DALRY PARK

Lichens and medicine

A little of history....

The evolution of the lichen symbiosis is interesting because the co-evolution of the alga and the fungus has taken place several times at different periods and for different species. Lichens represent a success story of several million years. Fossils of lichens have been found and have been dated to approximately 418 million years ago (between 420 and 350 million years ago), in the Devonian period. To give you an idea, humans appeared 200 million years ago, and the big bang happened 13.8 billion years ago.

If you could go back in time to that Devonian era, you wouldn't see trees or plants - which would exist but would be very small - but *Prototaxites*. These organisms, sometimes the size of a house, dominated the landscapes in Africa, Australia, Europe, North America and Asia for 40 million years, 20 times the lifetime of humans. These huge organisms were large lichen-like structures created by the symbiosis between algae and fungi. Despite the *Prototaxites* being very similar to lichens, there is still much debate on what this organism was. The *Prototaxites* disappeared, probably due to the increased size of shrubs and trees which would have shaded the organisms and prevented them from using sunlight for photosynthesis. Photo and more info on the uncertainty surrounding these organisms here.

Lichens have thus been around for a while and have changed their shapes and forms.

What makes up a lichen?

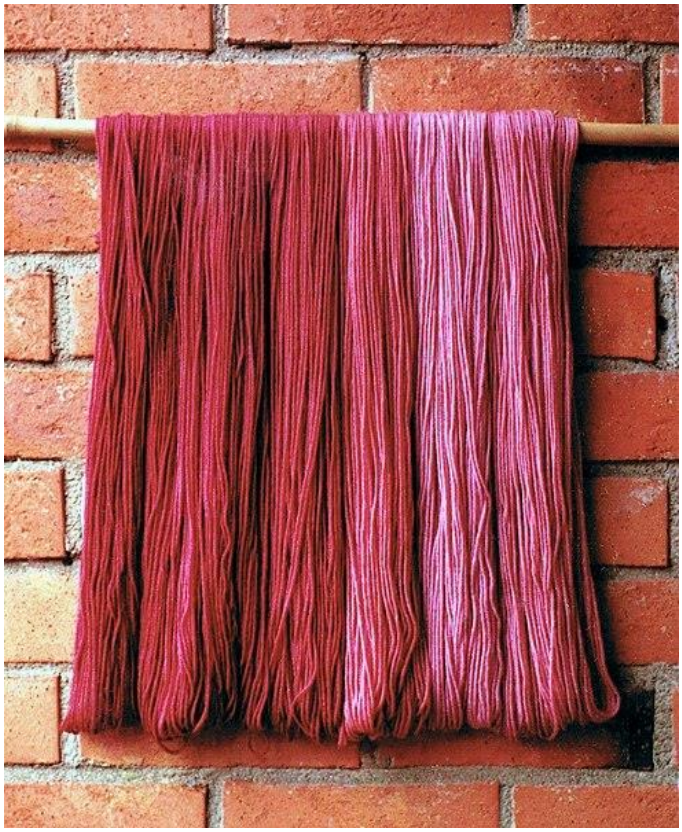
Lichens are full of chemicals.

To differentiate one species from another, lichenologists - the people who study lichens - apply bleach or caustic soda (among other things) on the thallus which creates a chemical reaction and causes the colour of the lichen thallus to change. Based on this colour, we can distinguish between two lichens that are morphologically similar but structurally different.

This type of test must be carefully done because it kills the lichens. Often the chemicals are applied to a very small part of the thallus and only to a few lichens found on the substrate - the surface on which the lichen is found.

In the past - and still today - lichens were used for dyeing. Lichens are full of chemicals and mixing them with other products, such as ammonia, creates colours which are interesting for colouring materials such as wool. In Scotland, a place where there was and still is a great deal of wool production, certain species of lichen were used extensively for dyeing, first on a small scale and then with commercial purposes. Three-legged cauldrons were often seen in the Scottish Highlands where lichens were boiled. The last producers of wool and traditional clothing ceased production in 1997.

The photo below shows the different colours that can be obtained by dyeing wool with lichens. The darker colours are obtained by dipping the yarns in the mixture several times.



