



PINELANDS LICHEN ECOLOGY

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1. What is a lichen?
2. How do they grow?
 - a. Crust like (crustose)
 - b. Leaf-like (foliose)
 - c. Shrub-like (fruticose)
3. Lichen reproduction
 - a. Apothecia
 - b. Soredia
 - c. Isidia
4. Lichen communities in the Pine Barrens
 - a. Living or dead trees
 - b. Soils
 - c. Insects
5. Lichen ecology

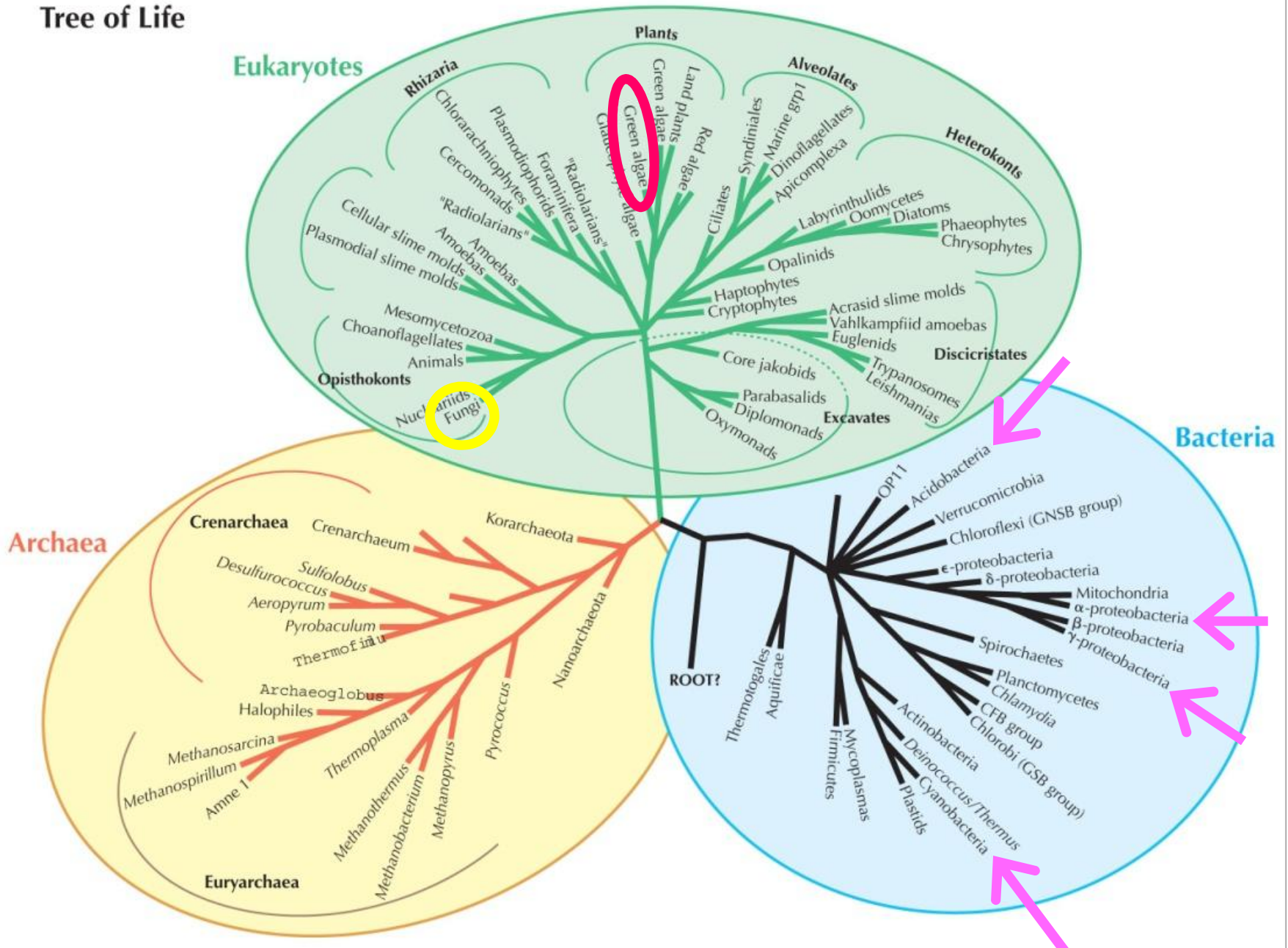
1. What is a lichen?



Lichen: composite organism made of a fungal species, photosynthesizing organisms and bacteria coexisting in a symbiotic relationship.

Composite Organism:

Tree of Life

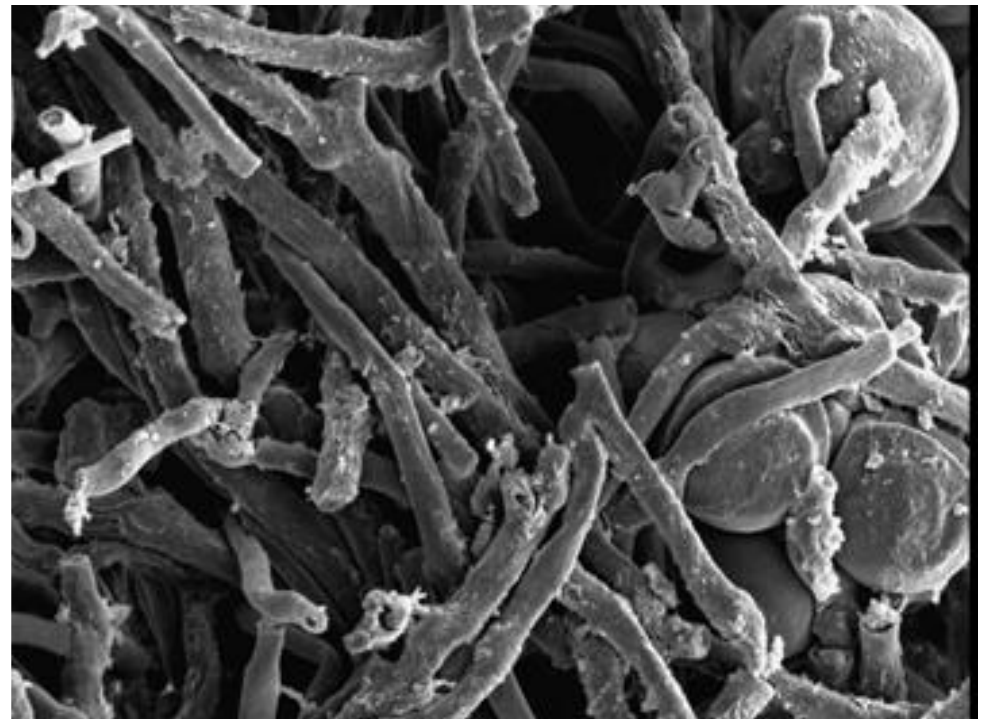


1. What is a lichen? **fungus**

- Lichen's name comes from fungal component
- Fungus:
 - Heterotroph
 - Eats organic matter
 - "Immobile" (most fungi)
 - Body (thallus) made of filamentous hyphae (most fungi)
- Most lichens are ascomycete fungi (spores in sacs)



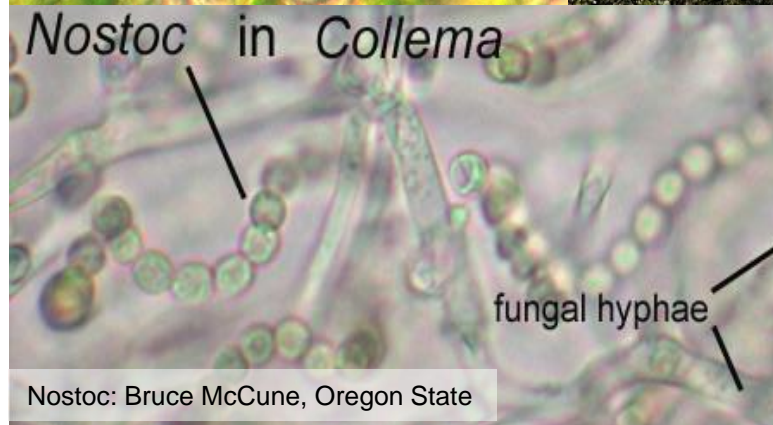
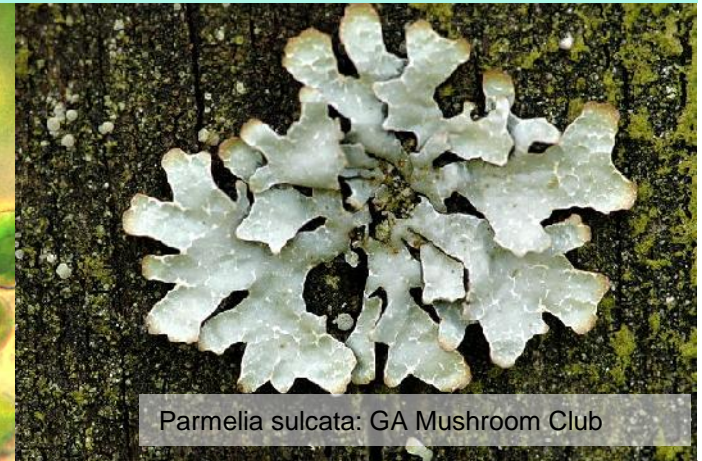
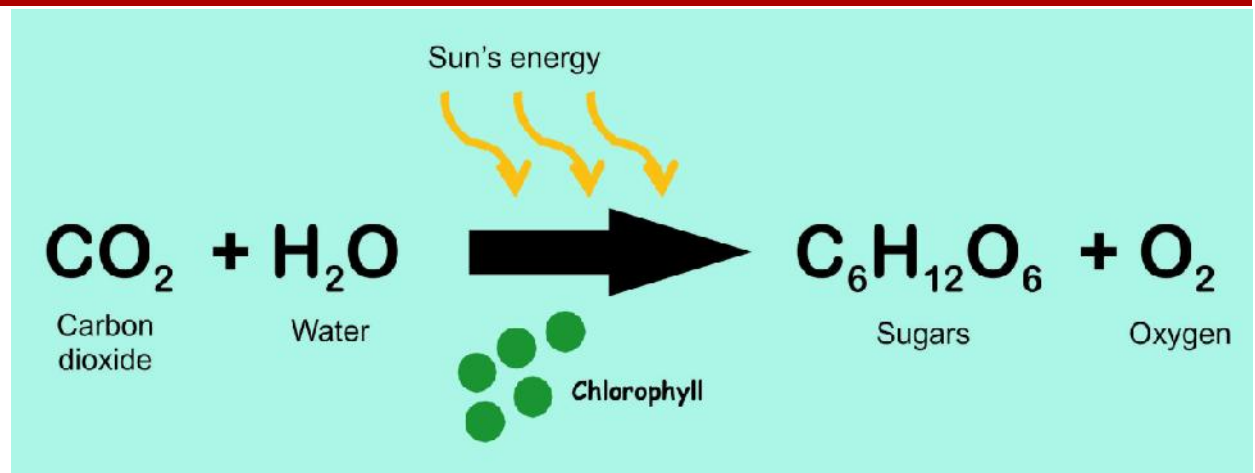
Fungal Hyphae on soil: Royal Botanic Gardens of Sydney



