In Praise of Lichens

We are lichenicolous fungi

Anna Maria Johnson[1] and John Villella[2, 3]

At Opal Creek Ancient Forest Center in Oregon, I scrape from a large rock, dripping wet with spring and covered in mosses, liverworts, and lichens, a clump of free-living *Nostoc* cyanobacteria, a glob of gray goo. I squish it between my fingers and think of the gelled contents of a discarded ice pack. Rolling it around, I discover, whoops, a little wriggling worm. Gray goo is a paradise to some of earth's creatures, but I tend to appreciate something more organised. On the same dripping rock, I find an intricately branched lichen, clear and gray like the goo, but sparkling like mouth-blown glass, delicately wrought into a shape resembling a network of rivers on a map, shrunk down to palm-size. This little thing of beauty, called jelly lichen, consists of *Nostoc* cyanobacteria too, but in combination with a *Leptogium* fungus whose hyphae have lent pattern, structure and stability to the raw photosynthesising power of the cyanobacteria. The form emerges from the relationship between the fungus and the cyanobacteria.

This relationship forms the lichen; lichen is embodied relationship.

Along the path, another *Nostoc*-containing lichen, called *Lobaria pulmonaria*, or tree lungwort, adorns the old-growth trees. This dark green, leaf-shaped lichen was thought in medieval times to cure pulmonary diseases because its pitted surface resembles a human lung. *Lobaria* had the distinct honour of being one of the first lichens to appear in printed illustrations for early herbal books, such as the *Ortus Sanitatus* (1491) and the herbal by L'Obel (1576). It is a tripartite lichen, containing all three: fungus, cyanobacteria and alga. Although we know today that *Lobaria* does not cure lung problems, it does share something in common with human lungs: the need for pure air. *Lobaria* lives only in unpolluted regions (Figure 1).

A lichen is a finely tuned community working together for the benefit of the whole. What the fungus lacks – the ability to produce food for itself – an alga or cyanobacterium (or sometimes both) provides. The latter two are remarkable chefs, able to cook up a fine meal out of mere sunlight and prepare a feast fit for the whole lichen. In turn, that which the cyanobacterium and the alga lack, the fungus provides. Without fungi, some of these, such as *Nostoc*, exist as formless globs of gel. Others, without their fungi, are found not to exist at all. *Trebouxia*, the most common photobiont in lichen, has never been observed outside of lichen in nature. What the fungus provides, then, is a place to live, a dwelling, a residence. Form. Organisation. Home.

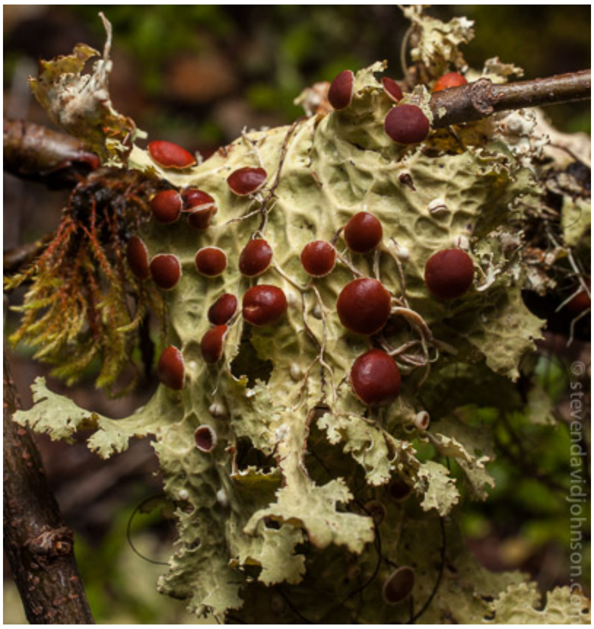

Figure 1. *Lobaria oregana* at Opal Creek Ancient Forest Center

An ecosystem in miniature, lichen is composed of many different living species, all playing their part to support the colony: fungus, green alga and/or cyanobacterium, with accompanying parasitic fungi and symbiotic bacteria. Lichen is an intimate symbiosis between several discrete organisms individually known as bionts, each part performing a unique and essential function. In collaboration, in an ongoing conversation, the collective performs its functions: photosynthesis, moisture regulation, nutrient cycling, self-organisation.