Orcein (pigment obtained from lichen) dyeing of wool from lichen. Credit: W. Carter on Wikimedia. CC0 1.0 Public Domain

Despite this, lichens, as we have already said, grow very slowly and their harvest must be done properly, considering the time they need to grow.

Traditional uses of lichens

Lichens have been used and are still used all over the world (Crawford, 2015), especially in traditional medicine. This is due to their second metabolites which are known to be physiologically active and can be used as antibiotics. Other uses of lichens depend on their carbohydrates.

In Europe, the origin of the use of lichens in traditional medicine can be traced back to the 4^{e} and 3^{e} century BC, when lichens were recorded by ancient Greeks. The most common uses of lichens in medicine are to treat wounds, skin and digestive problems as well as in obstetrics and gynaecology. The uses depended as much on the country and customs as on the species found in the area. For example, in the 18^{e} century, the "highlanders" - the inhabitants of the Highlands, in Scotland - mixed the lichen *Parmelia saxatilis* (pictured below), with tobacco. In Sweden, the same species was used to remove warts and in Bhutan it was used to treat leprosy, uterine bleeding and ulcers in children. Other species such as *Evernia prunastri* are used to create perfumes. Lichens are also used in pharmacology and cosmetology. *Evernia prunastri* and *Parmelia saxatilis* are not rare species and can easily be found - sometimes in cities. *Parmelia saxatilis* can also produce a red-brown dye.

Parmelia saxatilis by Jeremy Atkinson on Wikimedia. CC BY 2.0.

Evernia prunsatri by Tocekas on Wikimedia. CC BY-SA 3.0

Can we eat lichens?

Lichens are not digestible by animals, but some species have developed enzymes that allow them to digest the chemical components of lichens.

Reindeer that feed on lichens (the *Evernia* type) have special enzymes called lichenases to digest lichens and their chemicals. Nevertheless, in some customs, lichens are a source of food. The Salish people (North western USA and Canada) consumed lichens. Mixing them with other food sources captured carbohydrates. For example, lichens of the genus *Bryoria* were rinsed and soaked in water for several hours before being worked by hand to remove the vulpine acids (lethal to some gastropods). The lichens were then cooked in a covered fire pit (with moss and earth) heated over a fire for several days. When the lichens were dug up, they were gelatinous and black.

In our society, it is very rare to eat lichens, but sometimes there are few other options….

During the war in Bosnia-Herzegovina (1992-95), some lichens of the genus *Usnea* and *Evernia* were used in porridges and to create flour (Redzic et al., 2010). Finally, in Japan lichens of the genus *Umbelicaria* are edible if prepared properly. They have been used as a food source during famines.

Lichens have therefore been part of human life for centuries, whether it is to feed us, to keep the ecosystem functioning or to stimulate thought.

Activity

On this tree we will mostly see crustose lichens that we have already seen. Can you name them?

Naming the organisms we share the world with helps giving value and build companionship.

