

Some Ideas for Mosses and Liverwort Workshop by Daniel A. Salomon---Copyright Materials 2016---Please Do Not Reproduce Without Permission of Author

Outline for Workshop

Part 1: 45-minutes (The Ecology and Evolution of Mosses, Liverworts and Lichens)

- Mosses, Liverworts and Lichens with some discussion of Clubmosses, Spikemosses and Quillworts and some discussion of mosses, liverworts and lichens in the temperate rainforest. (pictures and diagrams from field guides)
- Go over collection of lichens. Have opportunities for participants to look at lichens with magnifying glasses.
- Handouts on some lichen species around the Hoyt visitor center and handouts on lichen morphology.
- Look at bryophyte cell slides under microscope for microscopic one-cell thick leaves and lichens under the microscope to look at the algae in the fungus which comprises the lichen.
- Q & A.
- 15-minute break.

Part 2: 45-minutes (Nature Walk, a Natural History of Mosses, Liverworts and Lichens)

- A short walk around the Hoyt Visitor Center and on the Overlook Trail to identify some common species

of mosses and lichens in their natural habitats.
Handicap Accessible and easy to traverse with possible muddy conditions in early March.

- 15-minute break.

Part 3: 45-minutes (So What? Why Moses, Liverworts and Lichens are important to human life and the whole planet)

- Ethno-Lichenology (Peter McCoy, *Radical Mycology-A Treatise on Seeing and Working with Fungi*).
Handout on Solomon's Temple.
- Ethnobotany of Moses and Liverworts (Pojar and Mackinnon).
- Lichens as Canaries in the Coal Mine for Air Quality (Contrasting lichens at Hoyt with Alphabet District). (Photos from Pojar and Mackinnon).
- Moses as Canaries in the Coal Mine for Air Quality (Talk about the role of tree mosses in discovering air pollution in several East Portland neighborhoods). (Bring in some news clippings)
- Thought experiment: How polluted is the air in your neighborhood? Look for the presence/absence of this pollution-tolerant lichen---*Xanthoria*? Are there any lichens in your neighborhood at all? (Photo). (Peter McCoy, *Radical Mycology-A Treatise on Seeing and Working with Fungi*).
- Q & A.

- Workshop will also include a bibliography and some additional hand-outs sent via e-mail which will be sent afterwards with survey.

Part 1: 45-minutes (The Ecology and Evolution of Moses, Liverworts and Lichens)

- Moses, Liverworts and Lichens with some discussion of Clubmosses, Spikemosses and Quillworts and some discussion of mosses, liverworts and lichens in the temperate rainforest. (pictures and diagrams from field guides)
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Moss Systematics and Temperate Rainforest Ecosystems (Peat Mosses and True Moses)

Pojar and Mackinnon *Revised Plants of the Pacific Northwest: Washington, Oregon, British Columbia and*

Alaska (Vancouver, British Columbia: Lone Pine Publishing, 1994) 437-483.

- Mosses like all bryophytes are non-vascular plants, plants which have less developed (differentiated) connective tissues for transporting water and nutrients. Bryophytes also encompass liverworts and hornworts.
- Vascular tissue, a well developed system for transporting water and nutrients around the body of a plant allows vascular plants like flowering plants, conifers and ferns to grow tall and thrive in places where water is not always available. Mosses like all bryophytes, remain small and grow in wet places.
- Because we live in a maritime climate, the climate which produces much rain, snow and other forms of precipitation, the climate of the temperate rain forest, bryophytes like mosses are abundant. In fact, mosses and other bryophytes, as well as lichens of all kinds, drape every layer of the temperate rainforest like a tapestry in a castle, from ceiling to floor. When scientists say that most of the biodiversity in the temperate rainforest is in the canopy like the tropical rainforest, I contend that much of this biodiversity is comprised of bryophytes like mosses and liverworts and lichens, as well as some ferns, which grow on the towering trees of the temperate rainforest, from trunk

to crown, helping to give the temperate rainforest, its distinctive, lush, rich, verdant appearance.

