What is a lichen – a prison or an opportunity?

Lichens cannot be classified as plants. They are **associations** between cup fungi ascomycetes *plus* either green algae (Trebuoxia sp.) or cyanobacteria (e.g. Nostoc), members of three kingdoms outside the plant kingdom.

Simon Schwendener discovered the dual nature of lichens in 1869: Ascomycetes surround some single-celled green algae with a fibrous net to compel the new **slaves** to work for them, a view that was replaced with romanticized notion of a harmonious symbiosis. Mycobiont gets sugar alcohols from green algae or glucose + nitrogen from cyanobacteria, which are stored in an inaccessible form (e.g. mannitol).
Lichens are a fascinating group of organisms that consist of a fungus (the mycobiont, mostly an ascomycete) and a photosynthetic partner (the photobiont or phycobiont), usually either a green alga (commonly *Trebouxia*) or cyanobacterium (*Nostoc*).

**All lichens have an upper cortex**, which is a dense, protective skin of fungal tissue that acts like a blind that opens after watering. Below that is a photosynthetic layer, which can be a colony of either green algae or cyanobacteria. Then there is a layer of loose threads (hyphae) of the fungus, called the **medulla or the medullary layer**. Fructicose & Foliose lichens **have a lower cortex**, others just have an exposed medulla. Crustose lichens never have a lower cortex-their fungal layer attaches firmly to the substrate.
What is that?

Is that a plant? Is that a fungus? Is that a lichen? What the …halloh!

Spanish moss (*Tillandsia usneoides*) closely resembles its namesake (*Usnea*, or beard lichen), but in fact it is not biologically related to either mosses or lichens. Instead, it is an angiosperm plant in the family Bromeliaceae that grows hanging from tree branches in full sun or partial shade.

Usnea is a lichen (a composite organism made from algae and fungi) and is referred to as Old Man's Beard. It looks very similar to Spanish moss, so much so that the latter plant's Latin name is derived from it (*Tillandsia usneoides*, the 'Usnea-like Tillandsia').
A lichen is a well-adapted hetero-hydric being

How does water + nutrients get into the thallus??

Lichens can absorb & lose water directly from the atmosphere. Can survive months of extreme drought with only 15% hydration. Upon rain absorb 2-4 x their dry weight (green algae) X or 16-20 x (cyanobacteria)

Effect of water content
A dry lichen is physiologically inactive and may absorb water from rain, dew or fog. Photosynthesis fixes carbon from carbon dioxide using chlorophyll and the energy of sunlight, whereas respiration produces carbon dioxide by breaking down sugars. Both processes occur in lichens and whether more carbon dioxide is fixed in photosynthesis than is released by respiration depends on how wet a lichen is.

The effect of water content on photosynthesis and respiration in the desert lichen Ramalina maciformis is shown above. At a water content of 22%, the amounts of carbon dioxide produced by photosynthesis and consumed in respiration are the same, so no net carbon is fixed as carbohydrate. Photosynthesis increases rapidly until a maximum is reached at 80% water content and then falls off at high water contents.
Live cycle of Xanthoria lichen

Sexual propagation in lichens is exclusively through fungal spores, which then have to capture new slave algae at the new location ➔

Asexual propagation of lichens involves special propagules that include both algae & fungus are distributed by the wind

1. **soredia**: powder-like clusters of algae wrapped into hyphae

2. **isidia**: smooth peg-like outgrowths from outer cortex break off

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**Life cycle of Xanthoria parietina**

- (a) germinating fungal ascospores;
- (b) developing fungal hyphae;
- (c) free-living lichen algae;
- (d) mature Xanthoria formed by fungal hyphae meeting lichen algae;
- (e) foreign algae not involved in lichen formation;
- (f) undifferentiated ‘lichen crust’ containing fungal hyphae and foreign algae;
- (g) Physcia sp. producing powdery soredia consisting of fungal hyphae intermixed with lichen algae;
- (h) Physcia thallus and soredia infected by Xanthoria fungal spores or the undifferentiated crust in (f) resulting in Physcia disseminating Xanthoria through powdery soredia, which Xanthoria itself does not produce;
- (i) Physcia producing spore-bearing fruiting bodies – apothecia;
- (j) Physcia thallus and apothecia infected by Xanthoria resulting in Physcia thallus producing Xanthoria spores. Yellow colour represents tissues infected by Xanthoria.
How slow do Lichens grow?

*Cladonia rangiferina* the reindeer lichen grows only 3-5 mm/year but this suffices to support the caribou. *Rhizocarpon geographicum* the map lichen grows only 0.5 mm/a and is used to date ice-age boulders. *Ramalina menziesii* from the CA dry lands grows up to 90 mm/a and has one the largest growth rates among lichens.

