COMMERCE & SCIENCING





# DEPARTMENT OF BOTANY

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**PROJECT WORK - LICHENS** 

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### Lichen

A lichen (/'laɪkən/ LY-kən, also UK: /'lɪtʃən/ LITCH-ən) is a that composite organism from algae or cyanobacteria living among filaments of species[1] fungi multiple a mutualistic relationship.[2][3][4] Lichens have properties different from those of their component organisms. They come in many colors, sizes, and forms and are sometimes plant-like, but are not plants. They may have tiny, leafless branches (fruticose); flat leaf-like structures (foliose); crust-like, adhering tightly to a surface (substrate) like a thick coat of paint (crustose); [5] a powder-like appearance (leprose); or other growth forms.[6]

A macrolichen is a lichen that is either bush-like or leafy; all other lichens are termed microlichens. [2] Here, "macro" and "micro" do not refer to size, but to the growth form. [2] Common names for lichens may contain the word moss (e.g., "reindeer moss", "Iceland moss"), and lichens may superficially look like and grow with mosses, but they are not closely related to mosses or any plant. [4]:3 Lichens do not have roots that absorb water and nutrients as plants do, [7]:2 but like plants, they produce their own nutrition by photosynthesis. [8] When they grow on plants, they do not live as parasites, but instead use the plant's surface as a substrate.



A tree covered with leafy foliose lichens and shrubby fruticose lichens

Lichens occur from sea level to high alpine elevations, in many environmental conditions, and can grow on almost any surface. They are abundant growing on bark, leaves, mosses, or other lichens and hanging from branches "living on thin air" (epiphytes) in rain forests and in temperate woodland. They grow on rock, walls, gravestones, roofs, exposed soil surfaces, rubber, bones, and in the soil as part of biological soil crusts. Different kinds of lichens have adapted to survive in some of the most extreme environments on Earth: arctic tundra, hot dry deserts, rocky coasts, and toxic slag heaps. They can even live inside solid rock, growing between the grains.

It is estimated that 6-8% of Earth's land surface is covered by lichens. [9] There are about 20,000 known species.[10] Some lichens have lost the ability to reproduce sexually, yet continue to speciate. [7][11] They can be seen as being relatively self-contained miniature ecosystems, where the fungi, algae, or cyanobacteria have the potential to engage with other microorganisms in a complex system may evolve as an even more that functioning organism. [12][13][14][15] Lichens may be long-lived, with some considered to be among the oldest living things. [4][16] They are among the first living things to grow on fresh rock exposed after an event such as a landslide. The long life-span and slow and regular growth rate of some species can be used to date events (lichenometry).

### **Pronunciation and etymology**

In American English, "lichen" is pronounced the same as the verb "liken" (/ˈlaɪkən/). In British English, both this pronunciation and one rhyming with "kitchen" /ˈlɪtʃən/) are used.[17][18][19]

English lichen derives from Greek λειχήν leichēn ("tree moss, lichen, lichen-like eruption on skin") via Latin lichen. [20][21][22] The Greek noun, which literally means "licker", derives from the verb λείχειν leichein, "to lick". [23][24]

Like the word *moss*, the word *lichen* is also used as an uncountable noun, as in "Lichen grows on rocks".

#### **Growth forms**

Lichens grow in a wide range of shapes and forms (morphologies). The shape of a lichen is usually determined by the organization of the fungal filaments. [25] The nonreproductive tissues, or vegetative body parts, are called the *thallus*. Lichens are grouped by thallus type, since the thallus is usually the most visually prominent part of the lichen. Thallus growth forms typically correspond to a few basic internal structure types. Common names for lichens often come from a growth form or color that is typical of a lichen genus.

Common groupings of lichen thallus growth forms are:

- 1. fruticose<sup>[26][27][28]</sup> growing like a tuft or multiple-branched leafless mini-shrub, upright or hanging down, 3-dimensional branches with nearly round cross section (terete) or flattened
- 2. foliose<sup>[26][27]</sup> growing in 2-dimensional, flat, leaf-like lobes
- crustose<sup>[5][26][27]</sup> crust-like, adhering tightly to a surface (substrate) like a thick coat of paint
- squamulose<sup>[28]</sup> formed of small leaf-like scales crustose below but free at the tips
- 5. leprose<sup>[29]</sup> powdery
- 6. gelatinous jelly-like
- 7. filamentous stringy or like matted hair
- 8. byssoid wispy, like teased wool
- 9. structureless

There are variations in growth types in a single lichen species, grey areas between the growth type descriptions, and overlapping between growth types, so some authors might describe lichens using different growth type descriptions.