[photograph]

- There are species of mosses which live in dry places like Apple Moss (*Bartramia pomiformis*) which you can find at places like Cooper Mountain in Washington Country, a restored prairie. Some species of mosses which grow in dry places have a special adaptation, the ability to dry-up for long periods of time and upon re-wetting, begin to photosynthesize almost immediately which is considered unusual in plants. [photograph]
- Mosses reproduce through a very complicated, absolutely amazing process. Like all bryophytes, mosses reproduce through fully fertilized spores. Fertilized spores need moisture to germinate, to differentiate and develop. Once the spore germinates growing into the visible moss plant (the gametophytes). The Gametophytes (the body of the moss) creates males and female sex organs which creates sperm and eggs. The sperm swims to the egg to fertilize the egg, creating the Sporophyte, the organ system in a moss which creates spores. The Sporophyte consists of a capsule on a stalk (the seta) which grows out of the Gametophyte. Fertilized spores are released from the capsule and the life cycle begins again. [diagram]

- If you can think of the main difference between a spore in bryophytes like mosses and a fully developed seed like flowering plants is that that a spore-producing plant *does not* have a protective hard casing and a spore is completely vulnerable and dependent on the external environment, while a seed-producing plant is better protected, fully ready to take on the external environment, even before the plant is born.
- All bryophytes including mosses lack true roots and attach to substrates (the platform which mosses grow on like wood or soil) through an anchor-like organ called the rhizoid.
- Most bryophytes are mosses. There are some 8000-9000 species of mosses worldwide.
- There are two major sub-genres of mosses in the bryophyte family: peat mosses and true mosses. Liverworts and hornworts are two additional sub-families also in the bryophyte family.
- The genus of peat mosses (*Sphagnum*) has 40 species which are native to the Pacific Northwest, many of them grow in bogs and fens, but peat mosses also grow in forests even cliff-faces. Peat Mosses have a more developed morphology (body or structure) than True Mosses. Peat Mosses have distinctive branches which occur in clusters, distinctive upright stems and have additional stem

leaves, giving them sort of a shaggy appearance, which is critical for identification. [Show diagram of peat moss]

- There are exceptions to everything in Nature! True mosses grow by the book, the textbook description of the lifecycle of mosses which we talked about earlier, while peat mosses have some ability to release spores upwards on dry, sunny days, allowing for more expansive spore distribution. This might have evolved in peat mosses because the habitats for peat mosses are more isolated from one another than true mosses, so their spores need to travel further. Peat mosses also have a more differentiated morphology than true mosses [show photograph of true moss versus peat moss]. There are 700 species of mosses native to the Pacific Northwest. True mosses are abundant at all elevations but are more noticeable and showy at lower elevations in coastal rainforests.

Liverwort Systematics and Temperate Rainforest Ecosystems

Pojar and Mackinnon, *Revised Plants of the Pacific Northwest: Washington, Oregon, British Columbia and Alaska* (Vancouver, British Columbia: Lone Pine Publishing, 1994)

- Liverworts are another sub-family in the Bryophyte family also called Hepatics. There are 6000 species of

liverworts worldwide and about 220 species of liverworts native to the Pacific Northwest. They are most abundant on moist substrates but liverworts can also grow on trees in periodically dry forests.

- Liverworts really captured my imagination in the first semester of freshman biology for majors when I was undergraduate when my professor, also a botanist, described liverworts as “not having any roots, stems or seeds, they are only a leaf.” I have always been fascinated by the simplicity of living beings. As a small child, it really captured my imagination that a sea sponge (a seemingly inanimate object which we use to bath and wash sinks with) was not only a naturally-occurring living organism but was actually an animal. It captured my imagination in undergraduate that a single leaf could be an autonomous plant. I saw my first liverwort anywhere when I enrolled in a field course, one summer, delivered in Olympic National Park, in undergraduate. In fact, I remember the forest floor of the old-growth temperate rainforest blanketed with fields of Lung Liverworts (*Marchintia polymorpha*) and brilliantly covered wildflowers. Growing-up and going to college and graduate school Back-East, I never saw a liverwort, either in the wild or in captivity or even a live or dried example of a liverwort. I only heard about this mysterious category of plants mentioned only in passing on plant lists, textbooks

and biology lectures. I only saw a photograph of the Lung Liverwort in my biology textbook.