Fungal hyphae in a lichen: Bates Biology Department

1. What is a lichen? **photosynthesizing organism**

- Autotroph
 - Produces sugars that the lichen fungus uses
- may be:
 - Green algae
 - (ex. Trebouxia)
 - Cyanobacteria
 - (ex. Nostoc)



1. What is a lichen?

Mutualism?

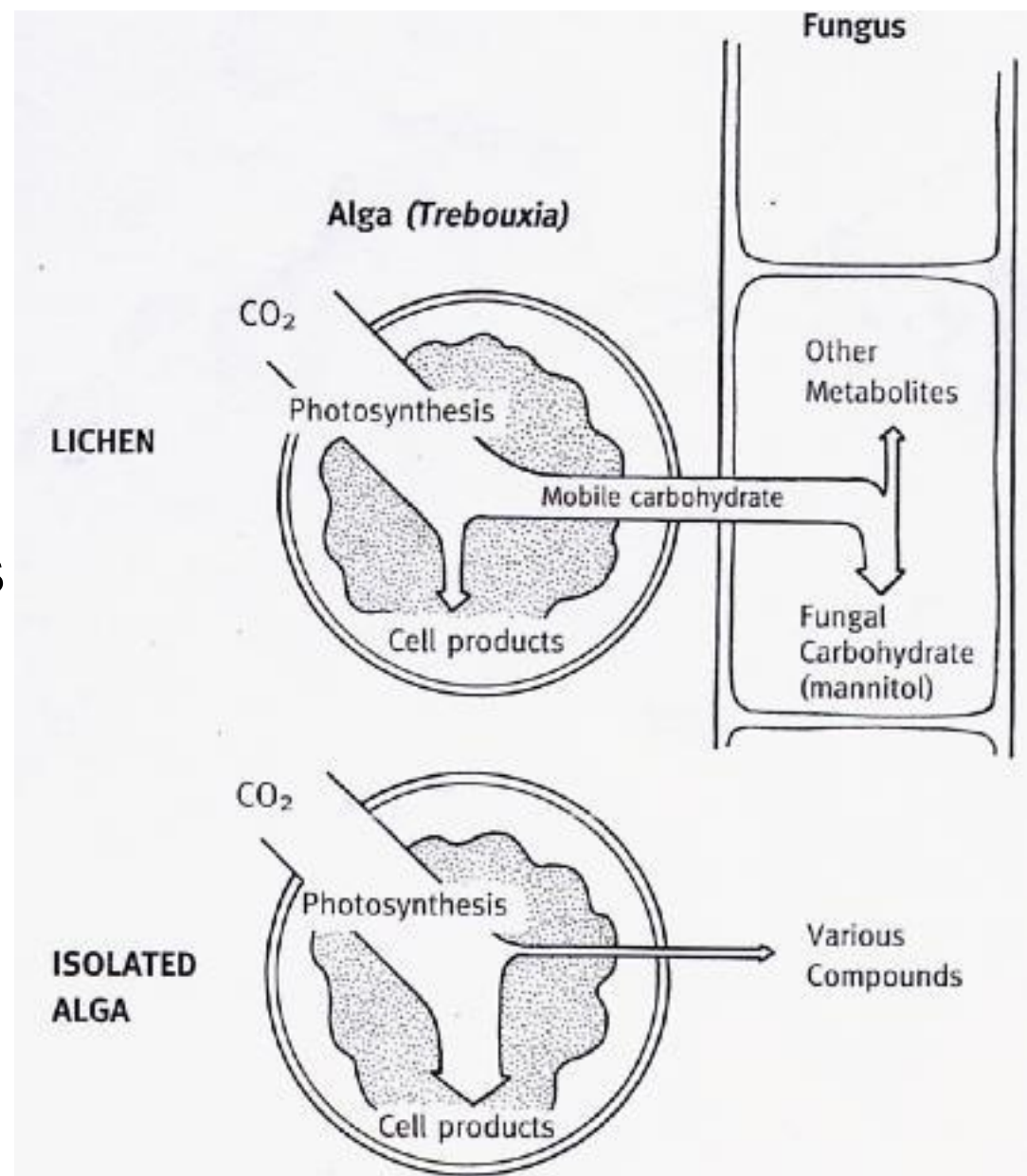
Or Controlled Parasitism?

Both parties benefit:

- Fungus provides protection & water
- Algae provides sugars

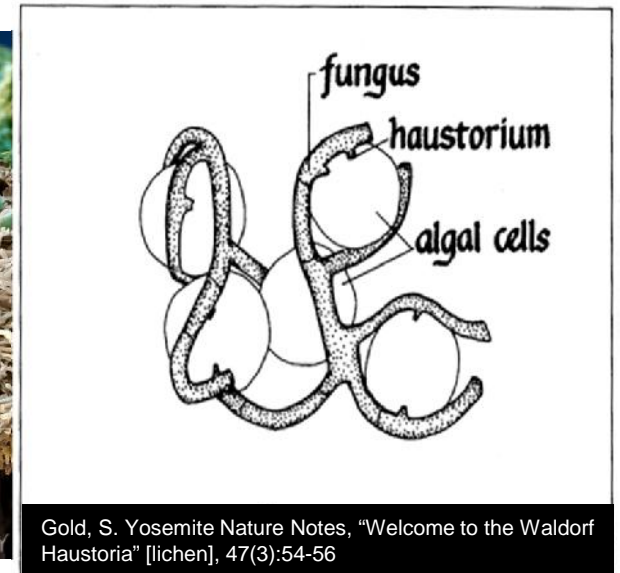
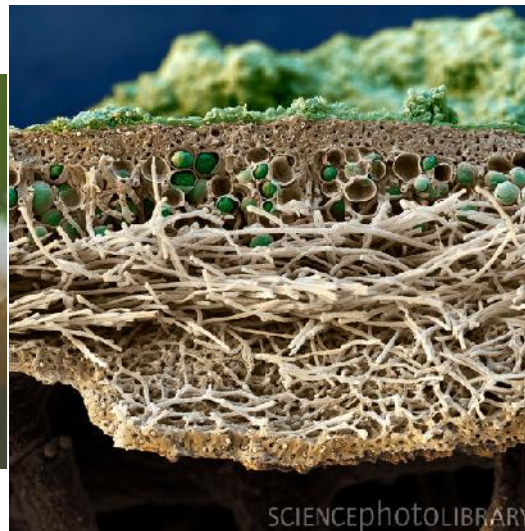
But some algae grow faster when free living.