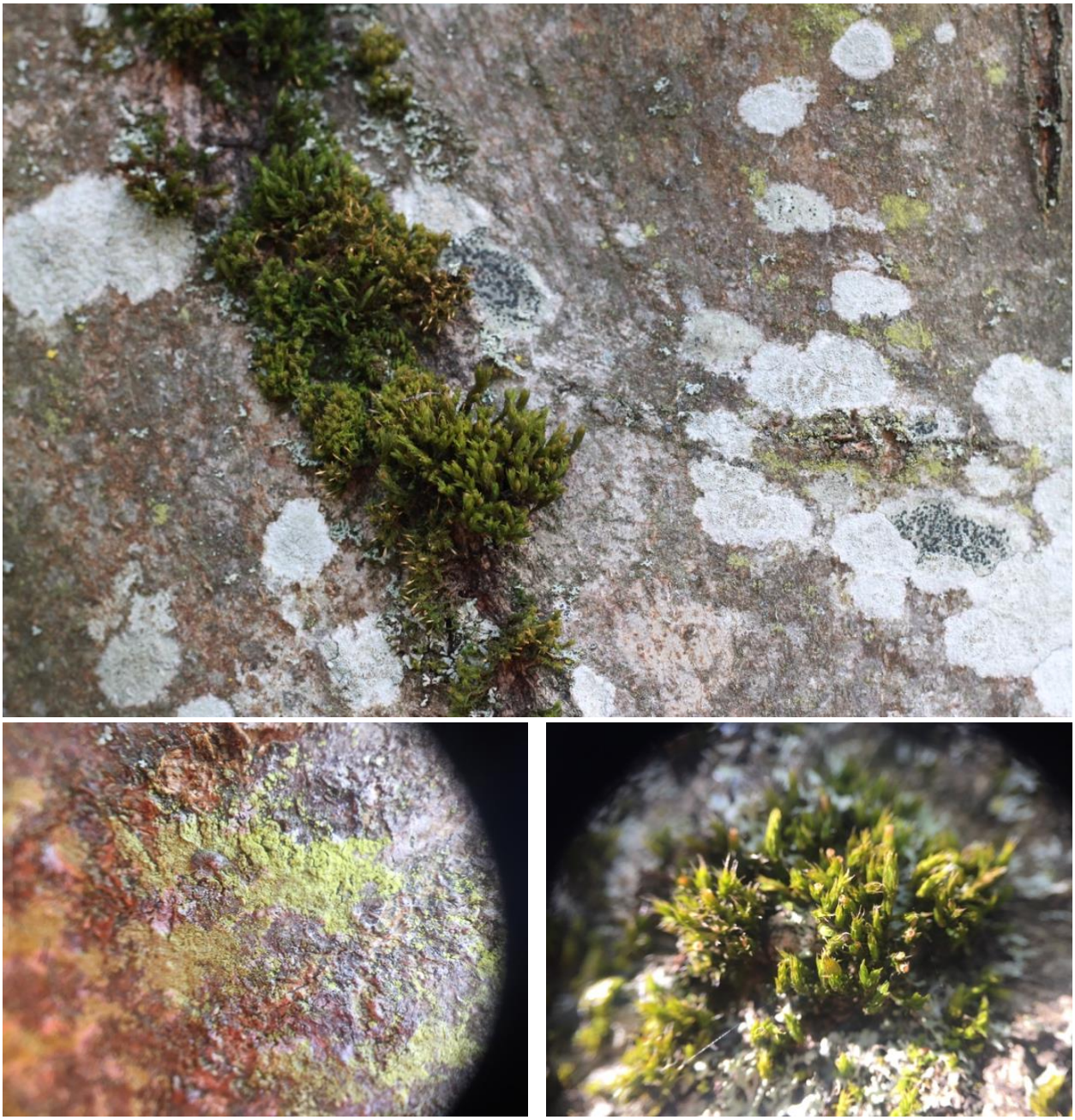
"Philosophers call this state of isolation and disconnection "species loneliness" —a deep, unnamed sadness stemming from estrangement from the rest of Creation, from the loss of relationship. As our human dominance of the world has grown, we have become more isolated, lonelier when we can no longer call out to our neighbors (the other living beings). It's no wonder that naming was the first job the Creator gave Nanabozho."

— Robin Wall Kimmerer, Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants

As a reminder, crustose lichens are lichens that are incrusted in the bark. It is impossible to remove the lichen without the substrate - the surface on which the lichen is found. The powdery green specimens next to this lichen of the genus *Lecanora* are unicellular algae – they are not part of a lichen. You can also see mosses. It's quite common to confuse lichens with mosses despite the fact that they are completely different. A moss is a plant, completely photosynthetic. As we said, a lichen is a symbiosis and is more of a fungus than a plant. Indeed, a lichen is composed of 95% fungus and the rest, algae.

On the picture below, you can see the difference between the unicellular alga – the powdery green cells that sticks onto your finger when you press it against the bark, the moss and the lichens.

There is a part of the trunk where there is more mosses and this could be due to the water pouring down the trunk. Mosses thrive in heavily watered environments.



Credits: top: Mosses, alga, *Lecidella elaeochroma* and *Lecanora chlarotera*, picture taken by the author (2021). CC BY-SA 4.0. left: Alga, picture taken by the author (2021). CC BY-SA 4.0. right: Moss, picture taken by the author (2021). CC BY-SA 4.0.