*Lichens* disrespectfully love to settle on gravestones. Since each stone carries is imprinted with the time of its appearance we can calculate the maximal age of the lichen patches on it.

\[
\text{radius / years} \Rightarrow \text{annual growth rate in mm/a}
\]

national lichen reserve, do not disturb!
Lichens can exist in extreme environments. Lichens can exist where few higher plants would dare to go: the high alpine (1) showing Xanthoria elegans, Antarctica with Usnea aurantiaco-atra (2), and even the true dry deserts of the world (3) showing Teloschistes.
Lichens in food, dyes, perfume, biomonitors, husbandry

**Umbilicaria esculenta** Iwatake is eaten as delicacy near Hiroshima.

**Cladonia** (subgenus *Cladina*) *sp.* Reindeer lichen /“reindeer moss” is extremely frost hardy, although it is slow growing (3-5 mm/year), it still dominates vegetation & food pyramid in arctic & alpine tundras basic food for reindeer alias caribou, collected for Christmas wreaths & tree models.
Lichens in food, dyes, **biomonitors**, husbandry

**Lichen biodiversity index**

**Lung cancer mortality**

**biomonitorting**

**lung diseases**
Lichens in food, dyes, perfume, biomonitors, husbandry

Crustose yellow lichen *Xanthoria parietina* growing on rocks = N-phil locations, contains

**Parietin** is a yellow pigment that turns into a deep purple red when a drop of KOH or BaOH is placed on it. See picture

**Lichen acids** can often be extracted with acetone. After evaporation they give characteristic crystals

**Cudbear:**

*Ochrolechia tartarea*

Fruiting bodies contain a yellow pigment. They swell to double the size in water & also turn red with KOH
Lichens in dyeing Textiles

**Basic Mordant:** 150 ml alum, 75 ml tartar, for 2 gallons of water

**Peltigera lichens:** soak overnight in same volume of water, next day boil for 1 hour, remove lichen & replace volume with water. Add mordanted cotton or wool. Boil for 40 min. Rinse and dry. ➔ yellow tan.

Follow with a bath of Potassium dichromate (1.5 teaspoons and 100 ml of vinegar. Biol gently for 10 min ➔ dark rose

**Usnea lichens:** soak overnight in same volume of water, next day boil for 1 hour, remove lichen & replace volume with water. Bring to boil and add mordanted cotton or wool. Boil for 30 min. Rinse and dry. ➔ beige

Add wool to mordant bath Potassium dichromate 0.6 teaspoons to 1 gallon water ➔ yellow Add wool to mordant bath Potassium dichromate 0.6 teaspoons to 1 gallon water plus 60 ml vinegar ➔ red color
Usnea lichens in Healing

Dr. Alfred Vogel (Switzerland) “The Nature Doctor” 1902-1996 once saw a deer on her hind legs eating beard lichen Usnea barbata growing on the Alp’s larch trees. He suspected self-medication against the cold and antibiotic functions. ➡️ used it against common cold with runny nose and sore throat. ➡️ developed “usneasan” against catarrhs.

**Catarrh** is a thick exudate of mucus and white blood cells caused by the swelling of the mucous membranes in the head in response to an infection. A symptom associated with the common cold and chesty coughs, but can also be found with infections of the adenoids, middle ear, sinus or tonsils.

Griggs B Green Pharmacy: the history and evolution of Western herbal medicine. Healing Arts Press Rochester, 1996
Usnic acids

Usnea is common to temperate forests of the Pacific Northwest effective against bacteria (gram negative + positive), fungal and even parasites.

Usnic acid is a **natural antibiotic** against *Mycobacterium tuberculosis*, *Staphylococcus*, *Streptococcus*, *Pneumococcus*, & some pathogenic fungi. It also exhibits antiviral, antiprotozoal, antimitotic, anti-inflammatory and analgesic activity. Test tube studies suggest anti-cancer anti-viral activity. Mucilage in Usnea in areas of respiration.

Scientists believe that usnic acid works by disrupting cellular metabolism, either by preventing the formation of ATP or by the stopping the action of oxidative phosphorylization.

**ultraviolet absorption** make it good for sunscreen.
Usnic acid is a dibenzofuran occurring in several lichens. It was first isolated by German scientist W. Knop in 1844 and first synthesized between 1933-1937. *Usnea, Cladonia, Lecanora, Ramalina, Evernia, Parmelia* and *Alectoria* as well as in kombucha tea and non-lichenized ascomycetes.

