

# Little things mean a lot!

The important ecological roles of lichens & bryophytes

Graeme Ambrose





# LICHENS

**Lichens** arise when a fungal spore germinates near an algal cell. It connects up with the alga. Both multiply to form a single organism that is really a mutually-beneficial partnership.

Lichens consist of:

- a **photosynthetic partner** (a green alga or a cyanobacterium (“blue-green alga”), which produces food and
- a **fungus**, which provides the overall structure and absorbs water and minerals. Lichen fruiting bodies are exclusively fungal.



(The fungal fruiting bodies are the convex brown lumps [arrow] on the rim of some cups.)



## Lichen growth forms



FOLIOSE



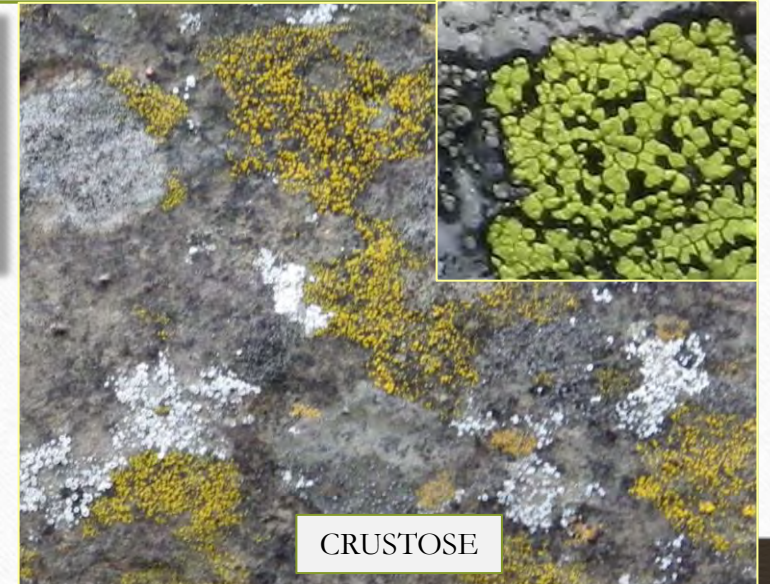
FRUTICOSE

**FOLIOSE:** leafy, more or less flat on the substrate. Some are **squamulose**: divided into leafy scales (squamules) -inset.

**FRUTICOSE:** erect or hanging (**pendulous**) -inset.

**CRUSTOSE:** crust- or stain-like. These may be divided into chunks (**areolate**) -inset. Embedded in the substrate.

**LEPROSE:** powdery, composed of tiny granules.



CRUSTOSE



LEPROSE



## What's inside a lichen?

Fungal threads (**hyphae**) are shown in **brown** and **algal (or cyanobacterial) cells** are shown in **green**.

Most of the lichen consists of fungal hyphae, while algae are confined to one layer. Hyphae connect up to each algal cell and the symbionts exchange nutrients and water.