Lichens are all around, always present, yet barely noticed even as they slowly obliterate the landscape's surfaces. Look closely at nearly anything outside – rocks, tree trunks and branches, stone and wooden buildings, sidewalks, stained glass windows, gravestones, abandoned cars, junkyard scraps – and you will see the subtle forms of lichens, often in two-dimensional pale orbs, or irregular dusky patches. In places with impeccable air quality, macro-lichens grow in three-dimensional shapes like leaves (Figure 1), upright stalks (Figure 2), hairy festoons (Figure 3), or in palm-sized shrubby structures (Figure 4).

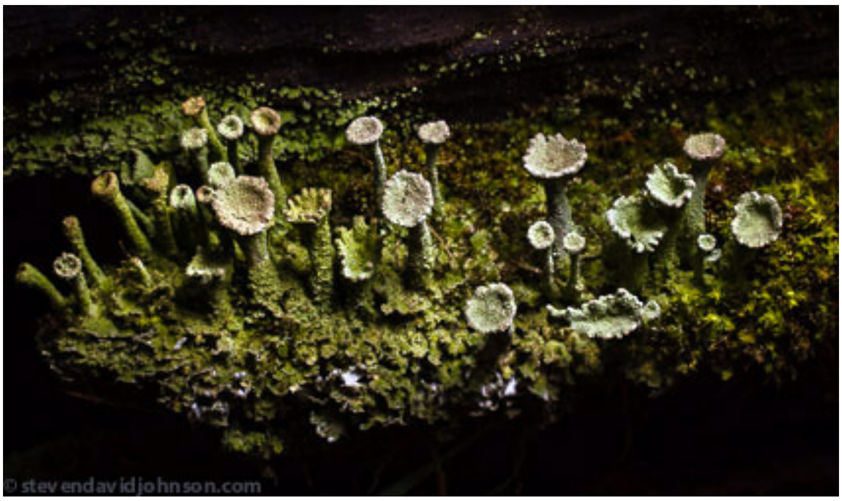

Figure 2. *Cladonia* grows in upright stalks

All fungi are heterotrophic organisms. Like human beings and other animals, they cannot produce their own food and instead must extract it from their surroundings. Lichenised fungi have found a clever way to derive nutrients by partnering with a single-celled photosynthetic partner known as a photobiont. Photobionts can be green algae or photosynthetic cyanobacteria, which both provide carbon to the fungus. The cyanobacteria also provide nitrogen. Although there are not as many photobionts compared to the number of mycobionts (fungi), they do form geographically distinct clades, analogous to a variety of corn or wheat that has been developed for a particular climate regime. This unique lichenised partnership has allowed both fungi and algae to exist in microclimates that would be inhospitable to either of them on their own – with extreme temperatures, extreme fluctuations in moisture, and in some cases, extreme toxins. Lichens thrive on rock surfaces from Antarctica to the Sahara. In temperate climates they range from the top of the soil to the top of the tallest tree. There are even lichens that can grow in the mouths of active volcanoes; these bright orange crusts have adapted to polluted urban environments such as Boston, Massachusetts.

Lichens have been under-appreciated, and misunderstood. The Greek word *lichen* means "wart", or "eruption", and was used to describe growths of various kinds found on trees and on skin. Even the venerable Carolus Linnaeus, who created the binomial system, called lichens the *rustici pauperrimi,* "the poor trash of vegetation",[4] and lumped them all into one genus, although lichenologists have now described over 10,000 species in several hundred genera.