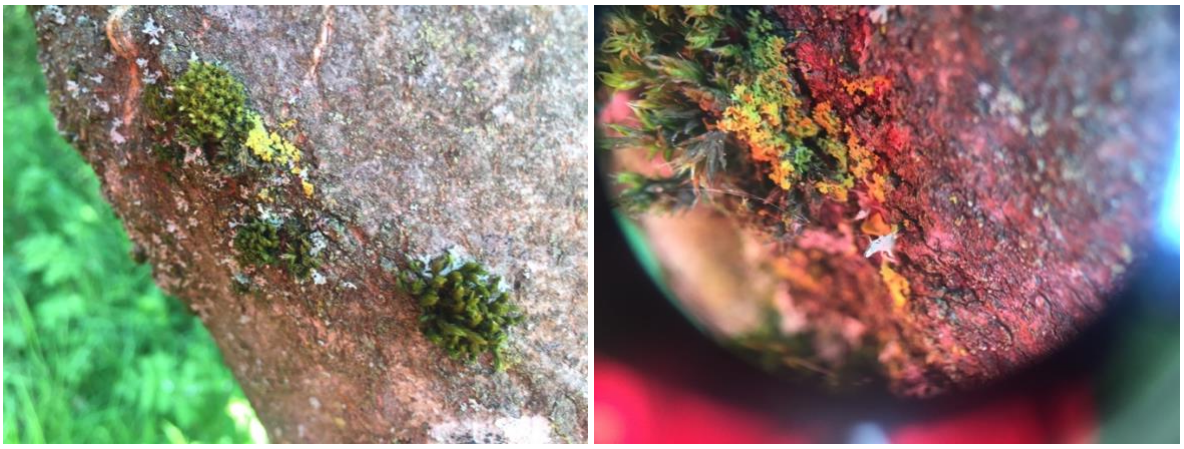
Credit: *Lecidella elaeochroma, Lecanora chlarotera*, mosses and alga, picture taken by the author (2021). CC BY-SA 4.0.

There are some other lichen species that are in minority but if you look for it you will be able to find them.

There are some *Physcia,* genus that we have already seen.

Credit: Tree trunk with lichen species, picture taken by Lucie Pestiaux (2021). CC BY-SA 4.0

A new type of lichens that we have not seen yet is *Candelaria concolor*. This lichen is hard to see with the naked eye. The lemon yellow to green thallus has a size of 0.5 to 2cm and is minutely foliose. The lobules - small lobes - are erect and produce dense clusters on the surface of the thallus ending with soredia on the margins. This species develops in dry well-lit environments.



Credit: *Candelaria concolor*, picture taken by Lucie Pestiaux (2021). CC BY-SA 4.0.

Lastly, you might spot, *Phaeophyscia orbicularis*. It has adpressed orbicular thallus of up to 3cm diameter, is very variable as it can be pale brownish grey to brown to black. The lobes are long and can be divided at the tips. This lichen is common on nutrient- enriched (enriched due to pollution) bark, twigs and basic stones. It is especially common in urban areas on concrete and trunks as it very tolerant to NO2 (released by car fuel).

At the next halt, I'll take you on a dive into the reproduction of lichens and like mushrooms, it's exciting but not always obvious!

References

- Information on Prototaxites was first found in:
Sheldrake, M. (2020). Entangled life: how fungi make our worlds, change our minds & shape our futures. Random House.

- Crawford, S. D. (2019). Lichens used in traditional medicine. In Lichen secondary metabolites (pp. 31-97). Springer, Cham.

- Redzic, S., Barudanovic, S., & Pilipovic, S. (2010). Wild mushrooms and lichens used as human food for survival in war conditions; Podrinje-Zepa Region (Bosnia and Herzegovina, W. Balkan). Human Ecology Review, 175-187.

Let's meet in Murieston Park ! As always more details on the location on the map 👇👇

Murieston Park

The reproduction of lichens

How do lichens disperse and reproduce?

Like fungi, lichens have quite complex and diverse reproductive strategies. The strategies that the lichens use depend on the environmental conditions.