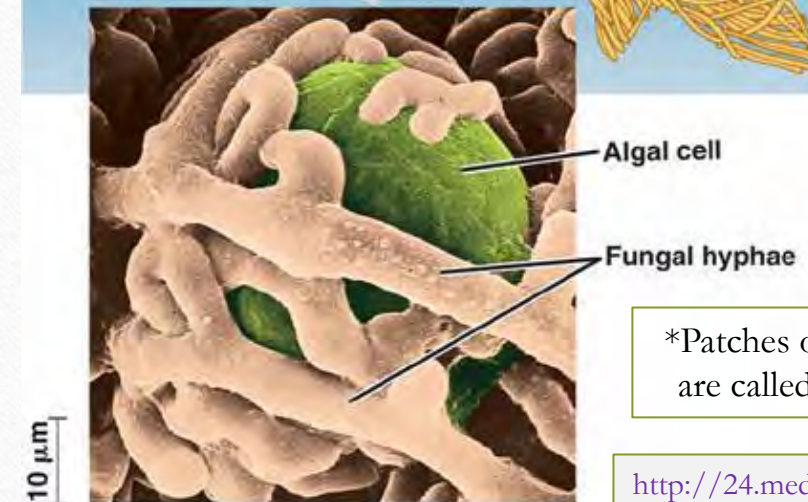
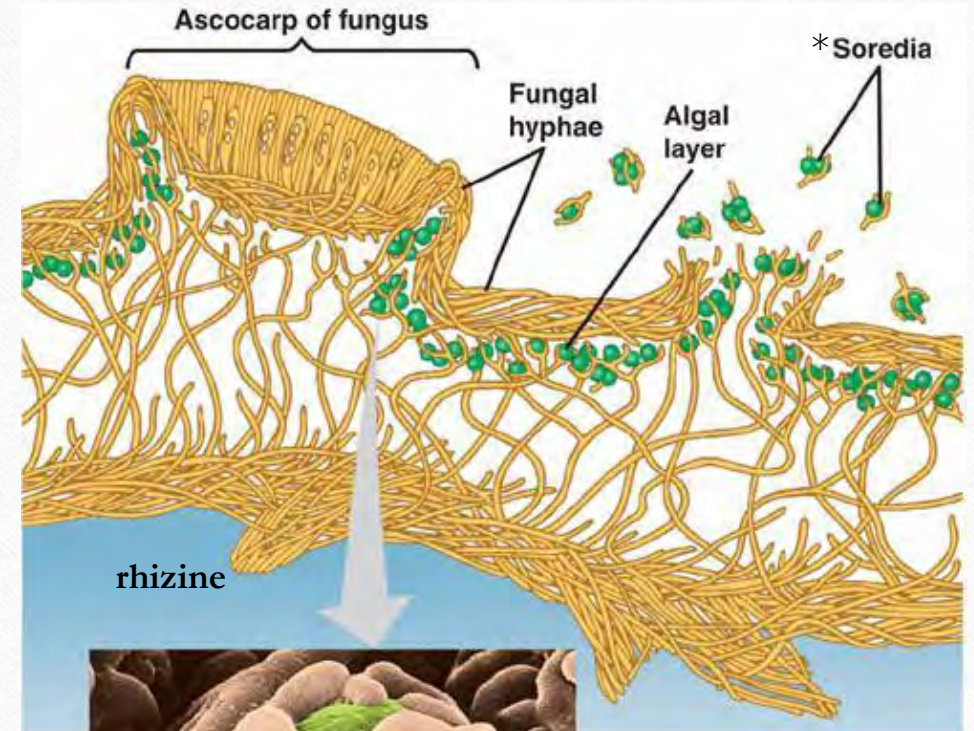
Hyphae are packed densely into an **upper cortex** and **lower cortex**, producing the outside layers. They are loosely packed into the central layer (**medulla**).

**Reproductive structures:** the **ascocarp** (fruiting body), which produces fungal spores sexually, and **soredia**, which are (asexual) bundles of algal and fungal cells that erupt onto the surface. They wash or blow away.

Upper cortex  
Algal layer

Medulla

Lower cortex



\*Patches of soredia are called **soralia**.

<http://24.media.tumblr.com>



## Sexual reproduction: apothecia and perithecia

Sexual reproduction in lichens only involves the production of fungal spores.

The spores are produced in flask-shaped structures called **asci**, surrounded by sterile fungal threads (**paraphyses**). As pressure mounts inside the **ascus**, the (8) spores are ejected through the tip of the ascus.

Reproductive organs that are disk- to dome-shaped (i.e. flat, concave or convex) are called **apothecia**.

Some lichens –especially crustose types- enclose their asci in **perithecia** (chambers). These have an exit pore.

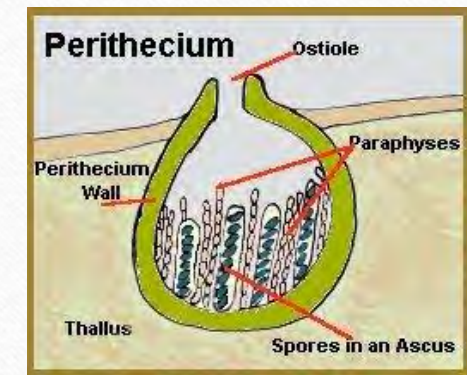
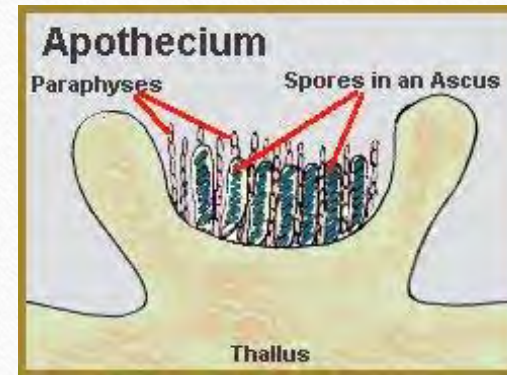


L: Asci (spore sacs), each containing 8 spores.

[www.anbg.gov.au](http://www.anbg.gov.au)

Below: XS of apothecium and perithecium.