This is not to say that lichens have gone entirely unnoticed all this time. Historically, various cultures have used lichens as food, and for making clothing, natural dyes, perfume, soaps, deodorants, medicines and holiday decorations. In Europe, certain lichens were used to kill wolves and, in Egypt, lichens were involved in the embalming process.

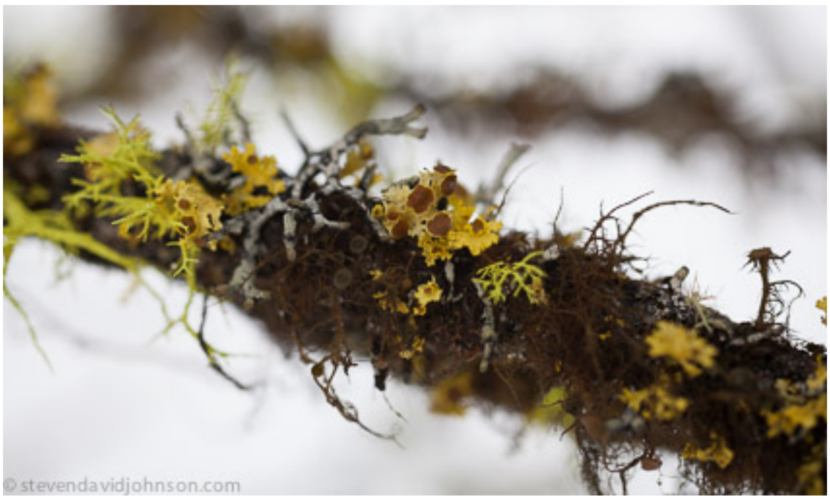

Figure 3. Twig community including *Vulpicida canadensis, Letharia vulpina* and *Nodobryoria*

Once I began noticing these little consortiums of organisms, I wondered how I had never seen them before. Paying more attention when I walk, I now observe bits of lichen quietly living on nearly every sidewalk, almost imperceptibly breaking down the concrete into food with its metabolic processes. Slowly it grows outward from the initial colonisation point to cover inches over a hundred years. Most likely, a lucky fungal spore hitchhiking on the shoe sole of some unsuspecting pedestrian was dislodged in the proximity of a once free-living algal cell. Their marriage long ago forms the lichen colony that endures, now quietly turning sidewalk into soil.

As I walk in the Cascade-Siskiyou National Monument of southern Oregon, I notice stray clumps of lichen on the grass along the creek, perhaps blown from the nearby junipers and ponderosa pines. Mostly wolf lichen, but a few other, paler macrolichen species as well, in shapes like miniature kale. *Vulpicida canadensis*, called by some brown-eyed sunshine (Figure 4). Their bright yellow-green colour indicates the presence of vulpinic acid.