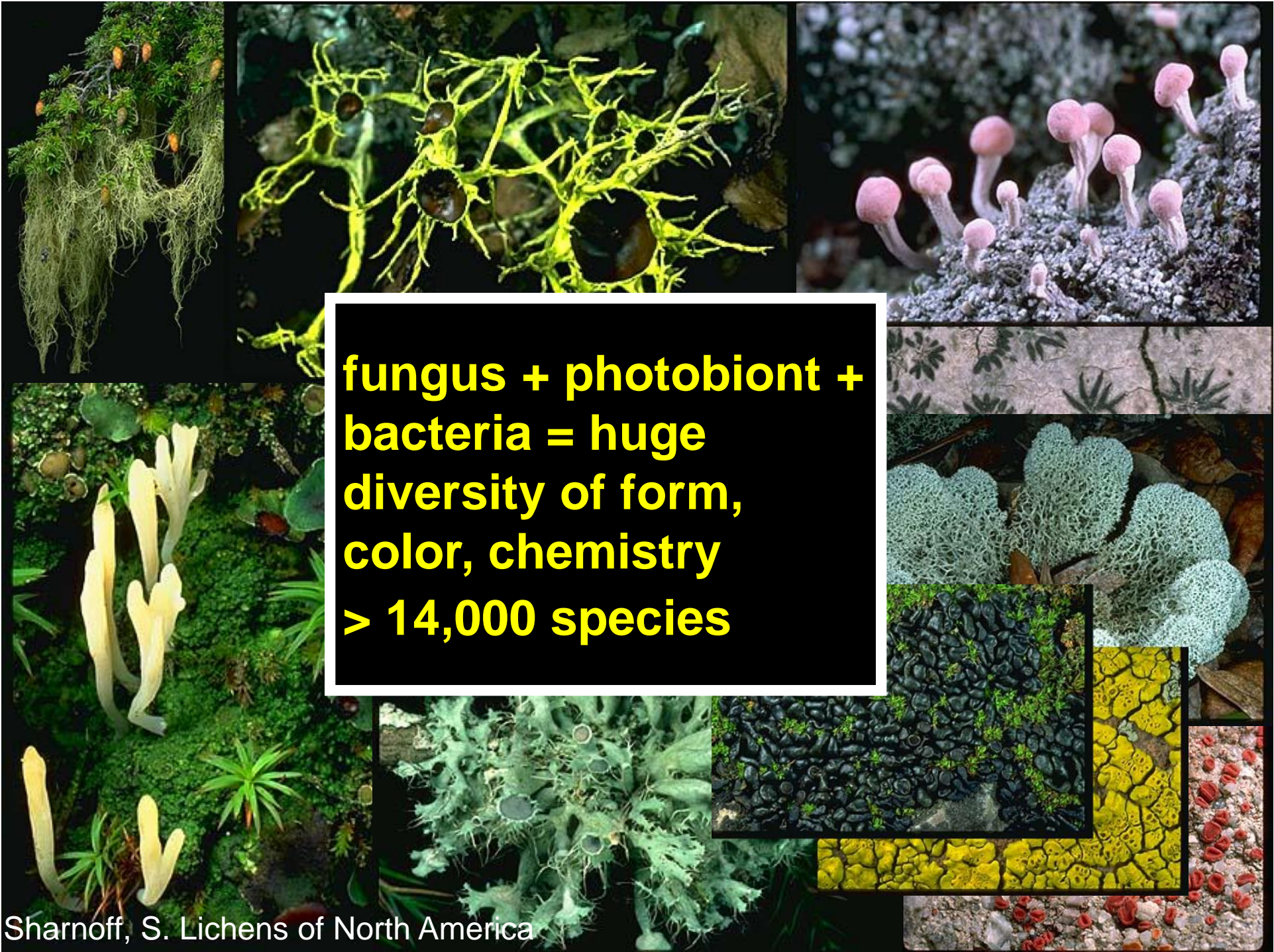
Lichens are fungi that have discovered farming!



2. Lichen Structure

- Lichens can have a huge variety of structures, but always, the algae is surrounded by fungal hyphae. This arrangement has evolved multiple times.



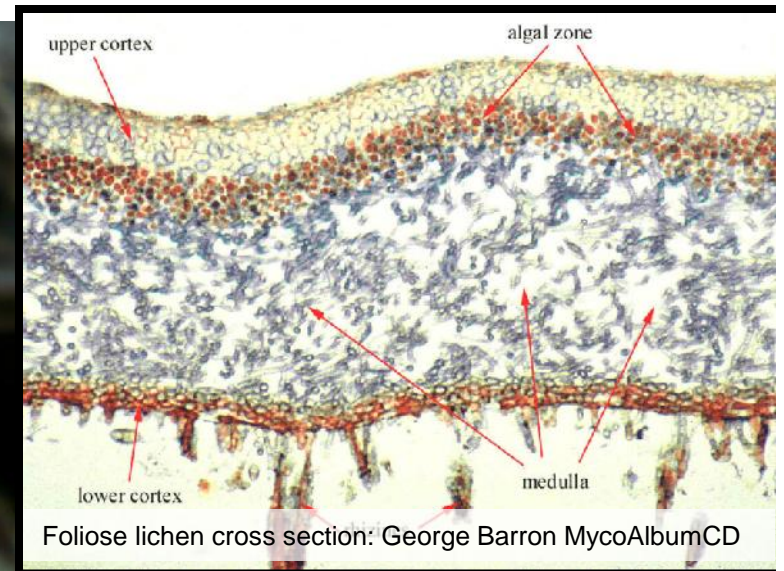


**fungus + photobiont +
bacteria = huge
diversity of form,
color, chemistry
> 14,000 species**

Sharnoff, S. Lichens of North America

2. Lichen growth forms

A. foliose (leafy)

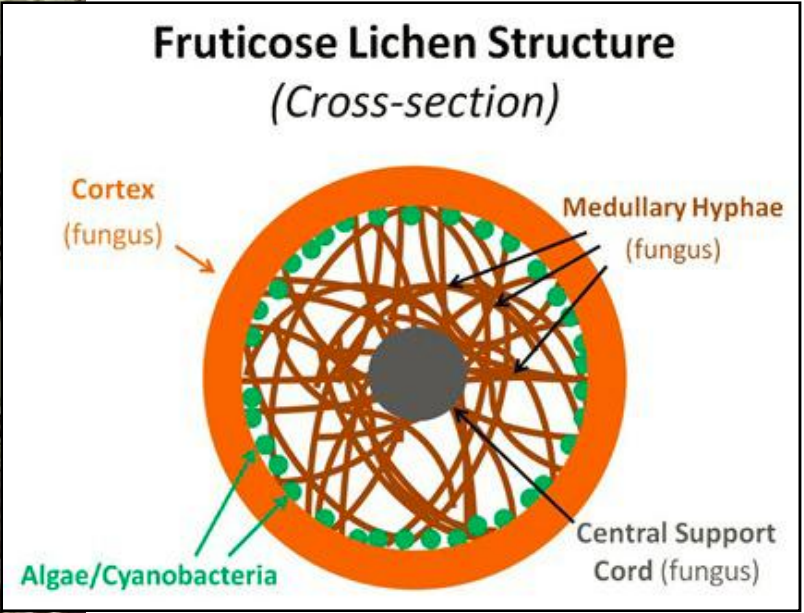


Flat cross section – can peel off substrate



2. Lichen growth forms

B. fruticose (shrubby/pendant)



From: Watching the world wake up

Round in cross section

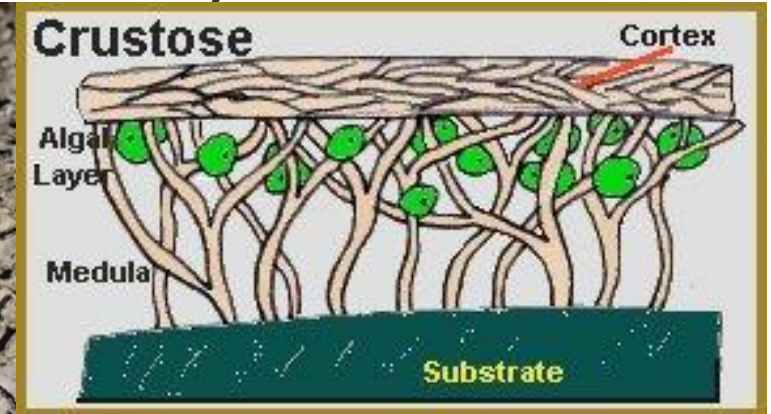
Usnea: NJ 2014

2. Lichen growth forms

C. crustose (crust on substrate)



Graphis, Lecanora, NC 2014



Lower surface
grows into
substrate,
difficult to
scrape off

2. Lichen growth forms

D. Leprose (powdery)



E. Squamulose (tiny flat pieces)



3. Lichen Reproduction

- Most lichens are in the fungal group ascomycetes: they produce spores in sacs (called an ascus)
- Apothecium: fruiting body that holds spores in a sac
- Some lichens have the colored apothecium on a stalk

Apothecium



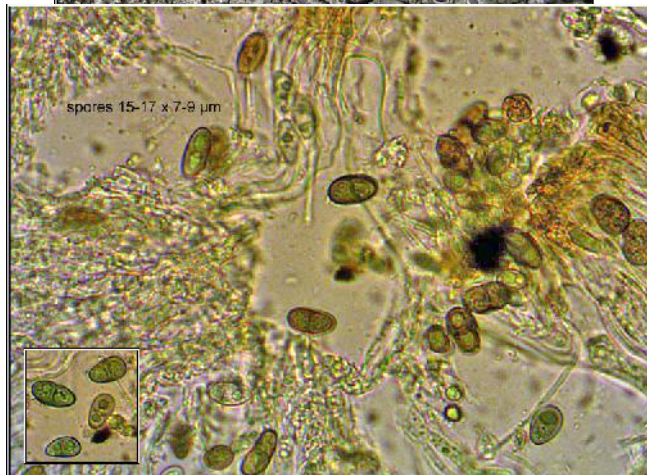
Brigantiaea leucoxantha: Troy McMullin 2014