[www.earthlife.net](http://www.earthlife.net)



R: Apothecia on Goldeneye Lichen *Teloschistes* and Rosette Lichen *Physcia*.

<http://2.bp.blogspot.com> Far R: Perithecia on a bark-living crustose lichen. [www.lichens.ei](http://www.lichens.ei)



## Asexual reproduction: soredia and soralia

**Soredia** are those tiny bundles of algae and fungi seen in the previous slide. They erupt from the lichen surface and are passively dispersed by wind and water. Sometimes they are concentrated in a specialised area, a **soralium**, which looks thickened and crumbly.

Soralia may be on the lichen surface or on the margins of its lobes. These two Ruffle Lichens have marginal soralia, easily visible, and some tiny scattered soredia.

Main photo: Ruffle Lichen *Parmotrema perlatum*. G. Ambrose.

Inset: Ruffle Lichen *Parmotrema chinense* <http://3.bp.blogspot.com>



Ruffle Lichen *Parmotrema perlatum*



## Asexual reproduction: isidia and fragmentation

**Isidia** are small projections on a lichen's surface. They contain both fungal and algal cells. They come in many shapes. Isidia break off and wash or blow away. This is a special case of **fragmentation**.

Lichens often become brittle when dry and can crumble when they are stepped on. The fragments can be carted away in fur or on muddy or wet feet (or on vehicle tyres).

L: Isidia on a Shield Lichen *Parmelia* sp. <http://farm3.static.flickr.com>  
R: Reindeer Lichen *Cladonia rangifer* in Alaska, growing among Alpine Bearberry (red leaves) and Crowberry, two other foods of Caribou (Reindeer) and other arctic mammals. <http://alaskaphotographics.photoshelter.com>





# BRYOPHYTES

**Bryophytes** (literally “moss plants”) are small, spore-producing plants that lack true vascular tissue. They include three distantly related divisions of plants:

- **Mosses**
- **Liverworts**
- **Hornworts**



*Bryum capillare* Capillary Thread-moss <http://3.bp.blogspot.com>



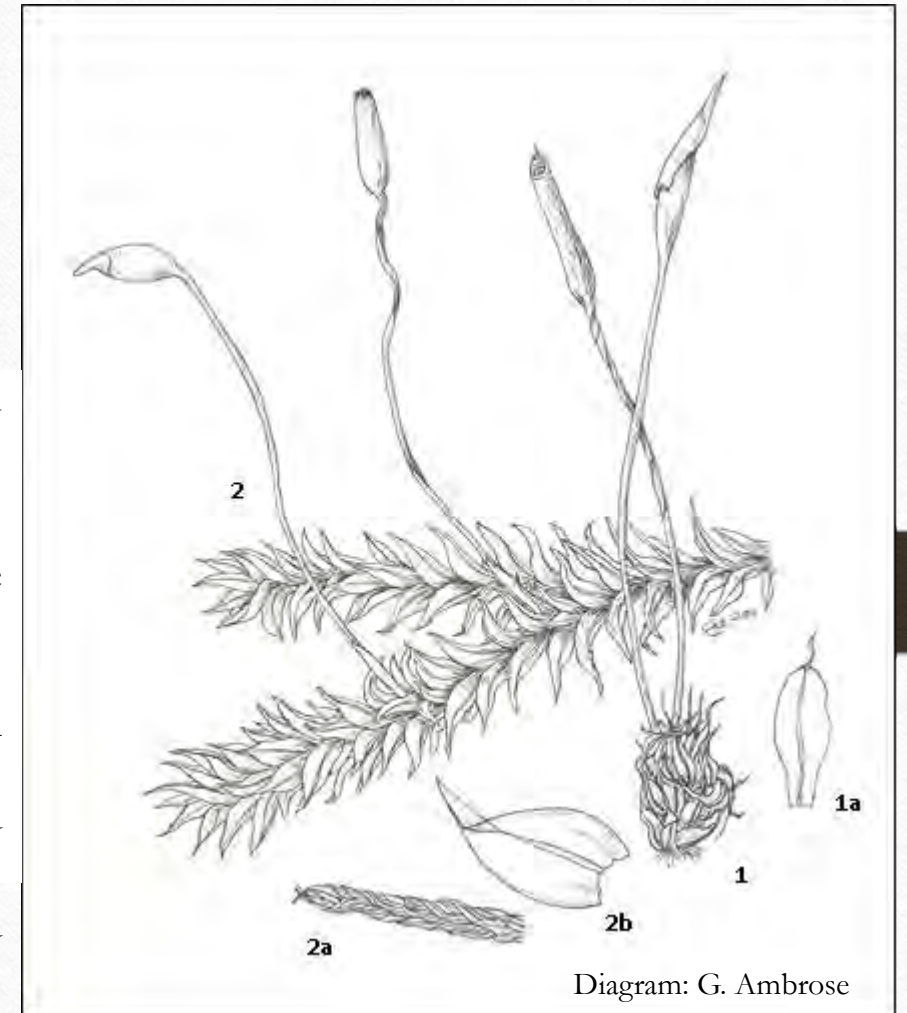
## Mosses (Division Bryophyta)