- No one ever thought me that that the liverwort leaf is really a complete, fully developed, yet undifferentiated plant body where the roots, stems and spores are less visible or pronounced.
- No one ever thought me that liverworts can come in all different types of sizes and shapes. Not just the lobed disk of the lung liverwort but also the moss-shape of the Common Scissor-Leaf Liverwort (*Herbertus aduncus*), the fern-shape of the Cedar-Shake Liverwort (*Plagiochila parelloides*), the lily pad shaped Snake Liverwort (*Conocepphalum conium*) with hexagonal markings, the Maple Liverwort (*Barbilophozia lycopadioides*) whose slender tapered lobes overlaps like shingles on a house, or the smooth Hard-Scale Liverwort (*Mylia taylorii*), just to name a few. One reason why liverworts are often mistaken for everything from mosses to lichens.
[show photographs]
- Liverworts have the same basic morphology as mosses; it is just that their rhizoids and sporophytes are less visible or pronounced.
- There are some liverworts, however, which *do not* have fully differentiated stems and leaves including not only the snake liverwort but also the lung liverwort which is the textbook example of a liverwort species

used in biology courses, although lung liverworts and snake liverworts do have a separate organ for creating fertilized spores, they even have a small stalk. The lung liverworts on the grounds of the apartment where I live definitely have small visible stalks to the naked eye. Hence my Freshman Biology's professor's comment, "Liverworts do not have any stems, roots or seeds, they are just a leaf." Ironically, most liverwort species *do not* just have the appearance of just a leaf but leafy like mosses (with a separate stock and leaf) or to be more exact, stem-y like ferns. And, little did I know as a kid that sea sponges are just another non-renewable resource which are being exploited by human beings. As I grew-up, I learned how complicated life can really get.

Club Mosses, Spikemosses and Quillworts

Club mosses, Spikemosses and Quillworts are families within the Fern and Allies Order, as are horsetails. They share characteristics in common with both bryophytes (e.g., moss and liverworts) and lichens (e.g., reproduce through spores verses seeds, they need abundant moisture to reproduce and often grow in wet places) and vascular plants (e.g., conifers and flowering plants) (e.g., internal vessels for transporting fluids like water). 417

Talk about Clubmosses, Spikemosses and Quillworts in lecture because of close resemblance in appearance to true mosses.

Both Clubmosses and Spikemosses are low growing.

Clubmosses look like little miniature Christmas trees if you use your imagination and grow as ground covers. (429, 432-434). [Pictures]

Spikemosses usually are short and creeping, often forming mats. Spikemosses have branching stems which are prostrate (hug the ground) but do not fork. One species of spikemoss which is native to the Pacific Northwest (*Selaginella oregana*) can even grow on trees. In fact, the famous hanging curtains or tapestries on maple trees on big leaf maples (*Acer macrophyllum*) in the temperate rainforest in Olympic National Park which you might have seen a photograph or footage of is usually made-up of this species of spikemoss interspersed with true moss. (429, 435-436). [Pictures]

Quillworts share in common with clubmosses and spikemoss a similar spore structure. Clubmosses, Spikemosses and Quillworts all produce spores in their leaves like liverworts. Some say that Quillworts have leaves which look like a bundle of quill pens hence their common name. The leaves actually look more grass-like and can be mistaken for grass. There are several species of Quillworts native to the Pacific Northwest. One is the

Bristle-like Quillwort (*Isoetes echinospora*) which is an aquatic herb. Bristle-like Quillworts have grass-like leaves with a bulb-like corm (base) which some have interpreted as a small stem. Bristle-like Quillwort grows in shallow (1 m deep), standing or flowing water. Often growing on sand or gravel at low to middle elevations. The Nuttall's Quillwort (*I. nuttallii*) is the only non-submerged species of Quillwort native to the Pacific Northwest growing in wet places like vernal pools and seepages. (436). [Diagram]

Lichen Systematics and Temperate Rainforest Ecosystems

Pojar and Mackinnon, *Revised Plants of the Pacific Northwest: Washington, Oregon, British Columbia and Alaska* (Vancouver, British Columbia: Lone Pine Publishing, 1994) 484-504.