Cladonia cristatella: NJ, 2015

3. Lichen reproduction

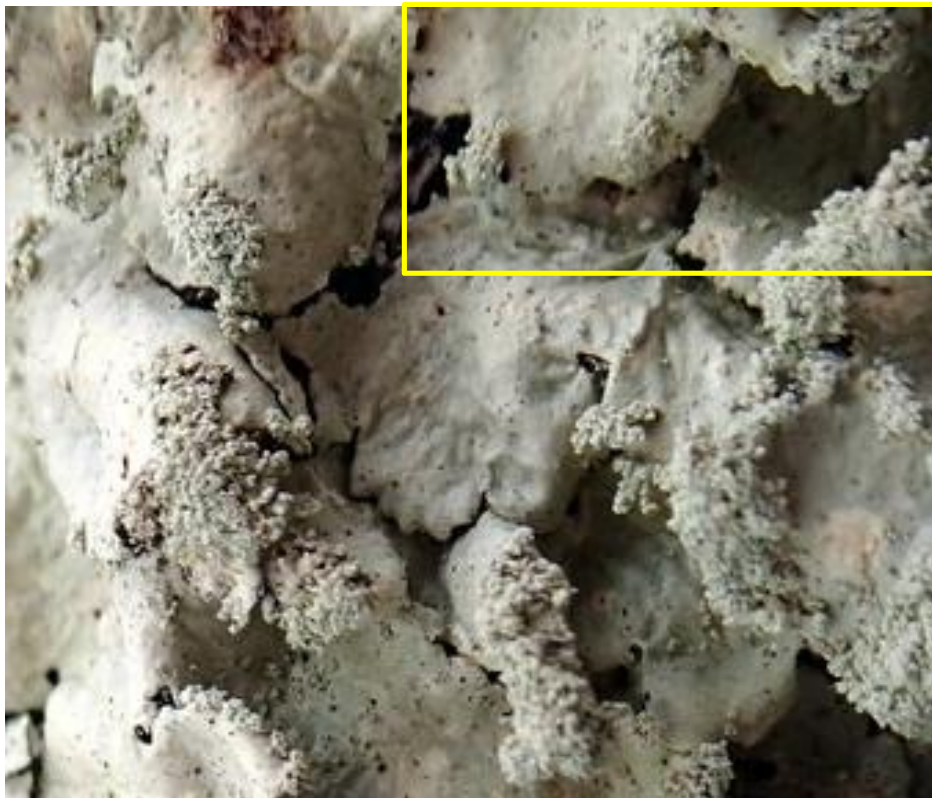
- To identify some lichens, you need to cut cross sections of apothecia and examine the spores in the microscope



L-R: *Hyperphyscia adglutinata*, *Graphina anguina*, *Bacidia lauroceracei* All photos: Jenny Seawright, Irish Lichens

3. Lichen reproduction

- Soredia: grainy or powdery material on lichen surface containing fungal hyphae and algal cells



- Isidia: fingerlike extensions off lichen surface containing fungal hyphae and algal cells



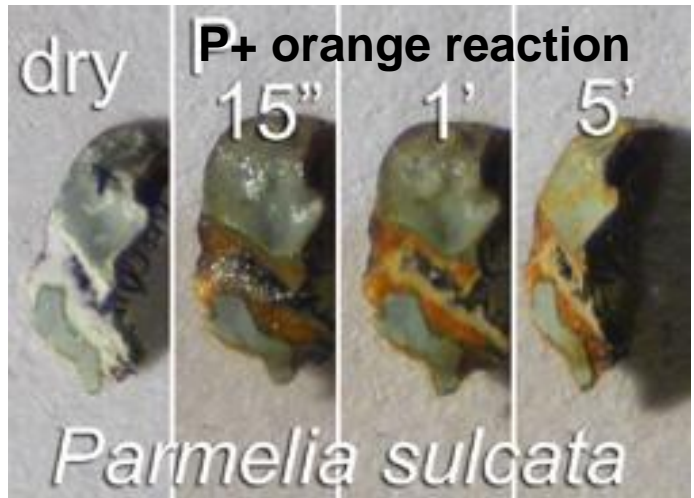
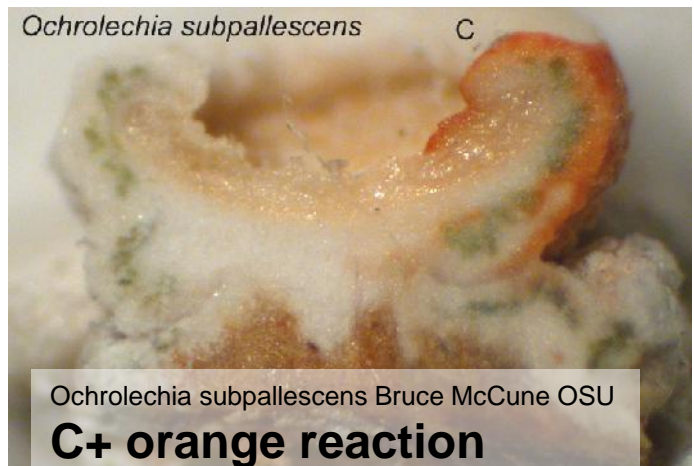
Flavoparmelia caperata, Natalie Howe, 2015 ; Crocodia aurata, Troy McMullin 2014; Parmelia sulcata, Natalie Howe, 2015

Lichen ID by Lichen Chemistry

Many lichens that actually are different species look very similar, and can only be told apart by chemistry.

Common chemical tests: (drop liquid on lichen and look for color changes)

- K (potassium hydroxide):
- C (sodium hypochlorite):
- P (phenylenediamine):



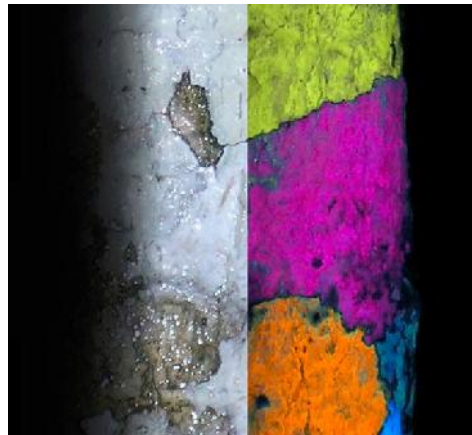
Lichen ID by lichen chemistry

UV: some specimens will fluoresce if you shine a UV light on them.

Lichens are not the only organisms that do this!