**Upright or ACROCARPOUS MOSSES**, grow as **erect**, seldom-branched stems. They bear stalked **capsules** on the **tips of erect leafy stems**.

- More common in open, well-lit situations or on bare surfaces.
- Some form extensive stands (**turfs**) or compact **cushions**, which are excellent at holding water. Leaves of dry plants often curl up.
- Short-lived acrocarps cope with unsuitable conditions (e.g. drought) by becoming dormant or by producing resistant spores or buds, then dying. Many acrocarps revive quickly and on becoming moist.

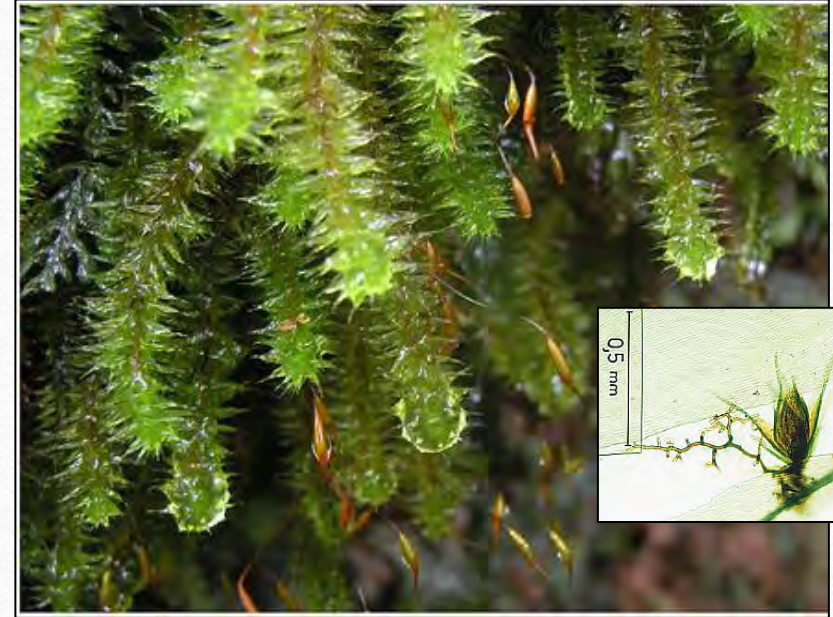
**Spreading or PLEUROCARPOUS MOSSES** sprawl horizontally. They branch readily and bear (usually few) stalked **capsules** on **short side branches**.

- Most are long-lived or grow indefinitely to form **mats** or loosely woven **wefts**. These are sometimes tall and lax, shedding leaf litter.
- **Pleurocarps** prefer humid sheltered sites and, because they sprawl, are efficient collectors of dim light and sun-flecks. However, those with a large surface area desiccate readily. Many are long-lived.



1: Wall Screw-moss *Tortula papillata*, dry stem with capsules, the one at right with a cap (calyptra), **1a**: moist leaf with hair-point.  
2: Common Twine-moss *Triquetrella papillosa*, moist stem with capsules (older one on R. lacks a cap). **2a**: dry stem, **2b**: moist leaf.





Above L and centre: Yellow-green Broom-moss *Dicranoloma billardieri* [picasaweb.google.com](https://picasaweb.google.com) R: Pipe Cleaners *Ptychomnion aciculare* (female & dwarf male) [web.Auckland.ac.nz](http://web.Auckland.ac.nz)  
Below L: Capillary Thread-moss on a gravel path. *Rosulabryum capillare* [www.andrewspink.nl](http://www.andrewspink.nl) R: A cushion of Wall Screw-moss *Tortula muralis* <https://www.kuleuven-kulak.be>



### **Pleurocarps**

(spreading mosses)  
above.

**Acrocarps** (upright  
mosses) below.





# Liverworts

## (Division Hepatophyta)

**Fleshy Liverworts** (class Marchantiopsida) have thick spongy **thalli\*** containing air chambers that can store moisture.