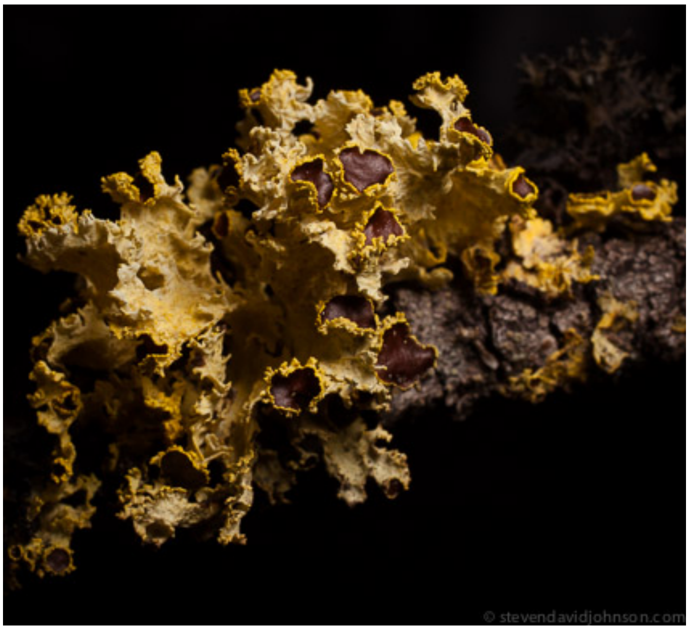

Figure 4. *Vulpicida canadensis*

If watching grass grow is too fast-paced an activity, one might try watching lichens grow, preferably under a hand lens. Here, a rock covered with a scabby crust of many varieties: ash-white flaky lichen like the crystals kids grow at home on charcoal bricks, bright orange-yellow-green, black, gray, brown, moss green. Also some blackened moss, looking as if it had been burned, but this is how moss sometimes looks in winter, desiccated and hopeless. Tiny sporophytes stick up from the gray-black moss, their presence a reminder that life continues.

Up slope, I find an aged, gnarled juniper adorned with many kinds of lichen as if it has been decked out for Christmas. Abundant tufts of poison green wolf lichen, and brown, hairy strands of *Bryoria*, like something swept up from beneath a barber's chair, adorn some of its branches, while other limbs, bare and weather-whitened, appear stippled with brick red dots, decorated with trace amounts of that orange-yellow scabby-looking lichen often found on rocks. Upon closer observation, I see that the red dots are growing as part of a greyish-white, velvety crust lichen. There is also a pale green kind of branching lichen, in tufts the size of the wolf lichen, but with slightly wider, flatter branches.

I see crenellated lichen with a grey-white upper side and a black-brown underside: bone lichen. There is graceful, pale green *Usnea* cascading over branches like a grandmother's lace shawl over her arms, and tufts of brown coyote's hair. I have read that this *Bryoria* is edible; Salish oral history explains that it came from the trickster Coyote who, while hunting swans, somehow got his hair tangled in tree branches. He cut himself free, declaring, "May my hair not go to waste; let it serve my people as food in times of scarcity".[5] Since then, some Salish peoples have eaten the black-brown hair-like lichen, called *wila*, as a normal part of the diet. Explorer David Douglas, in 1826, recorded the method by which a Spokane woman prepared tree lichen cakes: first, soaking the lichen in cold water until soft, then baking overnight in an earth oven. Next morning, they shaped the sticky goo into cakes. According to Douglas' journal, people he met frequently went on lichen-gathering forays in their carved canoes.[6]

I am not about to construct an earth oven and bake lichens into goo, but I would like the reassurance that I could survive if lost in the woods for a few days, so I pick a small lock of lichen to taste. Although it is hair-like in shape, the texture is brittle, so it is possible to bite off a small piece and chew it. I think of dried corn silk. I am surprised at the pleasantly crisp texture. The taste itself is not bad, something like the mineral flavour of rainwater, but stronger. I could eat this if I were starving. Good to know. Thank you, Coyote.

I muse a moment on what it would be like to have less food in reserve than what I am accustomed to. What would it be like to know that if the next hunting expedition were not successful, we would be forced to resort to foraging and earth ovens? Born an American in the late 1970s, I blithely rely on grocery stores and giant warehouses, stock months' worth of canned goods when they are on sale but never worry if I run out, keep a few weeks' worth of vegetables in a freezer. Studying edible wild plants is a mark of my eccentricity, never a matter of survival. My 1980s childhood was spent in the cornfields and hog lots of Iowa, where food is grown on a national scale, not a bioregional one. In Iowa, one of the most dramatically altered ecosystems on the planet, few of its once-plentiful lichens remain.

Lichens, including the *Bryoria* I nibbled just now, are indicators of pollution, partly because they retain the chemical compounds present in polluted air – lead, mercury, cadmium and so forth – at a much higher concentration than other life forms can typically sustain. Lichens are also able to absorb astonishing amounts of radioactive isotopes, such as strontium-90 and cesium-137. A 1965 study revealed that the bodies of Arctic people had much higher concentrations of these isotopes than any other people group because they ate the caribou that ate the lichen that ate the radiation from nuclear testing that had been prevalent prior to that time. This small amount of lichen I have ingested, I tell myself, is not enough to harm, but I would better not make whole meals of it. Save it for the flying squirrels, who use it as both nesting material and pantry provision.