When a crustose lichen gets old, the center may start to crack up like old-dried paint, old-broken asphalt paving, or like the polygonal "islands" of cracked-up mud in a dried lakebed. This is called being rimose or areolate, and the "island" pieces separated by the cracks are called areolas. [26] The areolas appear separated, but are (or were) connected by an underlying prothallus or "hypothallus".[29] When a crustose lichen grows from a center and appears to radiate out, it is called crustose placodioid. When the edges of the areolas lift up from the substrate, it is called squamulose. [30]:159[28]



Letharia vulpina, wolf lichen, grows like a multiple-branched tuft or leafless mini-shrub, so it has a fruticose growth form.



Flavoparmelia caperata has leaf-like structures, so it is foliose.



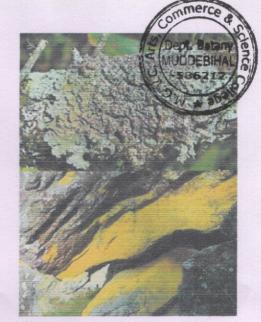
<u>Caloplaca marina</u> grows like an orange crust coating the rock, so it is crustose.



Caloplaca thallincola grows like a crust, and in a pattern that radiates outward from the center, so it has a crustose placodioid growth form.

These growth form groups are not precisely defined. Foliose lichens may sometimes branch and appear to be fruticose. Fruticose lichens may have flattened branching parts and appear leafy. Squamulose lichens may appear where the edges lift up. Gelatinous lichens may appear leafy when dry. [30]:159 Means of telling them apart in these cases are in the sections below.

Structures involved in reproduction often appear as discs, bumps, or squiggly lines on the surface of the thallus. [7]:4 The thallus is not always the part of the lichen that is most visually noticeable. Some lichens can grow *inside* solid rock between the grains (endolithic lichens), with only the sexual fruiting part visible growing outside the rock. [26] These may be dramatic in color or appearance. [26] Forms of these sexual parts are not in the above growth form categories. [26] The most visually noticeable reproductive parts are often circular, raised, plate-like or disc-like outgrowths, with crinkly edges, and are described in sections below.



Chrysothrix chlorina grows like powder dusted on the rock so it is leprose.



Collema nigrescens is gelatinous, without internal structure for its parts.

#### Color

Lichens come in many colors.<sup>[7]:4</sup> Coloration is usually determined by the photosynthetic component.<sup>[25]</sup> Special pigments, such as yellow usnic acid, give lichens a variety of colors, including reds, oranges, yellows, and browns, especially in exposed, dry habitats.<sup>[31]</sup> In the absence of special pigments, lichens are usually bright green to olive gray when wet, gray or grayish-green to brown when dry.<sup>[31]</sup> This is because moisture causes the surface skin (cortex) to become more transparent, exposing the green photobiont layer.<sup>[31]</sup> Different colored lichens covering large areas of exposed rock surfaces, or lichens covering

or hanging from bark can be a spectacular display when the patches of diverse colors "come to life" or "glow" in brilliant displays following rain.

Different colored lichens may inhabit different adjacent sections of a rock face, depending on the angle of exposure to light.<sup>[31]</sup> Colonies of lichens may be spectacular in appearance, dominating much of the surface of the visual landscape in forests and natural places, such as the vertical "paint" covering the vast rock faces of Yosemite National Park.<sup>[32]</sup>

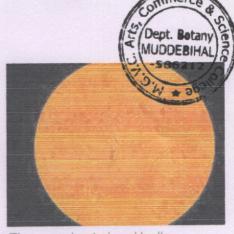
Color is used in identification. [33]:4 The color of a lichen changes depending on whether the lichen is wet or dry. [33] Color descriptions used for identification are based on the color that shows when the lichen is dry. [33] Dry lichens with a cyanobacterium as the photosynthetic partner tend to be dark grey, brown, or black. [33]

The underside of the leaf-like lobes of foliose lichens is a different color from the top side (dorsiventral), often brown or black, sometimes white. A fruticose lichen may have flattened "branches", appearing similar to a foliose lichen, but the underside of a leaf-like structure on a fruticose lichen is the *same* color as the top side. The leaf-like lobes of a foliose lichen may branch, giving the appearance of a fruticose lichen, but the underside will be a *different* color from the top side. [29]

The sheen on some jelly-like gelatinous lichens is created by mucilaginous secretions. [25]

#### Internal structure and growth forms

A lichen consists of a simple photosynthesizing organism, usually a green alga or cyanobacterium, surrounded by filaments of a fungus. Generally, most of a lichen's bulk is made of interwoven fungal filaments, [34] but this is reversed in filamentous and gelatinous lichens. [25] The fungus is called a *mycobiont*. The photosynthesizing organism is called a *photobiont*. Algal photobionts are called *phycobionts*. [35] Cyanobacteria photobionts are called *cyanobionts*. [35]