1: Female plant (**thallus\***) of Broad-lobe Marchantia *Marchantia berteroana*, with reproductive organs (archegoniophores) and a round **gemma cup**. This contains asexual buds that are splashed out by raindrops; **1a**: Male reproductive organ from a male plant. Both sex organs grow from beneath the thallus, through a notch. Sperm or eggs develop under these. Many species lack “umbrellas” and instead have inconspicuous sex organs.

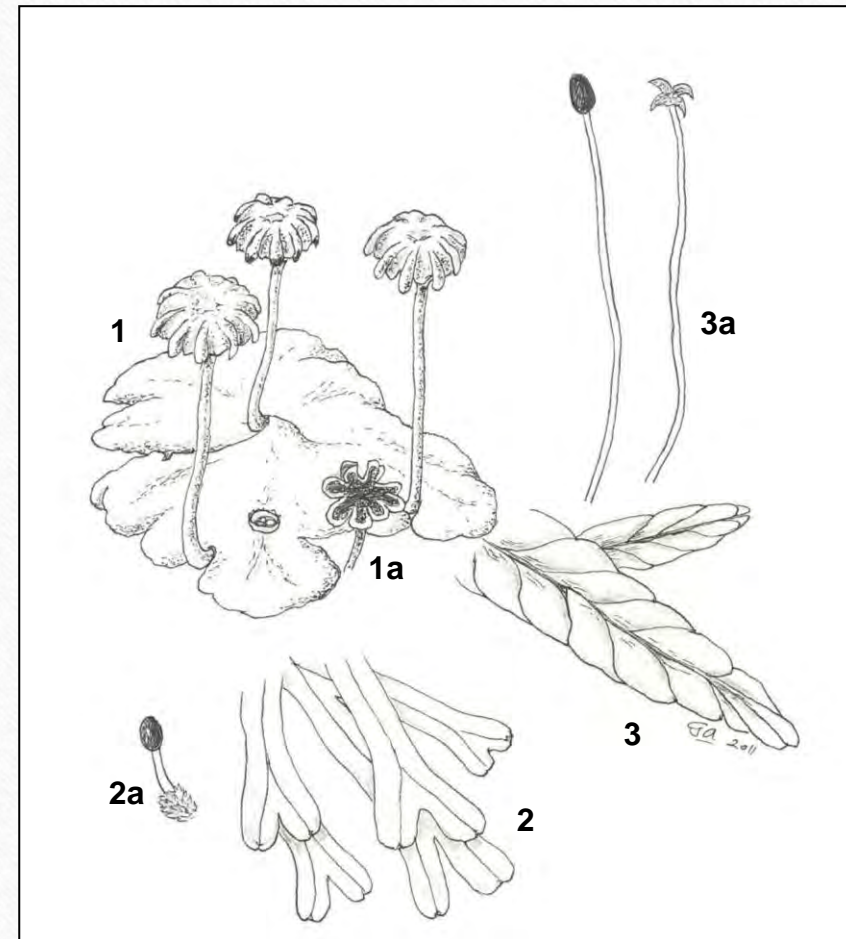
**Filmy Liverworts** have a filmy **thallus\***, one cell thick, with a central midrib. It forks repeatedly. Found in moist sheltered sites.

2: Deceptive Veilwort *Metzgeria decipiens*, with forking **thallus** lobes and veins. **2a**: Capsule with a fleshy stalk and basal, modified leaves. This grows from the midrib beneath a lobe.

**Leafy Liverworts** (Class Jungermanniopsida) have stems with 2-3 rows of leaves. The leaves, often 2 or 4-lobed, lack veins.

3: Scented Crestwort *Chiloscyphus semiteres* has two rows of large lateral leaves along each stem; a third row of smaller underleaves lies beneath the stem, **3a**: Dark capsules on long fleshy setae (stems) grow in winter. The capsule on the right has opened to release spores.

Diagram: G. Ambrose



\*A **thallus** (plural: **thalli**) is a plant body (or an alga or seaweed) that is not divided into stems and leaves.





L: Crescent-cup Liverwort *Lunularia cruciata*, fleshy liverwort. Dark patches: sex organs. [www.nism.uzh.ch](http://www.nism.uzh.ch) R: Deceptive Veilwort *Metzgeria decipiens*, a filmy liverwort. [www.education.eol.org](http://www.education.eol.org)  
Below L: Grassy Crestwort *Chiloscyphus bidentata* [www.aphotoflora.com](http://www.aphotoflora.com) R: Rufous Scalewort *Frullania falciloba*, a marsupial liverwort. Its cup-like lower lobes hold water. [www.utas.edu.au](http://www.utas.edu.au)





## Hornworts

**Hornworts** are fleshy, with many cell layers. The thallus contains cavities with mucilage that are invaded by cyanobacteria (“blue-green algae”) such as *Nostoc*.