There are specialised fungi that live only on specific lichens: lichenicolous fungi, a lovely and fun word to say ("lichen-nickel-us"). Some are benign, while others are parasitic to their lichen hosts, sucking nutrients until the host dies. Whatever their effect, the vast majority of the lichenicolous species are obligates with their lichen, which means they are found nowhere else in nature.

Let us imagine what this is like. Think of an old married couple, joined five decades or more, the sort of couple who, if one dies, the other is sure within three months to die also or else swiftly remarry. Once I heard a minister cheerfully pronounce a newly wedded couple, "Now you no longer independent, but co-dependent!" This minister probably meant to say "interdependent", but in the case we are imagining now, this old, married, lichenised couple, it is truly a case of co-dependence; one of them is unable to even make toast, while the other partner's activities would dwindle away to nothing without the first's prodding demands. Today it is common to disparage such a marriage, to perhaps urge each member to try therapy in order to become more self-actualised and independent, but in this lichenised marriage, let us simply observe them for what they are, with a measure of humility.

Imagine that the somewhat dominating old man is the fungus, and the eternally kitchen-bound old lady is the alga.

Now enters a stray person who comes to live at their house and benefit from their hospitality. Pretend that interloper is you, a type of lichenicolous fungi. Perhaps you mow their lawn for them and drive them to their medical appointments, but mostly you enjoy the home-baked cookies and the free cable television. Depending on what type of fungus you are, perhaps you even go so far as to eat them out of house and home. (I am not here to judge.) But for the sake of preserving the compact between author and reader, we shall assume you are not *that* sort of fungus, but rather the sort that eats just what the old couple can afford to spare, then kindly washes the dishes afterward. Rest assured, you would not find such an easy arrangement elsewhere, so you are obliged to stay. That is how you earn the title, "obligate lichenicolous fungus".

There are those who accuse human beings of becoming a parasite to our host planet, like a parasitic lichenicolous fungus, but I hold out hope that we might adapt to be the sort of lichenicolous fungi that does not harm our host. Because we cannot perform photosynthesis ourselves, we must derive our nutrients from somewhere, but we can strive to be obligate lichenicolous fungi without being parasitic.

If I die first, I say to my companion, do not let me be embalmed. Let me be claimed instead by the earth, by bacteria, by lichen, by fungi. Let my body nourish another round of life; let me leave no trace. *Leave no trace*: the credo of good wilderness backpackers. But upon further reflection, I recognise that the mantra, "leave no trace", is counter to the general human tendency to wish to make a mark on history, to leave a legacy. I may say I wish to leave no trace, to fade back into the natural progression of cells being recycled into other organisms, but with every word I record in my notebook, my actions embody the opposite sentiment: I make marks, create form. Words are the traces I leave. Form resists formlessness; my own form is no exception. The *Nostoc* bacterium, once lichenised, does not readily jump ship and return to goo. The lifespan of lichenised *Nostoc* is much greater than that of its free-living counterparts. (Similarly, statistically-speaking, the lifespan of married people is greater than that of free-living singles.) Sharing language is a legacy I want to leave behind. Sharing a love for lichens is another.

Graphis scripta, the script lichen, appears white with black markings as if made by pencil in an obscure language. There are other marks I make, words that I carve, if not on a tomb, then on particular human hearts. One way or another, I leave traces on these people who share my life. WIFE AND MOTHER or HUSBAND AND FATHER, for instance: words I deem worthwhile to inscribe. The phrase calls to my mind a headstone, which leads my thoughts back to lichen, since headstones become substrates for many lichens. This is convenient for lichenometry, the science of calculating age by the growth rates of lichens: the dated headstones provide a reliable marker. Does all death lead inevitably back to lichen, to fungi, one way or another?