- More than a thousand kinds of lichens are native to the Pacific Northwest. Based on my research, lichens seem to have a fluid species concept. There are many sub-species which are classified as separate species with their own Latin binominal nomenclatural names. This is possibly because this is a relatively new field with much which still needs to be studied and worked-out. In recent years there has been more study of these obscure creatures in the Biological World partially as a response to the genetic revolution

where there has been an impetus in the scientific community to learn as much as we can about the genetics of different life forms and their evolutionary interrelationships. How exactly are all the species genetically related through creating a detailed picture of the evolution of life which is called the Phylogenetic tree where the metaphor of the Tree of Life is sometimes used. Only a few hundred kinds of lichens, however, are widespread and conspicuous in the Pacific Northwest.

- Many species of lichens live in old-growth forests.
- In the Coastal Regions of the Pacific Northwest, lichens are often found in the greatest numbers in rocky headlands, ventilated forests and the alpine.
- Lichens are technically classified in the fungus kingdom, the same kingdom as mushrooms, molds, mildews and yeasts.
- Lichens are really composite creatures, a real-life composite creature liken to the composite creatures found in mythology and fantasy and science fiction literature.
- This is because lichens have an interconnected, interpenetrated, integrated, mutualistic relationship (a co-beneficial relationship) with algae (and sometimes even photosynthetic bacteria). Algae and blue-green bacteria are also photosynthetic. Lichens provide a greenhouse for algae and photosynthetic bacteria in

exchange for eating the food which the photosynthetic algae and bacteria have created through harnessing sunlight to turn into food.

- This separates lichens from other members of the fungus kingdom. The other members of the fungus kingdom are decomposers, scavengers or parasites, although there are some parasitic lichen species. Lichens are consumers like animals. Lichens cannot make their own food from the sunlight or other inorganic chemicals like many members of the plant, bacteria and protista kingdoms. By the way, algae are in the protista kingdom, the same kingdom which includes seaweeds, kelps, amebas, slime molds and many microorganisms. Algae are photosynthetic. Nor, can lichens like other funguses, digest the nutrition found in detritus, dead organic matter, like what is found in soil and in rotting animals and plants.
- The viable portion of the lichens which you will be able to see, touch and identify today are the physical manifestation of this interconnected, interpenetrated, integrated, mutualistic relationship between fungous and algae and fungous and bacteria. You can only see the interconnected, interpenetrated, integrated, mutualistic relationship with your naked eye. You cannot see the fungus, algae or bacteria with your naked eye. Although, pale green coloring can indicate the presence of algae, while darker, blue-green

coloring can indicate the presence of bacteria. In other words, lichens make abstract ecological concepts like interconnectiveness, mutuality and the whole, concrete and tangible, so lichens are a great way to understand at a deeper level, the ecological principles of interconnectiveness, mutuality and the whole which define the structure of temperate rainforest ecosystems, for example. Lichens are also a microcosm of the interconnected, interpenetrated, integrated structure of Earth as a whole liken to a singular self-regulating living organism.

- Also, it is worth talking about the photosynthetic bacteria which lichens sometimes cultivate. The photosynthetic bacteria which lichen cultivate is a cyanobacterium, whose common name is the blue-green algae.
- Lichens reproduce in three ways. In some cases, the lichen fungus produces, saucer-like fruiting bodies known as *apothecia*. In some other cases, the lichen fungous reproduces through clusters of tiny, powdery balls called *soredia*, found on the expose surfaces of the lichen body. In still other cases, the lichen fungus reproduces through tiny, wart-like outgrowths called *isidea*, found on the upper service of the lichen body. [show diagram]
- Lichens come in many different shapes, but they never form leafy stems as mosses do.