The asexual reproductive organ is shaped like a horn. It grows in spring, then splits and peels back at the tip, shedding spores over a long period.

Hornworts are recognised by their dark green, slimy thallus and horn-like capsule. The bulges are sex organs. A lobe of the thallus wraps around its base.

They prefer bare, often clayey soil in damp situations.



Hornwort *Phaeoceros* (*Anthoceros*) *laevis* [www.cisfbr.org.uk](http://www.cisfbr.org.uk)



# Cryptogams

- **Cryptogams** are organisms that produce spores, as opposed to the seeds produced by higher plants. Most, except ferns, lack true vascular tissue.
- They include bryophytes (mosses, liverworts and hornworts), lichens, bacteria (including cyanobacteria), algae and moulds.
- **Crypto+gam** means “hidden reproduction”, since the spore producing organs are usually small or hidden. By contrast, the cones of conifers and flowers of flowering plants are large and conspicuous.
- This is a term of convenience, as these organisms often occur together.



# Cryptogam ecology

- Many cryptogams are **intolerant of competition**, though not all. They often grow in mixed stands.
- **Cryptogam communities vary over short distances** (cm/mm), responding to gradients in soil moisture and nutrients, humidity, exposure to sunlight and wind, as well as competition.
- **Bryophytes generally need more nutrients and moisture than lichens**, as many metabolise and grow faster than lichens.
- **Lichens often do better in drier and nutrient-poor situations**. They do well in extreme conditions because of their slow growth and ability to become dormant when necessary. That said, both groups show a range of adaptations.



Drier, more exposed sites on this north-facing rock wall tend to host crustose lichens (white, grey, orange and yellow). Sheltered sites or areas with more run-off feature mosses and liverworts. Since these areas dry out seasonally, most bryophytes here are dense cushions or carpets that can absorb and hold water and collect water-washed silt and dust. (GA)



**Cypress Plait-moss** *Hypnum cupressiforme* shows sun-screening orange and yellow pigments. It forms a dense, **smooth mat** on sunny northern and western rock faces.

**Common Feather-moss** *Eurhynchium praelongum* (an introduced species) forms a **smooth mat** on well-lit, steeper upper slopes.

**Capillary Thread-moss** *Rosulabryum capillare* forms **short turfs** (< 2 cm) in the slight depressions (vesicles) on well-drained slopes. Elsewhere it would soon be overgrown.

**Paper Moss (Pipe Cleaners)** *Ptychomnion aciculare*, a desiccation-intolerant species, forms **tall cushions** (> 5 cm). It grows on the southern (foreground) and eastern faces of the basalt rock.

### **Bryophytes respond to subtle environmental gradients over short distances.**

Over a 20 year period, ten species colonised this basalt rock (42 cm long) at the University of Ballarat. It remained after an 'Environmental Art' display in the early 1990s. The southern face gets water flow, no direct sun and is well sheltered. Photo: Singarayer Florentine (2012).



**Broody Swan-neck Moss** *Campylopus clavatus* tolerates direct sun and desiccation. It forms **tall turfs** (> 2 cm high) on well-drained areas.

Gentle upper slopes bear a lush, moisture-retaining **smooth mat** of intertwined mosses (*Eurhynchium praelongum*, *Dicranoloma billardieri* and *Hypnum cupressiforme*) and a leafy liverwort (*Chiloscyphus semiteres*).

**Bird damage?** This part of the moss mat has sloughed off and lies on the ground nearby. Birds often scratch at and overturn cryptogam mats, searching for invertebrates.

**Common Carpet-moss** *Racomitrium cuspidigerum* (an introduced species) forms **mats** or **open wefts** in moist, shady sites below the Paper Moss cushions. *E. praelongum* and a native filmy liverwort, *Metzgeria decipiens*, intertwine with it.



## VARIABLE & HARSH ENVIRONMENTS

Many **TOLERATORS** in these environments are **short-lived and small**.

Some are **longer-lived compact or embedded species** (e.g. Cushion-moss *Grimmia*, Screw-moss *Tortula*, Haircap-moss *Polytrichum* and crustose lichens). These effectively become dormant under extreme conditions.