A suite of lichens grows on old bones. During medieval times, lichens grown on human skulls were used in medicine and were worth their weight in gold. Egyptians used a type of lichen, *Pseudevernia furfuracea,* to pack inside dead bodies during the embalming process. Its absorbent and antibiotic properties were both aids to preservation. In Arctic tundra, bone and antlers persist for many years, accumulating lichen over time.

Lichens survive in many conditions we would find difficult. When dry, lichens can "hibernate", or remain in a state of suspended animation, through extreme temperatures both high and low. Then, when re-wetted, they pick up where they left off, photosynthesising and metabolising. They tolerate high concentrations of heavy metals, minerals and even radiation. But they have their limits: sulphur dioxide and other pollutants have transformed some urban areas into virtual lichen deserts, places where only a few specially adapted lichen species thrive. None of the large, leaf-shaped foliose species or drooping fruticose lichens that festoon old-growth forest branches can withstand most urban environments. This is a loss, aesthetically as well as biologically.

Desert soils, like those found in arid parts of Australia and North America, bear a hard crust of lichen communities, protecting against run-off and erosion in areas where few rooted plants survive. When damaged, the crust requires hundreds of years to grow back. Pioneer wagon trains, when passing west across North America, wore ruts in this biological soil crust still visible today. Ecological havoc in straight, parallel lines. Twin tracks of microscopic ecological apocalypse.

Near a creek, I sprawl on a bank, my black rubber boots dangling, and lean back, back, straining my focus up past the tips of ponderosa pines, straight up into blue sky, textured with striations of clouds in the shape of tyre tracks. Smack in the middle of my view, a plane contrail mars the sky like a scar. Clouds are, after the creek water, the fastest things here. I watch clouds drift until the scar breaks apart, and leaves no trace. I am filled with hope that, given time and enough revolutions of the earth, other human-made scars will shift, heal, fade. Pioneer tracks, clearcuts. It will take lots of time. But geology – and lichenology, too – reveal nothing if not the fact that time is indeed abundant. Arctic environments include lichens estimated to be 4,000 years old. The lichen relationship itself, that symbiosis of fungus and photobiont, is ancient, much more ancient than us. Lichens – some, though not all – will surely outlive our own species' reign on earth. I find this a comfort.

David Richardson writes in *Vanishing Lichens*, "the reclining figure by Henry Moore in the gardens of Dartington Hall, Devon, England, is a fascinating study of ecological niches. The head and knee of the statue are covered by a distinctive nitrogen-loving community of lichens that grow because these parts are used as perches by wild birds which deposit quantities of droppings. In addition, several species requiring moisture are to be found in the damp armpit, while the day-shaded back of the statue exhibits a third community of lichens".[7]

Cross the creek, climb a steep slope up to a rock ridge like a stone retaining wall, formed by naturally occurring volcanic rock. On top of this rock spine, I pause to examine what grows on it: a spring green lichen that grows in mounds as if imitating moss is dotted in black India ink, a mint green fungus in the shape of tiny leaves is interspersed with beige bubbles, a putty-colored patch is flecked with blue-grey, browns like chocolate, mocha, caramel, coffee. A flaky gray patch sloughs off at the merest fingernail scratch. Black crust, matte and faded, contrasts with vivid, dark orange-yellow like encaustic paint. Shades of gray fill the empty spaces so that I do not believe I detect the actual rock surface visible anywhere.