- Lichens can come in the form of dust, crust, scale, leaf, club and hair. [Show diagram]
- There is a subgroup of lichens called Rag Lichens (Platismatia) which seem to share in common--- having a many branched body. The north Pacific is particularly rich in rag lichens. Of the five true species of rag lichens which occur in the Pacific Northwest, three true species of rag lichens are found nowhere else in the world. [Show photographs of leaf, club and hair form]

Part 3: 45-minutes (So What? Why Moses, Liverworts and Lichens are important to human life and the whole planet)

- Ethno-Lichenology (Peter McCoy, *Radical Mycology- A Treatise on Seeing and Working with Fungi*). Handout on Solomon's Temple.
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- Moses as Canaries in the Coal Mine for Air Quality (Talk about the role of tree mosses in discovering air pollution in several East Portland neighborhoods). (Bring in some news clippings)

- Thought experiment: How polluted is the air in your neighborhood? Look for the presence/absence of this pollution-tolerant lichen---*Xanthoria*? Are there any lichens in your neighborhood at all? (Photo). (Peter McCoy, *Radical Mycology-A Treatise on Seeing and Working with Fungi*).
- Q & A.
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Ethnolichenology (Peter McCoy, *Radical Mycology-A Treatise on Seeing and Working with Fungi*)

- According to lichenologist Nastassja Noell, “while lichens have played a helpful role in the development of many cultures around the world, their cultural significance amongst botanists and mycologists have largely been [overshadowed] by the interactions of humans with plants and mushrooms. Still, the small field of *ethnolichenology* holds a few fascinating insights into how lichens can assist in personal and societal resilience.” (130)
- Noell writes, “Lichens are expressions of pure joy. Their variety of color, morphology, chemical constituents and inexhaustible capacity for adaptability is proof that the living world is not purely utilitarian. Lichens remind us that life is art and that deeply integrated into one’s environments is the most

refined expression of that art. Lichens paint the rocks of the desert with living murals, drape the temperate forest with lace ribbons and thrive in the harshest climatic conditions. From antarctic to tropical systems, from rainforests to deserts, lichens are every-present, showing us a way of fungal being that is always exposed, always present. Humbly, they slowly grow by crystallizing sunlight and vapor into delicate but resilient symbiotic systems. Inside the ecosystem of a lichen are most of the primary components of life: fungi, bacteria, algae, and cyanobacteria, all living in a discrete synergistic system that can rarely be synthesize *in virta* but can withstand the extreme conditions of outer space... This symbiosis of fungus and algae is thought to date back to the first ancestors of terrestrial life. As landforms diversified and developed, as mountains rose defiantly and weathered into soft hills, lichens have been patiently watching from their perches. Some contemporary lichens are over 5,000 years old---relics from a distant age. Lichens are the beholders of stores on landscapes and climate, if one takes the time to witness them clearly. Through their slow and ancient nature leads to lichens beings lost in the larger members in their ecosystems, these fascinating beings are not static. Rather, they perform numerous mutualistic roles with bacteria, insects, rodents,

ungulates, and humans. And there are four main reasons that humans work with lichens: as medicine, as a natural dye source, to monitor environmental health, and to study ecosystem biodiversity and dynamics.” (111)

- Lichens as medicine: Lichens produce over 1500 chemicals. Most of these chemicals are not found in plants or other fungi but are exclusive to lichens. Lichen chemicals range from menstrual teas to powerful antibiotics. Lichen-derived antifungal, anti-HIV, anti-microbial, and anti-cancer elixirs have been used by healers and health practitioners around the world for thousands of years. For example, green-beard lichens in the *Usnea* genus (we saw *Usnea* lichens on our walk, the shrub lichens) are among the most widely used medical species worked with in traditional Chinese and Ancient Greek medicine alike. The Usnic acid found in these lichens has also been found to have powerful anti-cancer properties against leukemia, breast cancer and pancreatic cancer. However, working with lichens as medicine can be quite dangerous if you do not know what you are doing, so don't try this at home. [131].
- Lichens as dye source: Lichens have been worked with as a dye source by First Nations around the world. Written accounts of lichens being worked with as a dye source dates back to the 3rd century C.E.