The cyanobacterium Hyella caespitosa with fungal hyphae in the lichen Pyrenocollema halodytes

The part of a lichen that is not involved in reproduction, the "body" or "vegetative tissue" of a lichen, is called the *thallus*. The thallus form is very different from any form where the fungus or

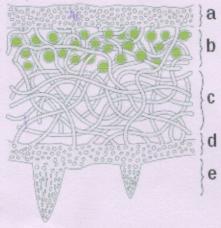
alga are growing separately. The thallus is made up of filaments of the fungus called *hyphae*. The filaments grow by branching then rejoining to create a mesh, which is called being "anastomosed". The mesh of fungal filaments may be dense or loose.

Generally, the fungal mesh surrounds the algal or cyanobacterial cells, often enclosing them within complex fungal tissues that are unique to lichen associations. The thallus may or may not have a protective "skin" of densely packed fungal filaments, often containing a second fungal species, which is called a *cortex*. Fruticose lichens have one cortex layer wrapping around the "branches". Foliose lichens have an upper cortex on the top side of the "leaf", and a separate lower cortex on the bottom side. Crustose and squamulose lichens have only an upper cortex, with the "inside" of the lichen in direct contact with the surface they grow on (the *substrate*). Even if the edges peel up from the substrate and appear flat and leaf-like, they lack a lower cortex, unlike foliose lichens. Filamentous, byssoid, leprose, gelatinous, and other lichens do not have a cortex, which is called being ecorticate. [36]

Fruticose, foliose, crustose, and squamulose lichens generally have up to three different types of tissue, differentiated by having different densities of fungal filaments. [34] The top layer, where the lichen contacts the environment, is called a *cortex*. [34] The cortex is made of densely tightly woven, packed, and glued together (agglutinated) fungal filaments. [34] The dense packing makes the cortex act like a protective "skin", keeping other organisms out, and reducing the intensity of sunlight on the layers below. [34] The cortex layer can be up to several hundred micrometers (µm) in thickness (less than a millimeter). [37] The cortex may be further topped by an epicortex of secretions, not cells, 0.6–1 µm thick in some lichens. [37] This secretion layer may or may not have pores. [37]

Below the cortex layer is a layer called the *photobiontic layer* or *symbiont layer*.<sup>[27][34]</sup> The symbiont layer has less densely packed fungal filaments, with the photosynthetic partner embedded in them.<sup>[34]</sup> The less dense packing allows air circulation during photosynthesis, similar to the anatomy of a leaf.<sup>[34]</sup> Each cell or group of cells of the photobiont is usually individually wrapped by hyphae, and in some cases penetrated by a haustorium.<sup>[25]</sup> In crustose and foliose lichens, algae in the photobiontic layer are diffuse among the fungal filaments, decreasing in gradation into the layer below. In fruticose lichens, the photobiontic layer is sharply distinct from the layer below.<sup>[25]</sup>

The layer beneath the symbiont layer called is called the *medulla*. The medulla is less densely packed with fungal filaments than the layers above. In foliose lichens, there is usually, as in *Peltigera*, [30]:159 another densely packed layer of fungal filaments called the lower cortex. [29][34] Root-like fungal structures called *rhizines* (usually)[30]:159 grow from the lower cortex to attach or anchor the lichen to the substrate. [2][29] Fruticose lichens have a single cortex wrapping all the way around the "stems" and "branches". [30] The medulla is the lowest layer, and may form a



Schematic cross section of foliose lichen:

- (a) The <u>cortex</u> is the outer layer of tightly woven fungus filaments (hyphae)
- (b) This photobiont layer has photosynthesizing green algae
- (c) Loosely packed hyphae in the medulla
- (d) A tightly woven lower cortex
- (e) Anchoring hyphae called <u>rhizines</u> where the fungus attaches to the substrate

cottony white inner core for the branchlike thallus, or it may be hollow. [30]:159 Crustose and squamulose lichens lack a lower cortex, and the medulla is in direct contact with the substrate that the lichen grows on.

In crustose areolate lichens, the edges of the areolas peel up from the substrate and appear leafy. In squamulose lichens the part of the lichen thallus that is not attached to the substrate may also appear leafy. But these leafy parts lack a lower cortex, which distinguishes crustose and squamulose lichens from foliose lichens. [34] Conversely, foliose lichens may appear flattened against the substrate like a crustose lichen, but most of the leaf-like lobes can be lifted up from the substrate because it is separated from it by a tightly packed lower cortex. [29]

Gelatinous, [30]:159 byssoid, and leprose lichens lack a cortex (are ecorticate), and generally have only undifferentiated tissue, similar to only having a symbiont layer.