Most **AVOIDERS** **grow and reproduce rapidly** after **disturbance** (e.g. fire or soil disturbance). They produce **numerous propagules** (spores, bulbs, tubers, fragments), then die. They **regrow** from these and re-establish when favourable conditions return. Most are intolerant of competition.

Soils that are burnt, trampled or dug have many of these short-lived avoiders.

Alternatively they **disperse widely** by various means and can **recolonise** areas from afar. The numerous spores of fire mosses are a notable example.

Some avoiders (e.g. Fire Moss *Funaria*, Thread Moss *Leptobryum*, Stubble Moss *Weissia*, Crescent-cup Liverwort *Lunularia*) are **weedy**. This is because they disperse widely and have a high reproductive output.

**Some avoiders seek sheltered or moister microhabitats** such as depressions, rock crevices or soil at the base of water-shedding boulders.

Grey Cushion-moss *Grimmia pulvinata* forms dense cushions that trap moisture, silt and dust. Side stems are shorter, producing the dome shape. The swan-necked capsules shelter in the cushion when young, then emerge. [upload.wikimedia.org](http://upload.wikimedia.org)



The long hyaline hair-point on each leaf tip is a condensation point for dewdrops. The hyaline cells absorb and store the moisture. [www.mnu.edu](http://www.mnu.edu)

Dry cushion-moss looks like a grey furry mouse because the white hair-points stand erect, shading the moss. Note the dark UV-screening pigment and erect ripe capsules. [wisplants.uwsp.edu](http://wisplants.uwsp.edu)





## HARVESTING WATER AND DUST

**HYALINE CELLS** are largely empty and colourless. They have a large central balloon-like pouch (vacuole) that **absorbs and stores water**. They are often on the outer leaf margin, teeth or hair-point. Dewdrops form on long hyaline hair-points and are 'consumed'. **Hair-points** also give **shade** and slow down air currents, **trapping dust** and **reducing evaporation**.



Above: Leaf of *Grimmia pulvinata*, with a very long hyaline hair-point on which dew condenses. The nerve below stores water as well. [www.wnmu.edu](http://www.wnmu.edu)

R: Leaf of *Polytrichum juniperinum*, with hyaline tip and teeth. Hyaline basal areas store water and erect the leaf when swollen with water. [plantdb.biology.duke.edu](http://plantdb.biology.duke.edu)



Silver Moss *Bryum argenteum* survives in small cracks in the footpath and on rocks! Hyaline cells (white) absorb moisture and act as UV shields. (Water absorbs UV rays.)

Above L: Silver Moss on a rock. [www.kuleuven-kortrijk.be/](http://www.kuleuven-kortrijk.be/)

Above R: A moist cushion (with leaves erect) and capsule. Some buds break off and are dispersed on wet shoes and feet. <http://bryophytes.plant.siu.edu>

R: Close-up, showing leaves with hyaline upper-parts and hair-point. <http://blogimg.goo.ne.jp>





## STABLE & LESS EXTREME ENVIRONMENTS

Some species are **FUGITIVES** that move between temporary surfaces. These are **shorter-lived species with a high reproductive effort** (e.g. *Breutelia*, Pocket-mosses *Fissidens*) **Temporary substrates** include eroding banks and soil that soon become covered in leaf litter. (See pictures at right.)

**TOLERATORS** are quite common. They are **perennial (long-lived)** and **gradually extend themselves** into their surroundings. They tend to spend **less energy and materials on reproducing** (e.g. mosses tend to produce fewer capsules) and **more on growth**.

Tolerators are often **luxuriant**, with a large total surface area to collect dim light and sun-flecks. This makes them more **vulnerable to desiccation**, so they do poorly in the open. (See next slide.)

These cryptogams depends on **long-lasting preferred substrates**. Banks and cliffs, tree trunks and decaying stumps and logs may be available over long periods. **Sloping surfaces are preferred**, as they **collect less leaf litter**.

**Cryptogams shuttle between these substrates** when their site eventually becomes unsuitable.



Top: Common *Breutelia affinis*. (GA.) Young *Breutelia* (in winter) has a frosted appearance. Below: Taylor's Pocket-moss *Fissidens taylori* <http://derella.ca/woods/> The horizontal fronds of Pocket-mosses effectively intercept light.