Lichen dyes were also worked with in Scandinavia in the Bronze and Iron ages. Pigments can be worked with to not only dye fiber but also paint objects, hair and skin. Many henna formulas used at weddings in many traditional religions and cultures contain several different species of lichens. [132]

- Lichens as food: Korean, Japanese and Chinese cuisine has found a way to eat a particular species of lichen by removing gyrophoric acid through a method involving boiling the lichen in a series of baths. There is even some evidence to suggest that the “manna” or “bread from heaven” spoken about in the Bible was actually a species of desert lichen which sustains herds of livestock in arid climates, even tell this day. Nortic peoples in the Arctic regions developed Icelandic Moss in the 9th century. In Turkey and Egypt, a particular species of lichen is worked with to be made into bread or porridge. In Saudi Arabia, Kuwait and Omen, a particular lichen species has been developed into a spice, while in India, another species in the same genus of lichens has been developed into a curry. Even right here in the Pacific Northwest, many First Nation peoples, not only ate a particular species of hanging hair lichen known as Wila, they have made Wila into fabric and into a reliable source of tinder for starting fires. Wila is cooked with roots, meats and berries. It is important

to realize that like mushrooms, you need to be completely certain that the species of lichens you are planning to eat is in fact your target species. The effects of the chemicals in many species of lichens are unknown, while many lichens can also absorb pollutants, such as heavy metals. Lichens like mushrooms soak-up toxins like a sponge. Don't try and harvest lichens at home! [130]

- Lichen Harvesting Ethics and Tips: Lichens can only grow on average only 1 millimeter a year, meaning harvesting lichens must be done with great care and awareness of the lichen life cycle. Unlike mushrooms, lichens do not have an underground body, like you have now personally witnessed. What you see is entire lichens, and what you collect are entire lifetimes. Most lichens require a decade or so to grow just a few centimeters. Some lichens have lived for over a 1000 years. For example, determining the age of lichens has helped determine the age of the stones on Easter Island, as well as ancient avalanches and earthquakes. This means that some of the lichens on rocks and in old-growth forests might in-fact be old-growth lichens. Also, lichens in any in-tact forest are integral members of this ecosystem and removing too many lichens can remove an interconnected, interdependent strand in the web of a forest ecosystem, weakening the entire ecosystem. Also,

know that any unauthorized harvesting of lichens like any other living organism, which also includes all plants, fruits and seeds in Forest Park including the Hoyt Arboretum is strictly prohibited. All the lichens, plants and other living organisms of Forest Park are preserved as a food source for wildlife and for the education and enjoyment of the whole human community. The removal of dead organisms like branches for firewood and inanimate objects like rocks is also strictly prohibited. Removing even small amounts of natural materials can rob future visitors of their opportunity to learn about and enjoy the natural beauty of the Hoyt Arboretum and Forest Park. I am going to strongly discourage the harvesting of all lichens outside the auspices of a legitimate program like what Erin our resident botanist offers here at the Hoyt Arboretum. The lichen collection which you had a chance to explore earlier, I have worked with Erin to develop for this educational workshop and we hope to add this to the Hoyt arboretum herbarium collection as an educational and scientific research resource.

[129]

Ethnobotany of Moses and Liverworts (Pojar and Mackinnon)

- Ring Peltia Liverwort (*Peltia neesiana*) means “resembling fish scales” in Hesquiat. The Hesquiat worked with this liverwort to develop a medicine for treating children’s sore mouth. [445] [photograph]
- Snake Liverwort (*Concephalum conicum*) means “seal’s tongue” in some languages like the Haida and was used as an eye medicine by the Ditidaht. [446] [photograph]
- Common Green Sphagnum (*Sphagnum girgensohnii*) is the species of Peat Moss used by gardeners. [450] [photograph]

Lichens in Alphabet District

Cladonia Scales (*Cladonia* sp.) (Pollution Tolerant)
[Photograph]

Hooded Bone: Hooded Tube Lichen (*Hypogymnia physodes*) (Pollution Tolerant) [Photograph]