These crustose lichens (Figure 5), growing attached to the surface on which they are found, require specific conditions, but given enough time will colonise almost anything. For instance, crustose lichens have been found growing on the surface of medieval stained glass, slowly pitting the blues and reds of cathedral light. There are crustose lichens that grow on newly exposed rock where glaciers retreat. The growth rates and size allow scientists to calculate the approximate age of the glaciers. David Richardson writes, "while in most cases a freshly exposed rock surface is completely covered with a mosaic of lichen thalli after 100-300 years, the largest thalli in the mosaic continue to grow at a steady rate replacing and outgrowing smaller thalli. How this comes about has not been satisfactorily explained".[8] I love an admission such as this, when knowledge falls away in deference to mystery, to wonder.

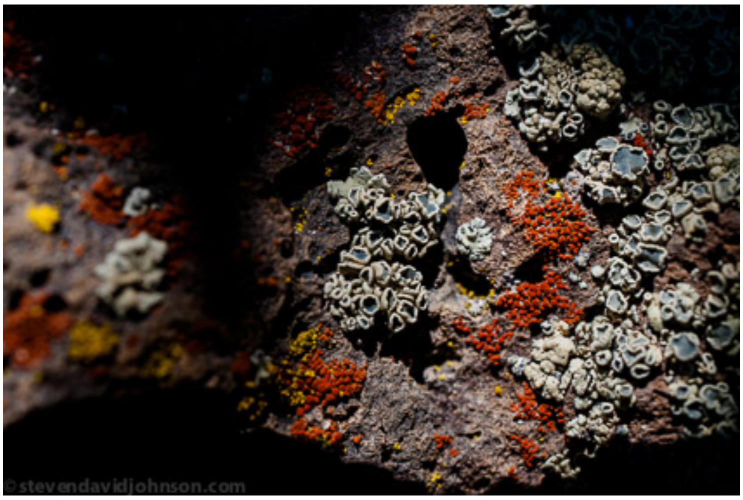

Figure 5. Rock dwelling species including *Lecanora* and *Xanthoria*

Lichen serves vital roles to animals other than ourselves, though perhaps we know only a small degree of the extent. In addition to making the perfect nesting material for golden plovers and many hummingbirds, complete with antibiotic properties to aid the offspring, lichens make fine camouflage (Figure 6). In New Guinea, giant tree beetles grow a kind of lichen on their backs; they are like the walking-shrub disguises depicted in cartoons. (Male Galapagos tortoises grow lichen on part of their shells, also, though they are hardly *in cognito*.) A weevil in New Guinea dresses itself in leaf litter and the soredia of lichens, so that it resembles a lichen walking about on stilts. Eighteenth century Scotsmen wore wool clothing dyed in crottle, a type of lichen, which produced a rich golden-brown that blended in with the heather and bracken on the ground. Lacewing larvae and long-tailed silky flycatchers in Costa Rica and in western Panama specialise in lichen-made camouflage for themselves or for their nests. The loss of any one component could result in catastrophe with a domino effect for the various ecological webs these animals reside in – although the Scotsmen seem to have adapted.