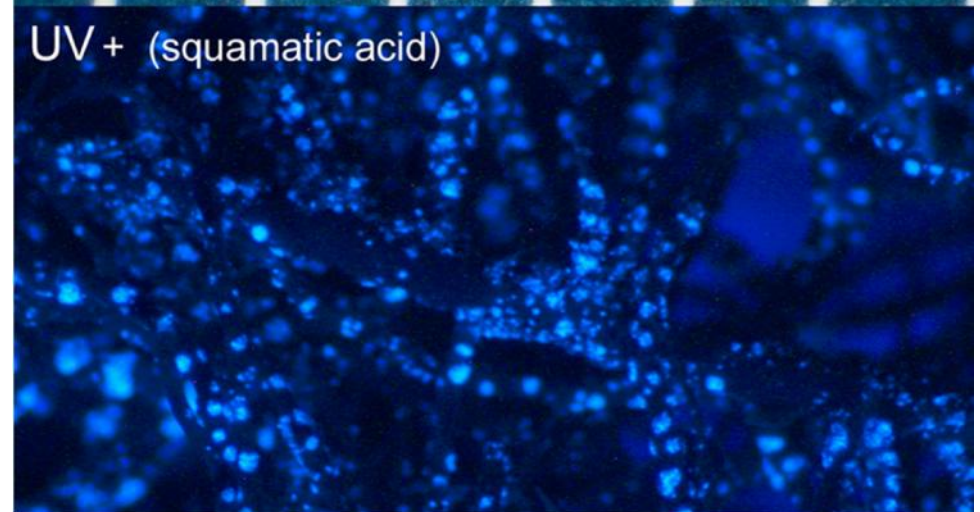
Dailymail.co.uk



Robert Lucking, Canadian Museum of Nature

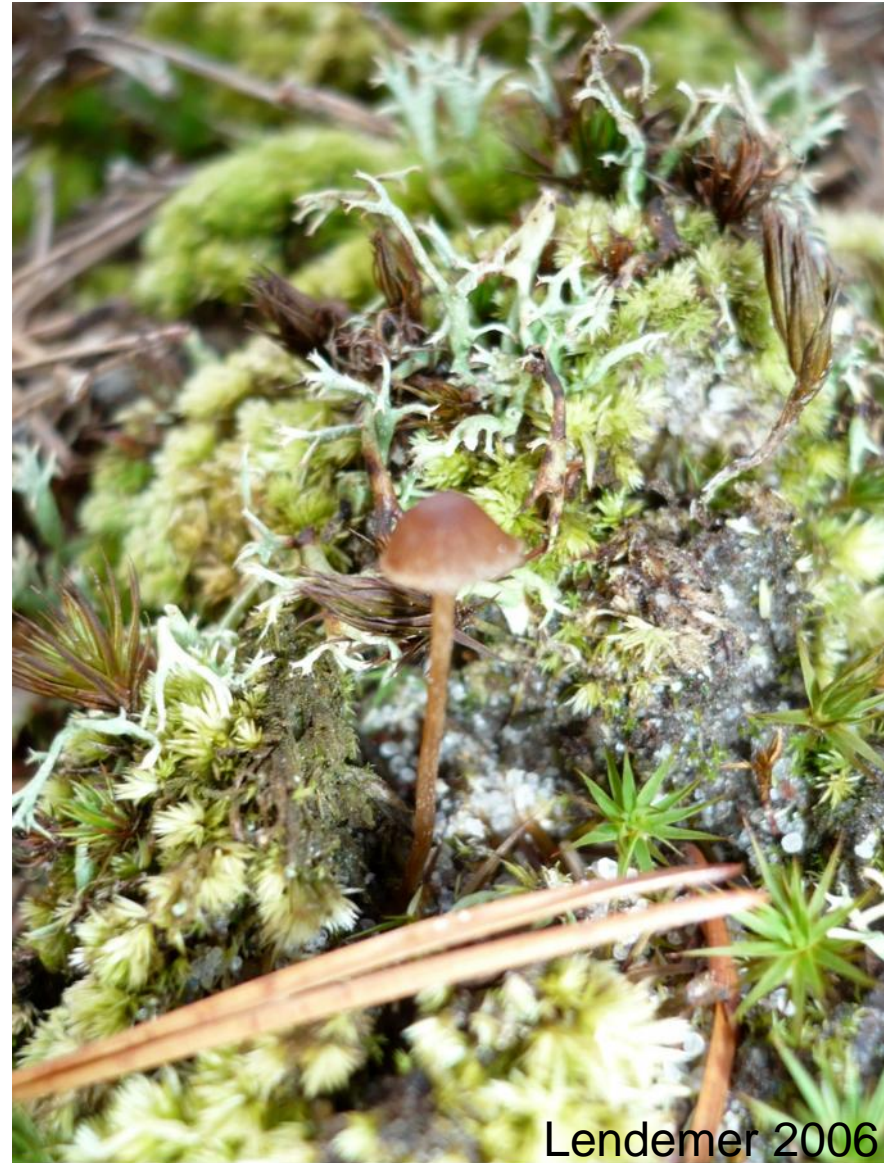


UV+ (squamatic acid)



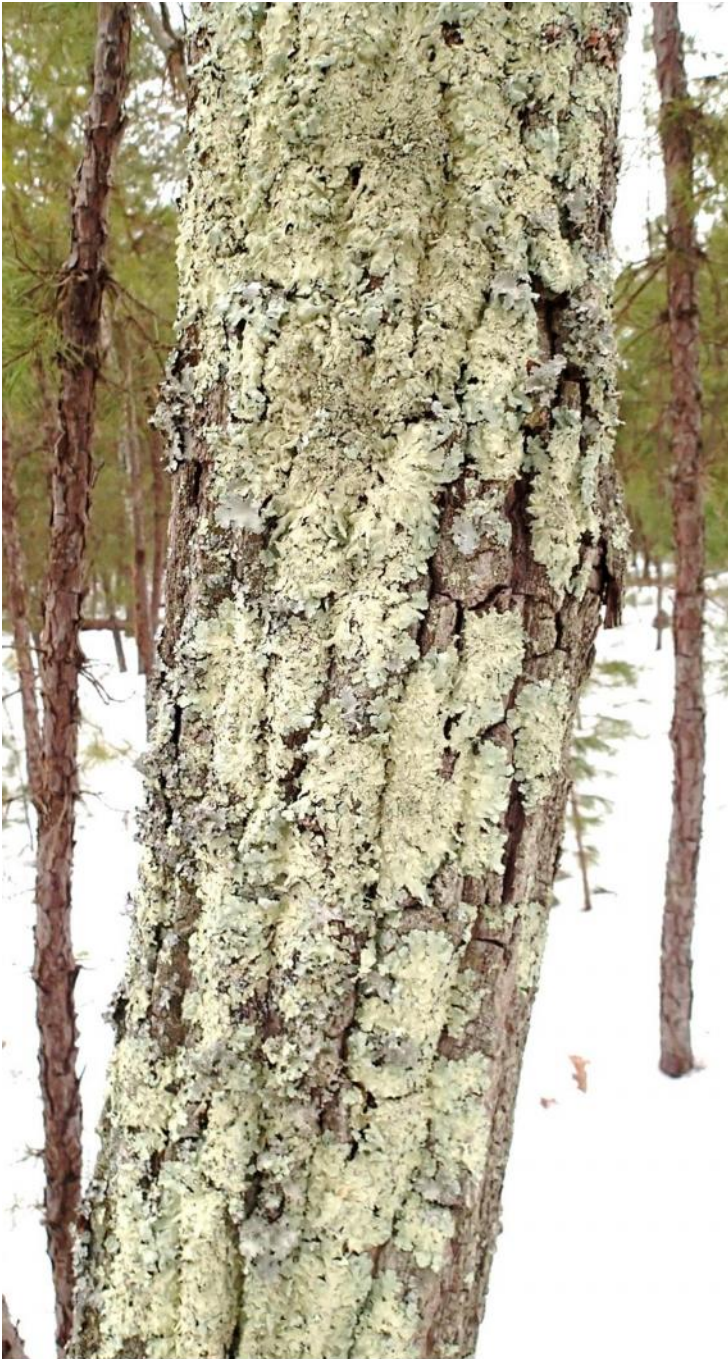
Bruce McCune, Oregon State University

Lichens are all over the pinelands:
190 species in Wharton State Forest!



Lendemer 2006

Common Foliose Lichens on Pinelands Trees



- **Yellow Green:**

- Greenshield lichen (*Flavoparmelia caperata*)



- **Blue-green:**

- Ridges & soredia
 - Hammered shield lichen (*Parmelia sulcata*)
- White spots & isidia
 - Speckled shield (*Punctelia rudecta*)



- **Black hairs:**

- Light on edge of underside:
 - *Parmotrema perforatum*
- Brown on edge of underside:
 - *Parmotrema submarginale*





Common Fruiting Lichens on Pinelands Trees



- Shrubby
 - *Usnea sp*



- Peg-like
 - *Usu. Cladonia coniocraea*



- Cup-like
 - *Usu. Cladonia chlorophaea*



- Red-topped
 - *Usu. Cladonia cristatella*

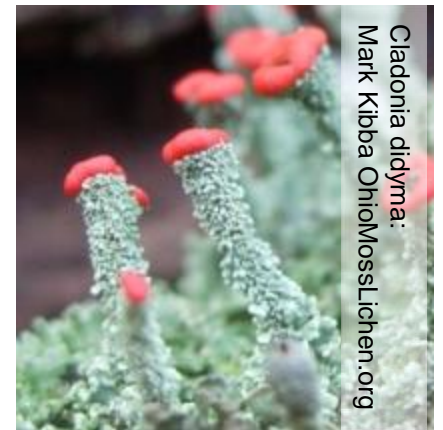


Many kinds of “British soldiers” (lichens with 1 stalk, no cups, red on top)

- If the stalks look grey-green and powdery (sorediate), but powder on the squamules is just on the edges:
 - And the stalk is covered with **fine** powder:
 - *Cladonia macilenta*
 - And the stalk is covered with **coarse** granules:
 - *Cladonia didyma*
- If the stalks have no powder and are yellow green:
 - And the squamules are powdery:
 - *Cladonia incrassata*
 - And the squamules are not powdery:
 - *Cladonia cristatella*



Cladonia macilenta:
James Lindsey Wikimedia



Cladonia didyma:
Mark Kiba OhioMossLichen.org



Cladonia cristatella:
Louise Browman, EPA,
Indiana Dunes Lakeshore



Cladonia incrassata:
Jenny Seawright DorsetNature.co.uk

Many kinds of cup lichens

- With soredia or granules (apothecia brown or absent)
 - Cups broad, goblet shaped, with grainy soredia covering cups:
 - *Cladonia chlorophaea*
 - Cups irregular
 - With starlike projections at edges of cups and with grainy soredia
 - *Cladonia rei*
- Without soredia or granules
 - Cups in towers, proliferating from center
 - *Cladonia rappii*
 - Cups proliferating from edges if at all
 - Cups full of tiny round disks
 - *Cladonia pyxidata*



Cladonia chlorophaea



Cladonia rappii, Jason Hollinger, Mushroom Observer



Cladonia rei, Steven Sharnoff, CNEELH



Cladonia pyxidata, Jason Hollinger, Mushroom Observer

- **With soredia**

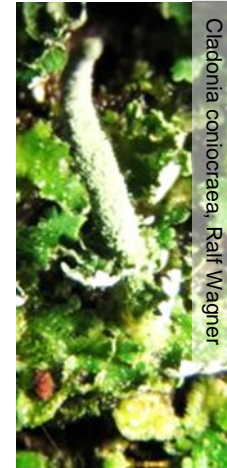
- Smooth, grey-green cortex on lower 1/3 to 2/3 of stalk with grainy soredia on top, squamules finely divided
 - *Cladonia ocrochlora*
- Almost entire stalk covered in powdery soredia
 - *Cladonia subulata*
- Almost entire stalk covered in powdery soredia and large unlobed squamules
 - *Cladonia coniocraea*

- **Without soredia**

- Very short stalks (1-3mm tall)
 - *Cladonia caespitica*
- Stalks >3 mm tall
 - On bark
 - Squamules mostly granular:
 - *Cladonia parasitica*
 - Squamules divided, turning yellow w/ PD
 - *Cladonia beaumontii*
 - Squamules divided, white under UV or yellow w/ K
 - *Cladonia squamosa*
 - On soil, moss or rock
 - Lots of squamules on stalk
 - *Cladonia squamosa*
 - Stalks look inflated
 - *Cladonia strepsilis*
 - Stalks warty, twisted
 - *Cladonia peziziformis*



