such a collection and talking with curators may facilitate communication with other people who can help you with lichen identifications and literature.■

Robert Dirig is Curator of Lichens at the L. H. Bailey Hortorium, Cornell University, Ithaca, NY, and a Research Associate with Hudsonia. Text in this article © 1998 by Robert Dirig.

Readers, we welcome your suggestions for articles and offers of underwriting for future issues. Coming this summer: Hudson River amphibians and reptiles, Part 2.

Back issues of *News from Hudsonia* are available free-of-charge while supplies last. Request a list of topics.

Hudsonia will donate its surplus books and journals to schools and non-profits. Ask for a list.

Lichen References for Eastern North America

How To Know the Lichens, second edition, by Mason E.Hale, The Pictured Key Nature Series, Wm. C. Brown Company Publishers, Dubuque, Iowa, 1979. The best book for eastern North America, with numerous black-and-white photos and good range maps. Scientific names are somewhat outdated and the book is a bit technical. Requires a dissecting microscope, and spot tests with chemicals.

The Lichen Book, Handbook of the Lichens of Northeastern United States, by G. G. Nearing, Eric Lundberg, Ashton, Maryland. This is the 1962 reprint of the 1947 edition published by the author. Covers the entire flora, and gives common names; many scientific names outdated. Very readable, despite keys that are difficult to use. Elegant line illustrations and accurate ecological accounts. The only fully-illustrated work dealing with the lichen flora of the Northeast.

Lichens of the Ottawa Region, second edition, by Irwin M. Brodo. Ottawa Field-Naturalists' Club Special Publication No. 3, Ottawa, 1988. A good general key to northern North American lichens, with excellent illustrations. Keys require chemical tests, and a dissecting and compound microscope.

Guide to the Literature for the Identification of North American Lichens, by Irwin M. Brodo, Syllogeus No. 56, ca. 1987. An index to technical identification literature and monographs for all North American lichen genera. Useful for the specialist.

A Sixth Checklist of the Lichen-forming, Lichenicolous, and Allied Fungi of the Continental United States and Canada, by Theodore L. Esslinger & Robert S. Egan, ***The Bryologist*** 98: 467-549, 1995. The most recent checklist of all U.S. and Canadian lichens, giving correct scientific names and synonyms from earlier literature. A convenient reference for figuring out what Nearing's, Hale's, and others' earlier names are in a modern context. Because lichen taxonomy is actively developing, many name changes occur each year, and it is impossible to be completely up-to-date; this reference is the most recent approximation. (Also available as a single publication from the American Bryological and Lichenological Society.)

Lichen Biology, edited by Thomas H. Nash III, Cambridge University Press, New York, 1996. An excellent technical overview of all aspects of lichenology, written by specialists.

The American Bryological and Lichenological Society is the professional organization for lichenologists in N.A. It publishes *The Bryologist* and *Evansia*, the latter for "amateurs." The International Association for Lichenology publishes a quarterly *International Lichenological Newsletter*, with news of people, new references, and upcoming lichen-oriented meetings. (This is a professional group, not oriented toward beginners.)

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David Voegtlin

Board of Directors: Lavett Smith has resigned from the Board to move to Colorado; Smitty, a long-time friend of Hudsonia, will continue to serve on the Advisory Board.

We are seeking new directors to help with fundraising, publicity and other work. Current Board members are Lawrence H. Weintraub (Chair), Deborah Meyer DeWan, Drayton Grant, Karen L. Jacobs (on leave), Michael W. Klemens, Thomas R. Lake (on leave), William T. Maple, and Jack Wertheim.

Research Associates: Hudsonia welcomes C. Barre Hellquist to our roster of Research Associates. Dr. Hellquist teaches at Massachusetts College of Liberal Arts and specializes in the taxonomy of freshwater aquatic plants.

Welcome: Victoria Balcomb has joined the staff of Hudsonia as Administrative Assistant. She has a Master's degree in public health from SUNY Albany, and a keen interest in natural history.

Hudsonia student assistants and interns:

Nadja Carneol
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Hudsonia technicians:

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Some of Hudsonia's 1998 projects:

- Surveys for river herring in Hudson River tributaries
- Surveys for Blanding's turtles in two wetland complexes of Dutchess County
- Assessment and mapping of biological, historical, archaeological, and recreational features on 6 state-owned sites on the Hudson River in Columbia and Ulster counties
- Monitoring vegetation and wildlife in constructed habitats for a rare species in Dutchess County
- Biological assessments at two state-owned properties in Columbia and Dutchess counties
- Refining our hydrogeomorphic functional models for Hudson River freshwater marshes
- Completion of the Biodiversity Assessment Manual for the Hudson River Corridor

1997 Donor of the Year:
Lavett Smith, who gave Hudsonia a Chevrolet AstroVan.

1997 Volunteer of the Year:
Lin Fagan, who has donated many weeks of her time to the Herbarium, to the Hudsonia office, and to Hudsonia fieldwork.

The **1997 Hudsonia Prize** is shared by Bard students Beth Coakley and Kate Mini. This prize is awarded each year to students showing promise in the field of environmental studies.

Beth Coakley has donated her time to the massive relabeling project for Herbarium specimens, and to updating the Herbarium catalogue database.

Kate Mini has helped with field data collection and data management for Hudsonia's fen research, and helped with numerous other projects at the Field Station, including trouble-shooting our computer problems.

We commend them for their exceptional work.

Master's Program in Environmental Studies: For information about the Bard College Graduate School of Environmental Studies, phone (914) 758-7483.

Wear a Hudsonia T-shirt this summer!

This Blanding's turtle is on the back of our 100% cotton T-shirts. Adult M, L, XL short-sleeved $18.50, long-sleeved $23. Child S, M, L short-sleeved $15. Specify white or buff. Blanding's turtle print is dark green with yellow throat. Tax and shipping are included.

Hudsonia's Wish List:

- Florida and Caribbean natural history literature
- other natural history books or magazines
- letter-size steel file cabinets
- used file folders and 3-ring binders
- clean one-pound tin cans with tight-fitting plastic covers.

Hudsonia Natural History Courses: Hudsonia offers one-day non-credit courses for professionals and amateurs with a strong interest in field science. The 1998 courses are listed below. Phone Victoria Balcomb at (914) 758-7023 for information and registration. Payment ($50 per course) is required 10 days in advance.

Saturday, June 6. **Amphibians at the Great Swamp** in Dutchess County will be taught by herpetologist **Michael Klemens**, Researcher at the Wildlife Conservation Society, Bronx Zoo.

Sunday, June 14. **Turtles of the Hudson Valley** will be taught by **Erik Kiviat**, Hudsonia's Executive Director.

Saturday, June 27. **Life in Vernal Pools** will be taught by **Spider Barbour**, Hudsonia Field Ecologist and well-known Hudson Valley naturalist.

News from Hudsonia credits: design and layout, Victoria Balcomb; editing and production, Gretchen Stevens.

Dear Friends,

Hudsonia is a leader in research on wetland ecology, biological diversity, and the flora and fauna of the Hudson Valley. We specialize in translating science and providing information to citizens and decision makers.

Our work is challenging and needs your financial support. Please send Hudsonia a check in any amount (tax deductible). Call Erik Kiviat or Gretchen Stevens if you would like to discuss Hudsonia's programs and capabilities.

Lawrence H. Weintraub
Chair, Board of Directors

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