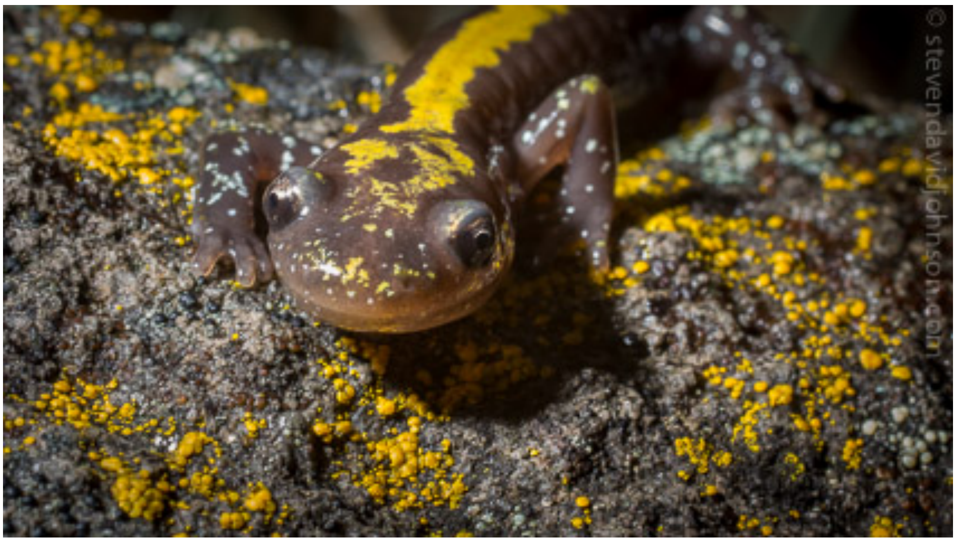

Figure 6. Long-toed Salamander and *Candellaria*

Lichenisation makes a worthy metaphor for human civilisation. Complex societies develop under a division of labour: you be the builders, you be the farmers.

Gretel Ehrlich, in *This Cold Heaven*, quotes an unnamed arctic biologist as saying: "A lichen is a fungus that grows its vegetables inside itself".[9] This statement parallels one by lichenologist Trevor Goward: "Lichen are fungi that have discovered agriculture".[10] Over a decade later, Goward now believes his former view is overly reductionist, reducing the fungi to farmers and the algae to domesticated crops or livestock when in reality, the relationship is more like a whole feedback system, or cybernetics. Instead of thinking of lichens exclusively in terms of their parts, he now thinks of lichens as a whole as being emergent, a new organism built of smaller organisms, somewhat like human beings who are individuals even though nine out of every ten cells inside of us are bacteria. Perhaps we are more akin to the "poor trash of vegetation" than Linnaeus would have liked to believe.

If contemporary human beings had a different perspective, perhaps we would be building temples where we would assemble to contemplate and express gratitude to the microorganisms – fungi, cyanobacteria, algae, bacteria – running the ecosystems that we depend on for life. Perhaps we would mouth "thank you" every time we clothed ourselves in lichen or lichen-dyed garments, each time we ate lichen baked into bread, whenever we took it in tincture to heal us, or while packing it into the bodily remains of our dead.

On our walks, whether through urban-scapes or forested hills, let us notice the lichens, free-living fungi and algae, contemplate the secret bacteria, and breathe a little deeper, knowing that the earth is doing what she can to clean our air, to absorb our pollution and radiation, to heal us from ourselves, to teach us the way of symbiosis. While we now know that the *Lobaria* lichen, although shaped like our lungs, will not cure pulmonary disease when ingested (as the medieval "doctrine of signatures" claimed), we do well to remember that its fate is inextricably linked to our own, for we are more similar to lichenicolous fungi than we dreamed.

Notes

1. Anna Maria Johnson is a writer and visual artist.
2. John Villella is a lichenologist from southern Oregon who conducts plant surveys throughout the Pacific Northwest of America.
3. Although the authors are two individuals, we've chosen to write in one voice without distinguishing between us, in imitation of lichen whose fungal, algal, and/or cyanobacterial components are difficult to separate out. Through this polyvocality, we intend that the form of this essay follow its content.
4. D. M. Richardson (1975), *Vanishing Lichens: Their History, Biology and Importance*, Hafner Press, Royal Oak, Michigan.
5. N. Turner (2005), *The Earth's Blanket: Traditional Teachings for Sustainable Living*, Douglas & McIntyre Ltd., Vancouver, p. 62, quoting Mourning Dove's 1933 book of Okanagan-Colville stories.
6. J. Nisbet (2009), *The Collector: David Douglas and the Natural History of the Northwest*, Sasquatch Books, Seattle.
7. D. M. Richardson (1975).
8. Ibid.
9. G. Ehrlich (2001), *This Cold Heaven*, Pantheon Books, New York, p. 104.
10. T. Goward (2008), "Twelve Readings of the Lichen Thallus: I. Face in the Mirror", *Evansia* vol. 25(2), pp. 23-25.

Photo credits: Steven David Johnson