Many kinds of stalk lichens with brown or no apothecia

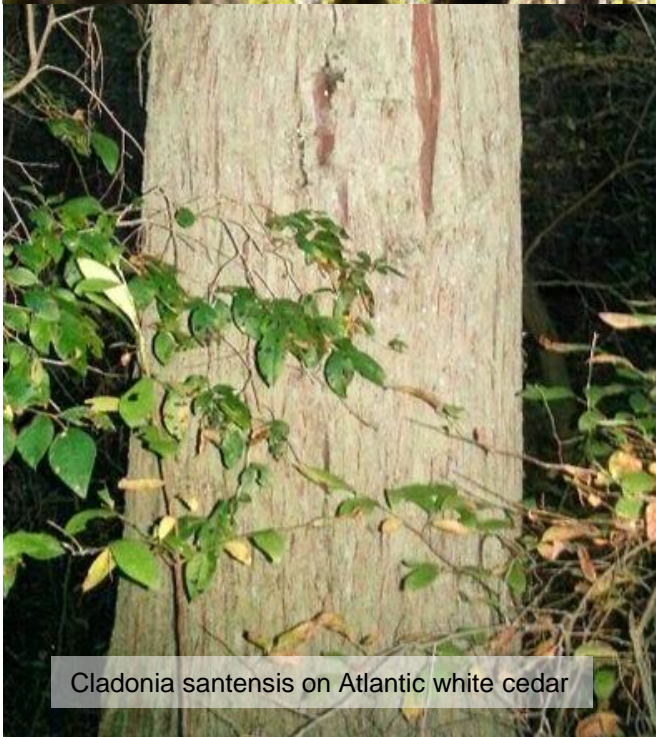




Candelaria concolor

Very small lichens with no visible fruiting bodies:

- The blue grey covering in Atlantic White Cedar swamps is usually *Cladonia santensis*
- Yellow lichen on urban trees is often *Candelariella concolor*.

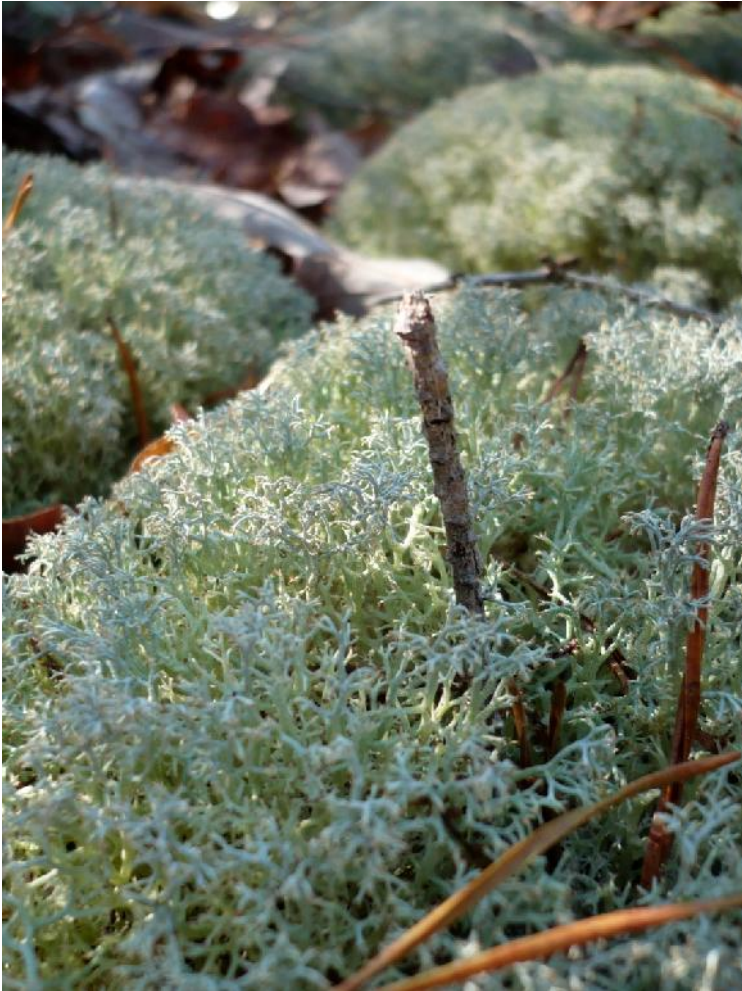


Cladonia santensis on Atlantic white cedar



Cladonia santensis on Atlantic white cedar. Tom potterfield 2004, flickr

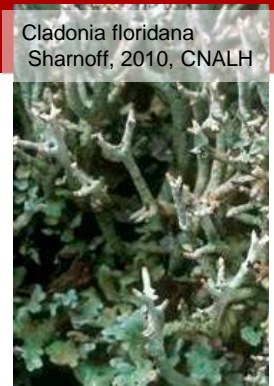
Common Frustricose lichens on soil



- Yellow-green
 - Thorn lichen
(*Cladonia uncialis*)
- Grey-green
 - Reindeer lichen
(*Cladonia submitis*)
 - Reindeer lichen
(*Cladonia subtenuis*)
- Brown green, with squamules
 - *Cladonia atlantica*



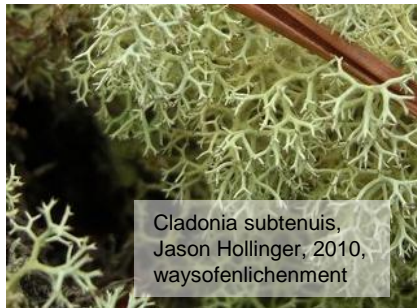
Cladonia Rangiferina,
Paul Morris, 2010, wikimedia



Cladonia floridana
Sharnoff, 2010, CNALH

Many kinds of “reindeer lichen” on soils

- Dull light green, branches bent mostly one way
 - Cladonia rangiferina
- Dull light green, branches going all directions.
 - PD+, Branching in 2s, stalks under .7 mm wide, no holes between branches
 - Cladonia subtenuis
 - Branching in 3s/4s, .5-.8 mm wide,
 - Cladonia arbuscula / Cladonia mitis
 - PD-, Branching in 3s/4s, wrinkled stalks .7-2mm wide w/ holes between branches
 - Cladonia submitis
- Shiny, gray-green
 - <25mm tall, primary squamules persistent
 - Cladonia floridana
- Shiny, yellow-green
 - Densely branched cushions with holes between branches
 - Cladonia uncialis
 - Flattened mats of slender branches, .5-1.5 mm wide
 - Cladonia dimorphoclada



Cladonia subtenuis,
Jason Hollinger, 2010,
waysofenlichenment



Cladonia uncialis



Cladonia arbuscula,
Tindall, digital mycology



Cladonia submitis, Sharnoff, 2010, CNALH

5. Lichen ecology

Tolerance of drought, freezing, low nutrient conditions allows them to exist in vast array of habitats: Bark, rock, soil +....

Pleasant Mills Church, 2014



5. Lichen Ecology

Stress Tolerance Adaptations

RADIATION: Lichens prevent damage from radiation using UV protective compounds:

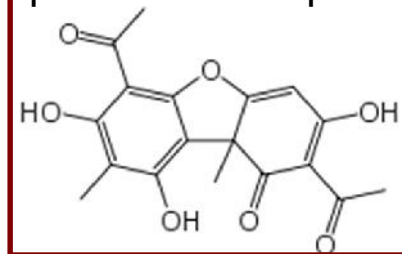
- Lichens can even survive in space!

LOW NUTRIENT CONDITIONS: Lichens survive low nitrogen conditions by partnering with cyanobacteria that can fix nitrogen



Raggio et al, 2011, Astrobiology

Usnic acid, one UV protective compound



Lucking et al., 2009. American Journal of Botany

5. Lichen Ecology

Stress tolerance adaptations

DROUGHT: Fungus in lichen can absorb water from the air, so the lichen can live on dry rocks, dry bark, or dry soils, like we have in the Pinelands

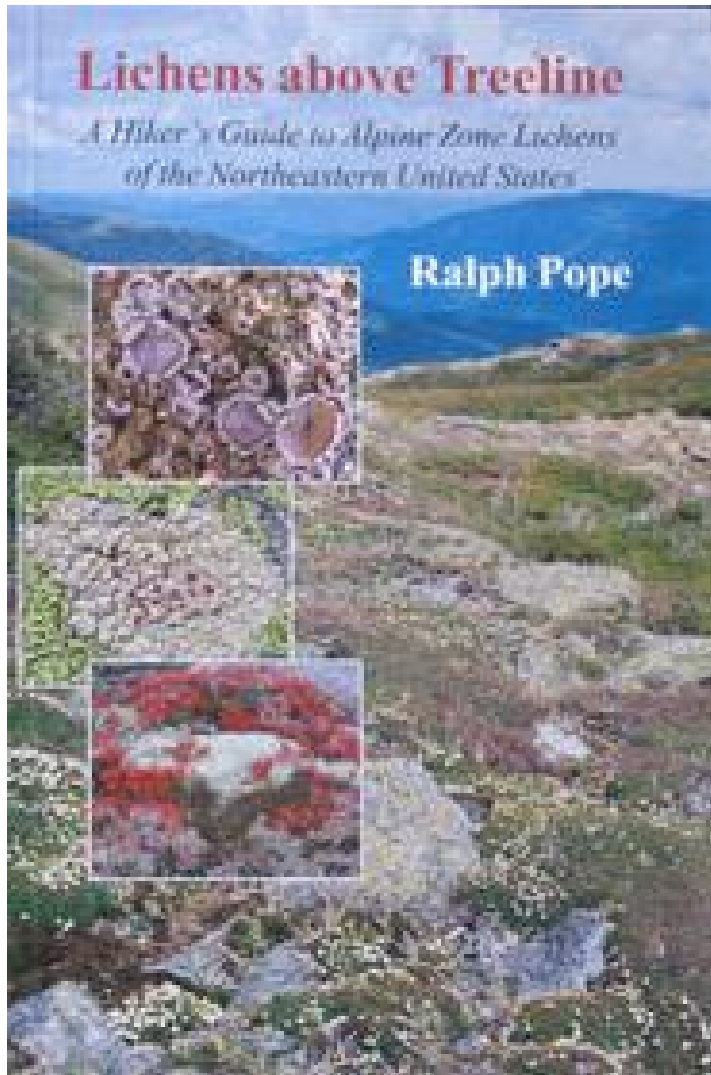
FREEZING: lichens live to -60 C! They can photosynthesize as low as -20C, and can absorb water from the air while buried under snow.

