LABORATORY 8: LICHEN ARCHITECTURE

The objective of this lab is for you to become acquainted with lichens, namely their composition, and structure.

Lichens are an association between a **fungus** (a heterotroph) and a **photosynthetic** partner (i.e., a green alga or a cyanobacterium, which are autotrophic). The fungus is the **exhabitant** and the photobiont, the **inhabitant**. Remember that the name of the lichen refers to the **fungus only**.

The lab will first take you through several sections including material on display only. Then you will be dissecting samples of some local species.

Display I: Growth forms of lichens
Lichens can be accommodated in three groups based on their growth form or habit:

1. - **crustose** lichens are intimately attached to the substrate, the thallus is essentially two dimensional, and can hardly be removed from the substrate). Species shown:

   Icmadophila ericetorum: common on decaying wood in the boreal forest.

   Cryptothecia rubrocincta (*Chiodectyon sanguinarum*): (sub)tropical lichen; some say that the abundance of this lichen in lowland forests is what gave Baton Rouge its name!

   Vezdaea leprosa: inconspicuous crust on heavy metal contaminated soil; the thallus is composed of **goniocysts**!

2. - **foliose** lichens consist in a lobed thallus, with the lobes basically freed from the substrate; lobes can be two to 50 mm broad, depending on the species. Species shown:

   Platismatia tuckermanii: widely distributed on conifers in Eastern NA.

   Flavoparmelia caperata: perhaps the most common Eastern NA species on trees.

   Umbilicaria mammulata: a common umbilicate (why so?) lichen on rocks across the Eastern US.

3. - **fruticose** lichens have a thallus that is radially symmetric in section, and thus consists in branched ± cylindrical axes. Species shown:

   Usnea longissima: this species can grow to several feet on length; it is endangered in Europe and confined in the New World to Western North America.

   Cladonia cristatella (British Soldier): a common lichen on soil in Eastern North America

Dibaeis roseus: a common species in Eastern North America, where it is part of the pioneer vegetation on soil. Can you distinguish the **thallus "horizontalis" and "verticalis"**?

Ramalina menziesii: note the reticulate thallus of the Pacific NorthWest lichen.

Display II: Reproduction in lichens

Symbiotic propagules:

Given the dual nature of lichens, successful "reproduction" will require for the symbiotic relationship to be recreated. Ideally, both partners could be dispersed together. Lichens develop several specialized structures. These are:

- **isidia**: outgrowth of the thallus that are branched or not, that comprise both the fungus and the alga, enclosed by a cortex. Isidia break easily off the thallus and are dispersed by wind or water. Example: *Sticta weigelii*.

- **soredia**: these structures differ from the isidia in that they lack a cortex, hence they look powdery; a soredia consists in a few hyphae surrounding some algal cells. Soredia typically erupt through the cortex. Example: *Hypogymnia physodes*. Take this sample and remove soredia and observe under the compound scope.

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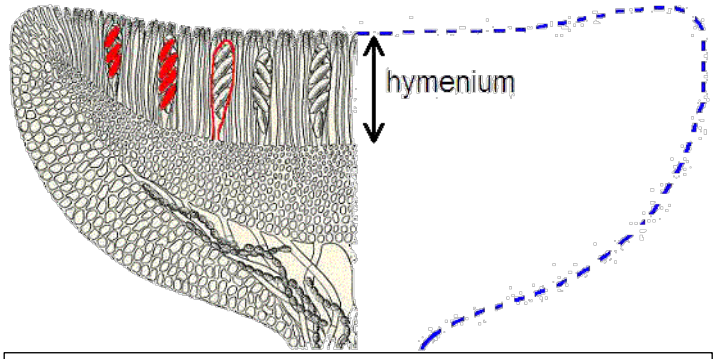
- **phyllidia**: these are miniature lobes; they are similar to isidia, except for their distinct bilateral (i.e., dorsi-ventral) symmetry. Example: *Pseudocyphellaria flavicans*.

- **schizidia**: in some taxa, the upper portion of the thallus breaks of into fragments. Example: *Peltigera elizabethae*.

- thallus fragments: the lichen *Thamnolia subuliformis* has a predominantly bipolar distribution, and is only known in the vegetative stage. No fruiting bodies have ever been found. The species furthermore has no specialized asexual reproductive structures. How does it get so widely distributed?

Aposymbiotic propagule.
Remember that only the fungus reproduces sexually in the lichen, or that at least, only the sexual reproductive structures of the fungus are conspicuous. Ascomycetes develop spores within an ascus. Thus, meiosis occurs within this structure, which is container defined by one or two membranes.

Meiosis typically yields 4 cells, but in many lichens each ascus may hold 8 spores, revealing that a mitotic division occurred immediately following meiosis. Others have fewer spores, with some species having only one large spore per ascus.



https://www.anbg.gov.au/lichen/form-structure-reproduction.html

Diagram of apothecium architecture of a lichenized fungus.

On display is a section of the apothecium with its asci and paraphyses of ***Solorina saccata***.

Also shown is the spore mass taken from the mazaedium of ***Calicium viride***, a pin lichen. Here the asci disintegrate and the spores are directly exposed to the wind, ready for dispersal.

Exercise 1.
In most ascolichens, the ascus remains intact, and spores are ejected out of the sac. You are given a piece of the lichen *Physcia stellaris* with black apothecia. Take a piece and place a drop of water on an apothecium. Let it soak. Remove the apothecium with your forceps and place it on a slide. Remove any thallus of woody debris from underneath the thallus. Now, cut off a small piece of the apothecium to reveal the fertile layer. Prepare a few cross sections of the apothecium. This is not easy. It is best done by 1) keeping the apothecium moist (not necessarily floating in water though!) and 2) by holding the apothecium down with your dissecting needle and gently cutting at right angle to the apothecium surface. Always cut from the top down. Cover with a coverslip.