Tolerators (persistent species) from  
moist, stable habitats



Pipe-cleaners *Ptychomnion aciculare* produces tall cushions that shed leaf litter readily. Older leaves are brown: there is only sufficient light for the newer, outer leaves. Beneath this is Cypress Moss *Hypnum cupressiforme*, a carpeting species. <http://c2.ststicflickr.com>



Shrubby lichens of the forest floor, *Cladonia* sp. (pale grey) and *Cladia aggregata* (olive green/brown) are long-lived and elaborate. Tall, lank structures tend to shed fallen leaves and not readily become buried. The tangled structure traps moist air. (GA)



# Ecological significance of cryptogams

**Cryptogams are important contributors to biodiversity. They:**

- Contribute substantially to **above-ground biomass** (lichens, bryophytes, algae), especially as **epiphytes** (on plants) and in harsh environments such as deserts, arctic regions and alpine areas. They create **peatlands in alpine bogs and elsewhere**. **Epiphytic species** are a feature of **wet forests** and collectively have a huge biomass.
- **Accumulate toxic chemicals** (e.g. terpenoids and polyphenols in bryophytes) as a defence against herbivores and pathogens. This is why many of them seem to be seldom eaten. The toxins alter the feeding patterns of herbivores and competitive relations with other plants. Cryptogam extracts can inhibit seedling growth at times.
- Influence **soil and vegetation hydrology** (e.g. water flow, soil moisture penetration and perseverance) and temperatures. This partly determines what other plants, fungi and animals can live in the area.
- Provide a **staple food** to mammals such as reindeer (lichens), as well as **food and humid shelter** for arthropods and other small invertebrates. These have important feedbacks to soils and biota.
- Both **facilitate and compete with vascular plants**. Biocrusts influence which seeds can penetrate and reach the soil to germinate and hence partly determine vegetation composition. For instance, biocrusts tend to favour native seeds that are slender and have evolved to penetrate them. Weeds with broad seeds may never reach the soil.





Bryophytes can hold many times their own weight in water. Rain water and dust are stored rather than flowing away. This provides a microhabitat for small animals and microbes that has extended moist periods when they can be active.

What a difference a short time makes! The photo above was taken on a Saturday after a few dry days. It rained the next day. The photo to the right was taken on Monday. After only an hour of sunshine the more exposed stems of the Common Twine-moss *Triquetrella papillata* are already drying out and the leaves twisting around the stem. Stubble-moss *Weissia controversa* (large leaves, top) and Grey Cushion-moss *Grimmia pulvinata* (below) are still well hydrated. (GA.)



R: Soft Skein-moss *Weymouthia mollis* hangs from trees in rainforests. The loose open nature of the skeins slows air currents, which deposit moisture and dust. It also provides a large collecting surface for dim sunlight. However, it makes them prone to desiccation. In more open situations the moss lives lower down and is more compact. Mosses on trees in the background slow the stem-flow of water from rain, reducing erosion. <https://www.flickr.com>





## Cryptogams contribute to soil formation, nutrient cycling and erosion. They:

- **Promote erosion of rocks.** Lichen acids leached into rocks increase the rate of mineralisation (the release of minerals, making it available to ecosystems). They foster the **creation of soil**, albeit very slowly.
- **Increase soil nitrogen.** **Nitrogen-fixing cyanobacteria** hosted by cryptogams provide a major input of nitrogen to soil (lichens, bryophytes).
- **Intercept dust and water through-flow**, e.g. stem flow and water shed by rocks. **Delayed run-off reduces erosion.** They **store water** and also **reduce the compaction of soil by raindrops** in heavy rainstorms.
- **Control soil chemistry and nutrition.** They add organic matter. Fungal symbionts in some bryophytes increase their uptake of phosphorus, potassium and nitrogen. This is temporarily unavailable to other plants.
- **Influence soil and vegetation hydrology** (e.g. water flow, soil moisture penetration and perseverance) and temperatures. Biocrusts **reduce the leaching of nutrients** from the soil by slowing water flow.
- **Prevent erosion.** Biocrusts of opportunist and fugitive species quickly colonise and stabilise burnt or damaged soils, given enough moisture, reducing wind or water erosion. They stabilise dunes and desert soils.



This colourful biocrust from desert near Whyalla is storing water and active while the soil is damp. [www.anbg.gov.au](http://www.anbg.gov.au)



*Xanthoparmelia arapilensis* is one of the components of our desert biocrusts that is very sensitive to trampling by hard-footed livestock and feral animals such as goats. It can take many decades to recover. [www.anbg.gov.au](http://www.anbg.gov.au)





Lichens and bryophytes are fascinating organisms with important ecological functions. It would be a shame to ignore them, as so many people do.

Above: Goldeneye *Teloschistes chrysophthalmus* on a Cherry Plum branch. (GA)

R: Beret Lichen *Baeomyces heteromorphus* on a damp shaded bank, Enfield State Park. (GA)