- Mechanisms
 - Sugar production in cells, to help them retain water
 - Proteins that stabilize membranes
- Allows lichen to tolerate:
 - Dry places (deserts, rock faces)
 - Places with no soil
 - Frozen water conditions



Kappen, Schroder, Green Scheppolt, 1998.
Polar Biology 19:101-106

Because they can tolerate drought, lichens are common on rocky faces...

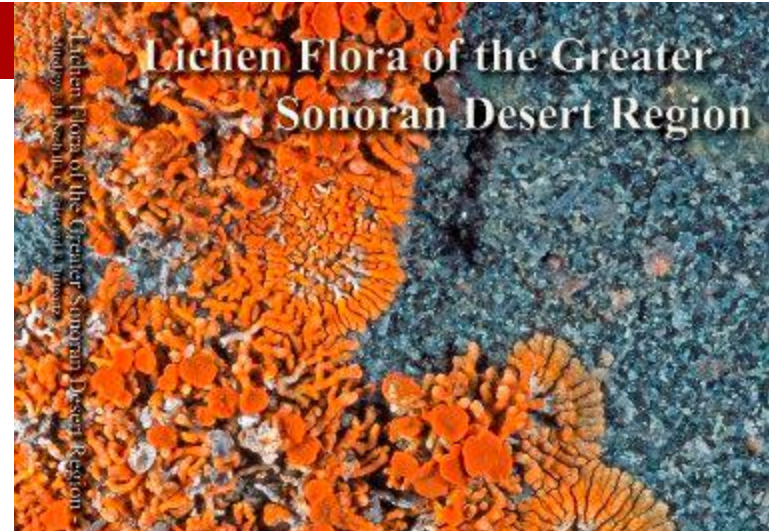


Sisters, Oregon. Mike Putnam



Mike Warren, 2001, NYNJ Trail Conference

... and in deserts, where they are important for soil stabilization, invasion prevention, and soil water retention.



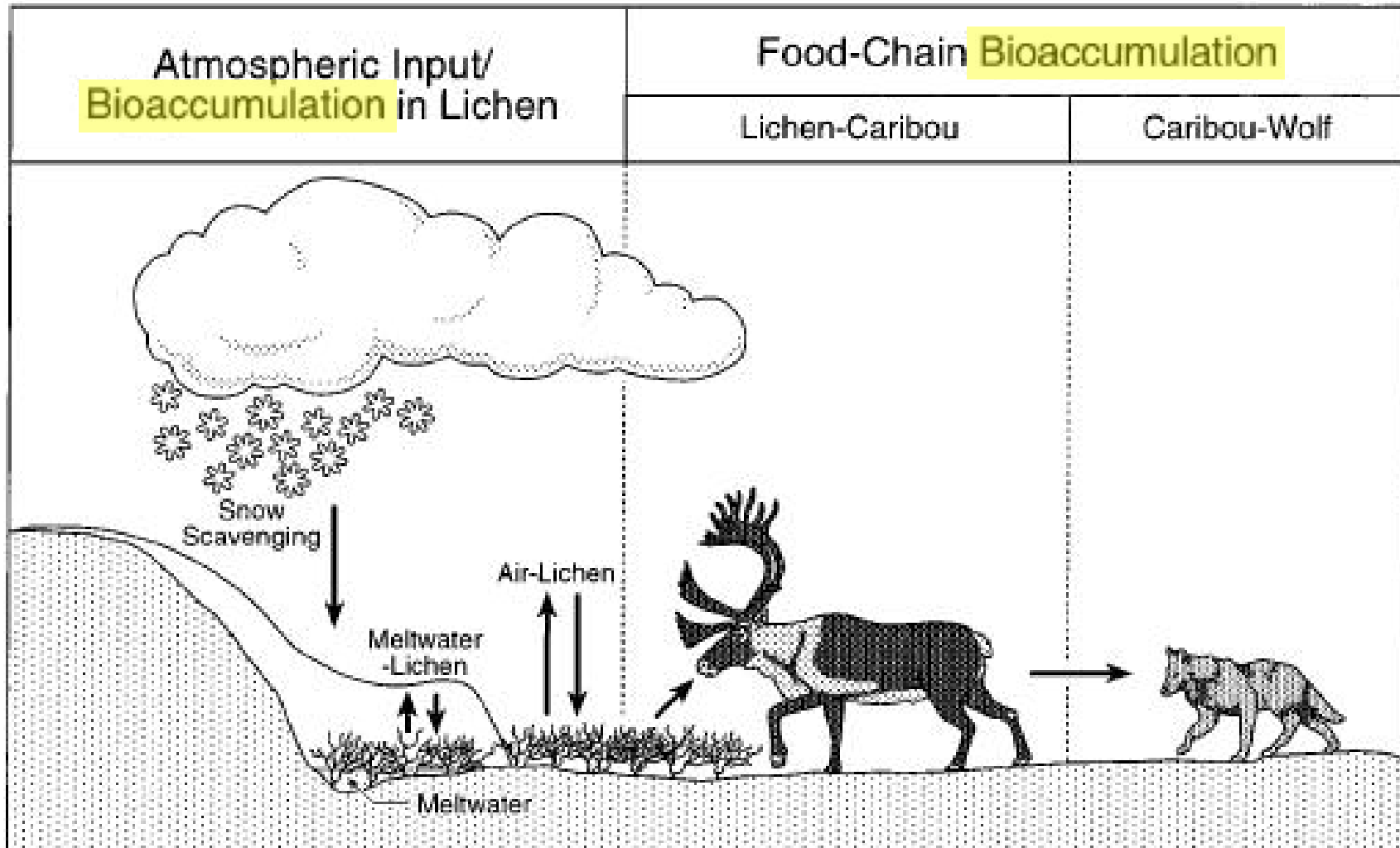
Tesloschistes capensis: Namib Desert travelnewsnamibia.com

Because they can tolerate freezing, lichens are important in arctic food webs.

- Lichens are winter survival food for caribou:
- 1.9-4.6 kg/lichen per day per animal!



Lichens can accumulate airborne pollutants, which can be detrimental

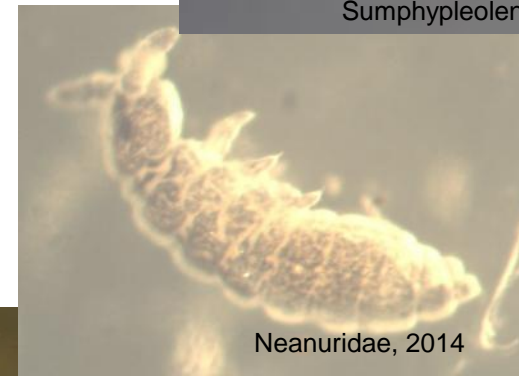
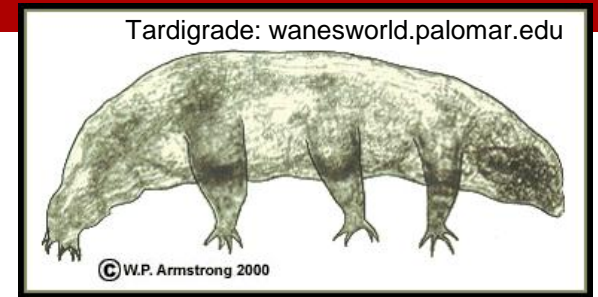


In NJ, lichens also interact extensively with smaller animals.

- Lichens can provide habitat for invertebrates in the soil
- lacewings larvae use lichens them for protection

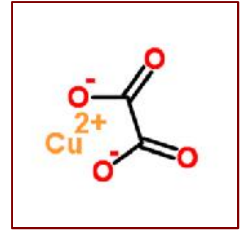


Lacewing: Bugguide.net, ngm.nationalgeographic.com



5. Lichen Ecology

Stress Tolerance Adaptation



Copper oxalate:
chemspider.com

POLLUTION: Lichens can tolerate heavy metal contamination by **chelation**. The lichens produce compounds bind the metal so it can't interact with lichen cells

Lichens prevent predation: many **antiherbivory compounds** that make the lichens taste bitter to animals.