In lichens that include both green algal *and* cyanobacterial symbionts, the cyanobacteria may be held on the upper or lower surface in small pustules called *cephalodia*.

Pruinia is a whitish coating on top of an upper surface. [38] An *epinecral layer* is "a layer of horny dead fungal hyphae with indistinct lumina in or near the cortex above the algal layer". [38]

In August 2016, it was reported that some macrolichens have more than one species of fungus in their tissues.<sup>[1]</sup>

## Physiology

### Symbiotic relation

Lichens are fungi that have discovered agriculture

- Trevor Goward [39]

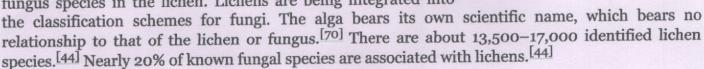
A lichen is a composite organism that emerges from algae or cyanobacteria living among the filaments (hyphae) of the fungi in a mutually beneficial symbiotic relationship. The fungi benefit from the carbohydrates produced by the algae or cyanobacteria via photosynthesis. The algae or cyanobacteria benefit by being protected from the environment by the filaments of the fungi, which also gather moisture and nutrients from the environment, and (usually) provide an anchor to it. Although some photosynthetic partners in a lichen can survive outside the lichen, the lichen symbiotic association extends the ecological range of both partners, whereby most descriptions of lichen associations describe them as symbiotic. Both partners gain water and mineral nutrients mainly from the atmosphere, through rain and dust. The fungal partner protects the alga by retaining water, serving as a larger capture area for mineral nutrients and, in some cases, provides minerals obtained from the substrate. If a cyanobacterium is present, as a primary partner or another symbiont in addition to a green alga as in certain tripartite lichens, they can fix atmospheric nitrogen, complementing the activities of the green alga.

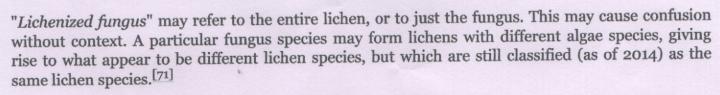
species reproduce sexually by self-fertilization (i.e. they are homothallic). This breeding system may enable successful reproduction in harsh environments.<sup>[69]</sup>

Mazaedia (singular: mazaedium) are apothecia shaped like a dressmaker's pin in pin lichens, where the fruiting body is a brown or black mass of loose ascospores enclosed by a cupshaped exciple, which sits on top of a tiny stalk. [7]:15

# **Taxonomy and classification**

Lichens are classified by the fungal component. Lichen species are given the same scientific name (binomial name) as the fungus species in the lichen. Lichens are being integrated into





Formerly, some lichen taxonomists placed lichens in their own division, the *Mycophycophyta*, but this practice is no longer accepted because the components belong to separate lineages. Neither the ascolichens nor the basidiolichens form monophyletic lineages in their respective fungal phyla, but they do form several major solely or primarily lichen-forming groups within each phylum. [72] Even more unusual than basidiolichens is the fungus *Geosiphon pyriforme*, a member of the Glomeromycota that is unique in that it encloses a cyanobacterial symbiont inside its cells. *Geosiphon* is not usually considered to be a lichen, and its peculiar symbiosis was not recognized for many years. The genus is more closely allied to endomycorrhizal genera. Fungi from Verrucariales also form marine lichens with the brown algae *Petroderma maculiforme*, [73] and have a symbiotic relationship with seaweed (such as rockweed) and *Blidingia minima*, where the algae are the dominant components. The fungi is thought to help the rockweeds to resist desiccation when exposed to air. [74][75] In addition, lichens can also use yellow-green algae (*Heterococcus*) as their symbiotic partner. [76]

Lichens independently emerged from fungi associating with algae and cyanobacteria multiple times throughout history. [77]

### Fungi

The fungal component of a lichen is called the *mycobiont*. The mycobiont may be an Ascomycete or Basidiomycete. [10] The associated lichens are called either ascolichens or basidiolichens, respectively. Living as a symbiont in a lichen appears to be a successful way for a fungus to derive essential nutrients, since about 20% of all fungal species have acquired this mode of life. [78]

Thalli produced by a given fungal symbiont with its differing partners may be similar, and the secondary metabolites identical, indicating that the fungus has the dominant role in determining the morphology of the lichen. But the same mycobiont with different photobionts may also produce very different growth forms. [71] Lichens are known in which there is one fungus associated with two or even three algal species.



Crust-like thallus with pseudopodetia