Observe. Ready to capture your observations?

Sketch the architecture of the apothecium and annotate.

Does the apothecial margin hold photobionts? _____

Does the hymenium include asci? How are they distributed? _____

How many spores does each ascus hold? _____

What is the color of the spores? _____

How many cells make up a spore? Draw one.

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Display III: Alternative life styles of lichens

Most lichenized fungi grow on tree (epiphytic), rocks (saxicolous), on decomposing wood (epixylic) or soil (terricolous). Some taxa have more specialized "habitats" such as other lichens, bryophytes, and perennial leaves of angiosperms.

A few of such taxa are displayed here:

- **Parasitic lichen**: *Diploschistes muscorum*: this fungus parasitizes *Cladonia spp*. and acquires its photobiont, with which it will form a new thallus. *Diploschites muscorum* soon becomes independent, with little or no trace of the original host left. The development of this species is more complex than most lichen parasites in that the fungus will ultimately acquire a new photobiont, which will replace the former one prior to the development of a mature and independent thallus!

- **Bryophilous lichens:** *Coenogonium pineti* grows over epiphytic bryophytes; *Bilimbia sabuletorum* grows over terricolous bryophytes

- **Foliicolous lichens**: *Roccellinastrum epiphyllum* grows on leaves of Araucaria and other evergreens in southern South America. Note the pinkish apothecia on each crescent shaped thallus. In the Tropics a single leaf can be colonized several (10-15) species of lichens.

- **Vagrant lichens**: *Xanthoparmelia semiviridis* occurs in the deserts of Australia. It is not attached to the soil. Instead it is carried by the wind. Upon hydration, the lobes fold open, and the lichen thallus spreads over the substrate. When it dries out, the lobes curl up and the lichen gets moved around.

- **freshwater lichens:** *Dermatocarpon luridum* grows on rock in stream and is at seasonally submerged. This also has sunken fruiting bodies.

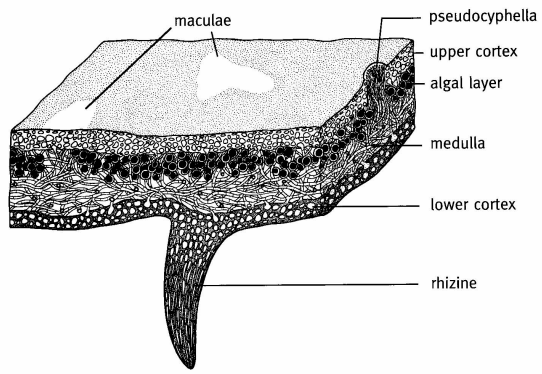
- marine lichens: *Collemopsidium halodytes* is found growing on barnacles. Look for tiny black dots, these are the fruiting bodies. Like other species of this genus it also grows on rocks in the littoral zone.

Display IV: The two main groups of lichenized fungi
Most lichenized fungi belong to the ascomycetes, meaning that they produce ascospore in asci organized in apothecia, typically plate-like (although sometimes strongly convex or concave and immersed) structures. Example: *Physcia stellaris*.

Few basidiomycetes, that is fungi developing basidiospores on basidia are lichenized. The fruiting bodies of basidiomycetes are typically a mushroom, but not always. Example: *Sulzbacheromyces sinensis*.

Lichen architecture

Most lichens have a well-structured thallus, with the **photobiont** confined to a layer immediately below the surface or cortex. Remember that the vegetative body of fungi consists of **hyphae**, which are filaments of cells. The cells composing the **cortex** of lichens are smaller, nearly isodiametric rather than rectangular or elongate. The cortex is generally thin.



In the algal layer, photobiontic cells are surrounded by hyphae, but the photosynthetic cells are abundant, and in section this layer is either green or blue-green depending on the nature of the photobiont.

Below the algal layer is the **medulla**, a tissue composed of interwoven hyphae; the medulla is typically white. The lower surface of the thallus can be corticated (lower cortex) or not. The thalli are often attached to the substrate by **rhizines**, which are fascicles of hyphae.

Exercise 2: At your disposal are: *Flavoparmelia caperata* and *Punctelia rudecta*. These are common local epiphytic species.

Take one of the species. Describe the upper surface (color, smooth vs ridged, hairy or naked, appendages present or lacking, …:

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Remove portion of the thallus from the substrate, so that you have about ½ an inch or more to examine. The lower surface may show a gradient in color, in the development of rhizines, … Describe the lower surface.

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Break off a lobe, place it in a drop of water, and **when fully hydrated**, and make a thin transverse section. It is critical that your sections are thin; you should be able to see through them!
The anatomy of the thallus, or its inner architecture should be what is called heteromerous, meaning "of different parts", with the parts being layers. Sketch the architecture and describe the layers.

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Is the photobiont a cyanobacterium or a green alga? Describe it. Is it unicellular, filamentous,…

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The upper and lower surface of the thallus may be differentiated into a cortex. Describe the cells composing the cortex. For this it is critical that your sections are thin.

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Exercise 2: The TA will give you a lobe of a specimen of *Leptogium*. Describe the lobe outline:

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Wet the lobe and make a cross section. Sketch and describe the anatomy of the thallus, (i.e., upper and lower cortex, medulla and photobiont).

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How does the anatomy of this lichen differ from those examined earlier?

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