(1) a potent antibiotic against gram positive bacteria, *Mycobacterium tuberculosis, Staphylococcus, Streptococcus*, and *Pneumococcus*;
(2) active against pathogenic fungi;
(3) antiviral, antiprotozoal, antimitotic, anti-inflammatory;
(4) ultraviolet absorption ➔ sunscreen
(5) antiherbivore & anti-insect properties as bitter or toxin

Usnic acid is an ingredient in creams, powders, toothpastes, mouthwash, deodorants, hair shampoos and sunscreen s. Usnea was one ingredient in *Lipokinetix*, promoted for weight loss via an increased metabolic rate (FDA warning for hepatotoxicity)

Lichens & Smell: the fragrant Oakmoss

*Evernia prunastri & Pseudoevernia furfuracea*: The lichens which produce this resinoid are found on oak and other trees. Chemical Constituent is **lichenol** - an ester of evernic acid.

**Perfumery Uses**: Blends well with Neroli, Lavender, Ylang, Jasmin, Tuberose. Often used as **perfume fixatives and base notes** key components of Fougère and Chypre class perfumes. **The lichen has a distinct odor**: woody, sharp and slightly sweet. When growing on pines ➔ turpentine odor.

*Psuedoevernia furfuracea*, or **tree moss**, is a lichen that grows on bark of firs and pines. Lichen is sensitive to air pollution indicating good air quality in growing place. The species has numerous uses, including use in perfume, embalming and in medicine. **Large amounts annually processed in France for perfume**
Lichens reproduce asexually by employing **simple fragmentation and production of soredia and isidia**. Soredia are powdery propagules composed of fungal hyphae wrapped around cyanobacteria or green algae. They are released through openings in the upper cortex & disperse to establish the lichen in a new location.

An **isidium** is a vegetative reproductive structure present in some lichens. Isidia are outgrowths of the thallus surface, and are corticated (i.e., containing the outermost layer of the thallus), usually with a columnar structure, and consisting of both fungal hyphae (the mycobiont) and algal cells (photobiont). The fragile structures break off and are distributed by wind, and splashing Rain drops.
Usnea is genus of several species of lichens, that generally grow hanging from tree branches, resembling hair. It is sometimes referred to commonly as Old Man's Beard. Usnea looks very similar to Bromeliad Spanish moss, so much so that the latter’s name is Tillandsia usneoides, the Usnea-like Tillandsia.

Letharia vulpina, the fructicose wolf lichen, in the family Parmeliaceae. It is bright yellow-green, and highly branched, and grows on the bark of living and dead conifers in Europe & Pacific Northwest. The yellow pigment vulpinic acid is somewhat toxic to mammals supposedly as poison for wolves (name!). Native Americans used pigment as source for dye.
**Lichens Species & Diversity**

*Cladonia rangiferina*, the **Reindeer lichen** is a light-colored, fruticose lichen in the family Cladoniaceae. It grows in both hot and cold climates being extremely cold-hardy. **Reindeer “moss”** is an exclusive food source for reindeer (caribou) in the snow-covered tundra. Since it is slow growing (3-5 mm per year) and may take decades to return from overgrazing.

**Rock tripe** or *Umbilicaria* grows on rocks in N Am. It is edible when properly prepared.

The closely related *Umbilicaria esculenta* is commonly used as a food in Asian cuisine and a restorative medicine in traditional Chinese medicine.

**Polysaccharides from the lichen have been shown to inhibit replication of the HIV virus** in laboratory tests.
**Lichens Species & Diversity**

*Peltigera* is a genus of lichens in the family Peltigeraceae. Dog lichen, lichens of *Peltigera* are growing on soil, on moss, trees, rocks. With cyanobacteria as symbions they obtain ability to fix nitrogen from the atmosphere. Dog lichen are closely related to the Peltigera species known as frog pelt.

*Lobaria pulmonaria* lungwort lichen is a large epiphytic lichen consisting of an *ascomycete fungus* and a *green algal partner* living together in a symbiotic relationship with a *cyanobacterium*. Sensitive to air pollution *L. pulmonaria* is considered endangered in many lowland areas.
**Lichens Species & Diversity**

*Cladonia cristatella*, commonly known as the **British soldier lichen**, is a fruticose lichen belonging to the family Cladoniaceae just like Reindeer lichens.

*Cladonia stellaris* is an ecologically important species of lichen that forms continuous mats over large areas of the ground in boreal and arctic regions around the circumpolar north. The species is a preferred food source of reindeer and caribou during the winter months. It has antimicrobials (e.g., Usnic acid), but it also has the unique distinction of being harvested and sold as 'fake trees' for model train displays.