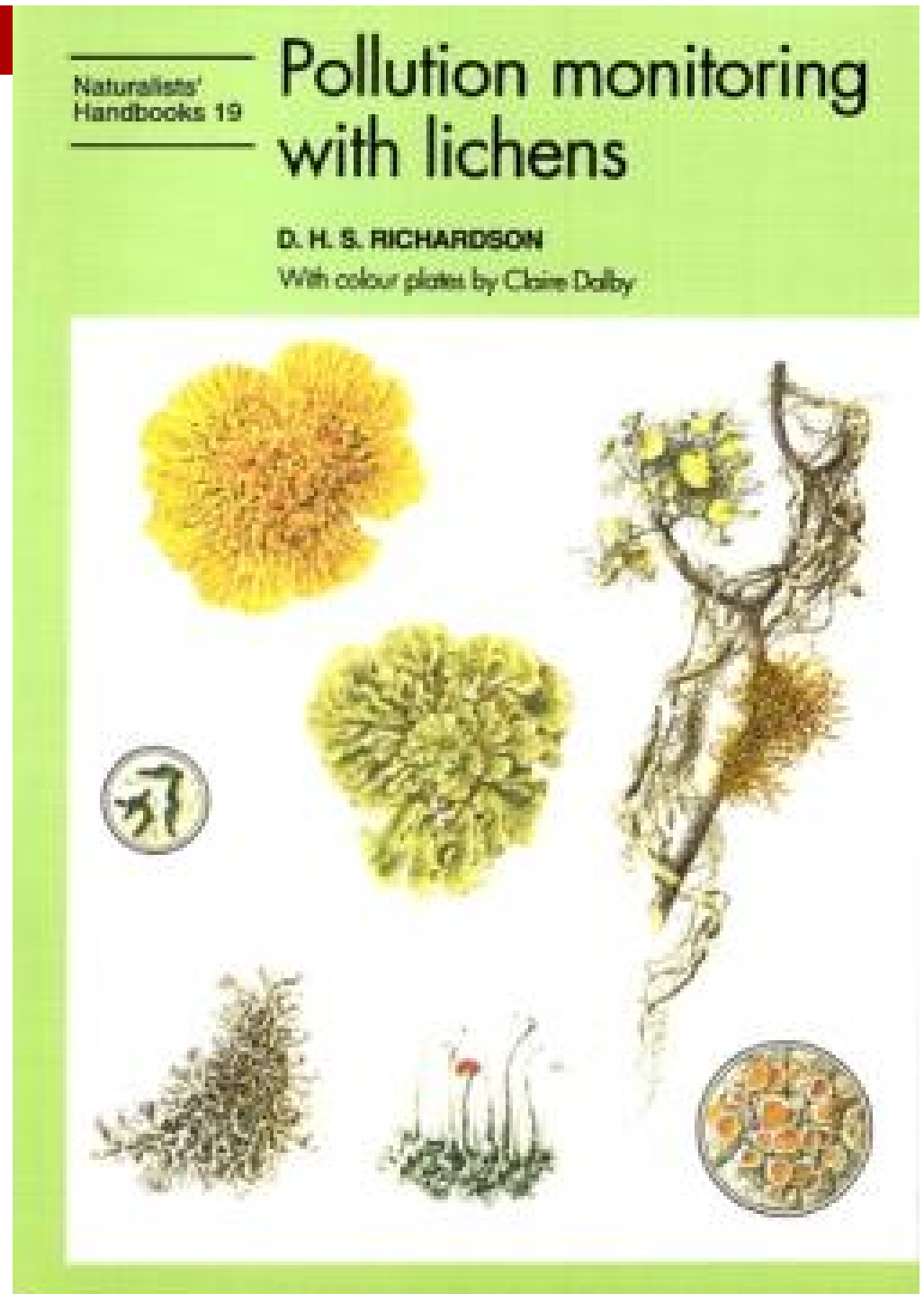
Acarospora sinopica, on old copper mine. FG. Jones - British lichens species gallery



Shutterstock.com

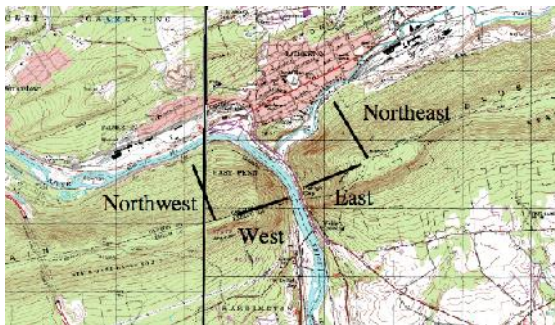
5. Lichen Ecology: Using lichens for pollution monitoring

- Depending of physiology of lichen (and growth form: crustose, foliose, fruticose) lichens have differential susceptibility to air pollution (NO_x , SO_2)



5. Lichen Ecology: Using lichens for pollution monitoring

Example: recovery of lichen community after end of Zn smelting at Palmerton PA



Lichens regrowing: *Porpidia albocaerulescens*, *Psiolechia lucida*, *Cladonia greyi*, *Dibaes baeomyces*

Collecting and Identifying Lichens

(Not in protected areas)



Holger Thues, NHM.AC.UK



Jessi Allen, NYBG.org



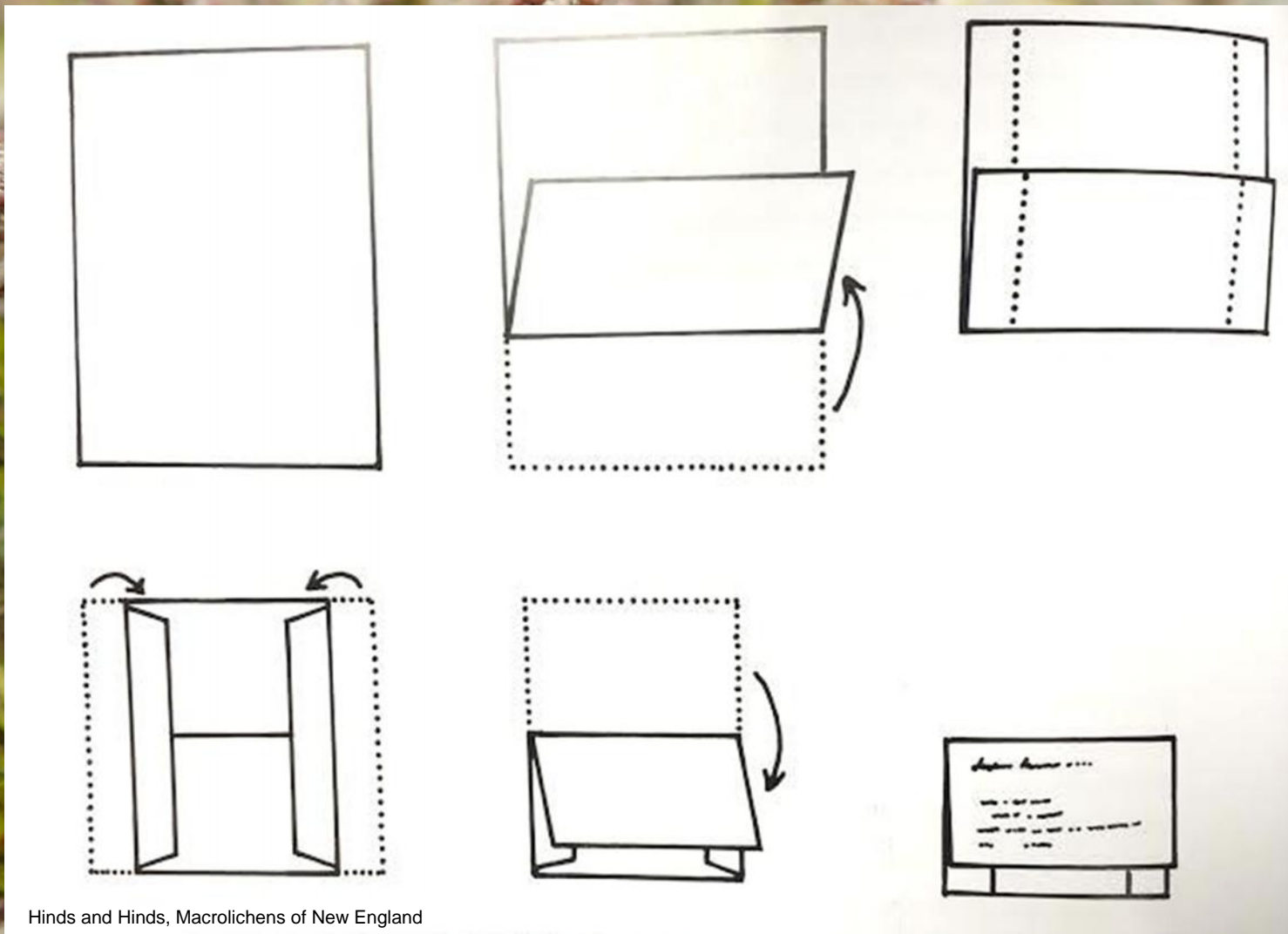
Chisca Derr, Sharnoffphotos.com

Collecting Tools



© T. Nash, ASU Herbarium

Once you collect the lichen, store it in paper to let it dry out. This is a good storage packet:



Hinds and Hinds, Macrolichens of New England

Use the packet to write down information about the specimen

(Not in protected areas)

LICHENS OF ALASKA

Lecidella stigmatea (Ach.) Hertel & Leuckert

Name

Location

58°37'N 134°56'W

Juneau: Sunshine Cove, at west end of road, 25 miles west of Auke Bay. Boulder beach and rocky cliff at north end of cove. On rocks at upper edge of beach, at point.

NOTES: Thallus C.

05 JUN 1988

Date

Collector I.M. Brodo, no: 26024A

with F. Brodo & R. O'Clair

CANL 108194

Det:



Questions?

Good references:

- Brodo, I.M, Sharnoff, S. and Sharnoff, S., 2001. Lichens of North America, Yale University Press, CT.
- McMullin, T. and Anderson, F., 2014. Common Lichens of Northeastern North America, New York Botanical Garden Press, NY.
- Hinds, J.W. and Hinds, P.L, 2007. New York Botanical Garden Press, NY.