To begin with, only the fungal partner can reproduce sexually. The photobiont (the photosynthetic partner) and the mycobiont (the fungal partner) together can reproduce asexually.

But what is the difference between sexual and asexual reproduction?

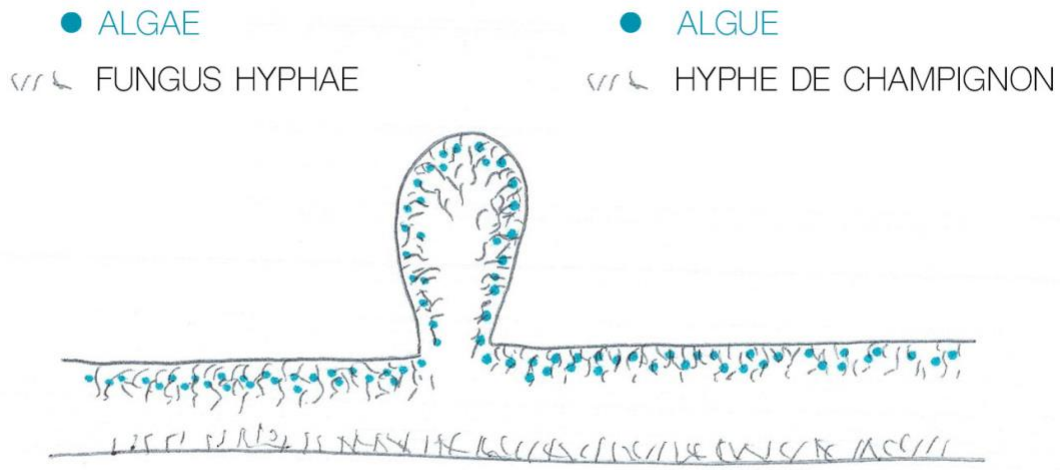
Asexual reproduction means that the offspring is created by only one parent without the fertilisation and the production of reproductive cells - called the gametes.

In sexual reproduction, offsprings are produced by two partners of different sexes. These partners produce gametes that are morphologically and genetically different. The union of these gametes produces a zygote that will become the offspring.

ASEXUAL REPRODUCTION IN LICHENS

This is done by fragmentation, by the breakage of specialised cells called soredia and isidia, which are dispersed by the force of the wind or the trampling of animals. For example, when a bird walks on the branches of a tree and fly to another tree, it may disperse the isidia on this other tree.

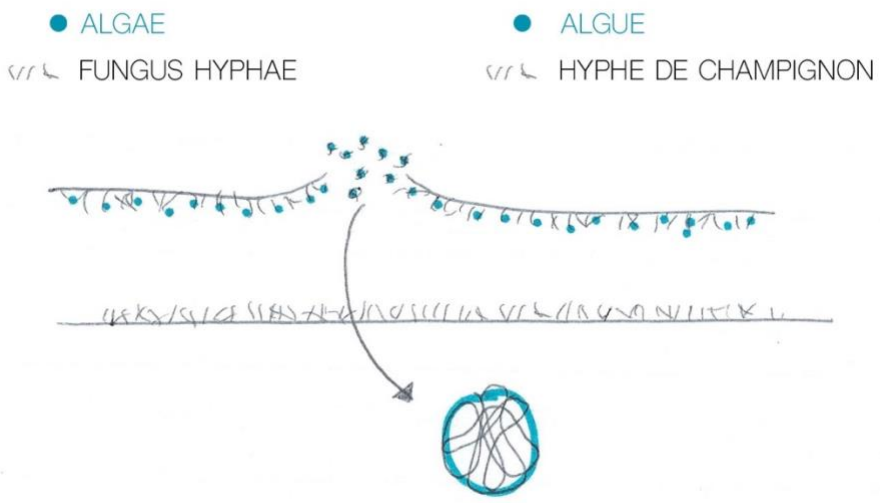
Isidia are small structures formed on the surface of the thallus that can detach from it. Both partners (fungus and algae) are present inside the isidia (see diagram). The forms of this structure are varied and constitute an important element in taxonomy. The second picture in the slideshow is a picture of the isidia of



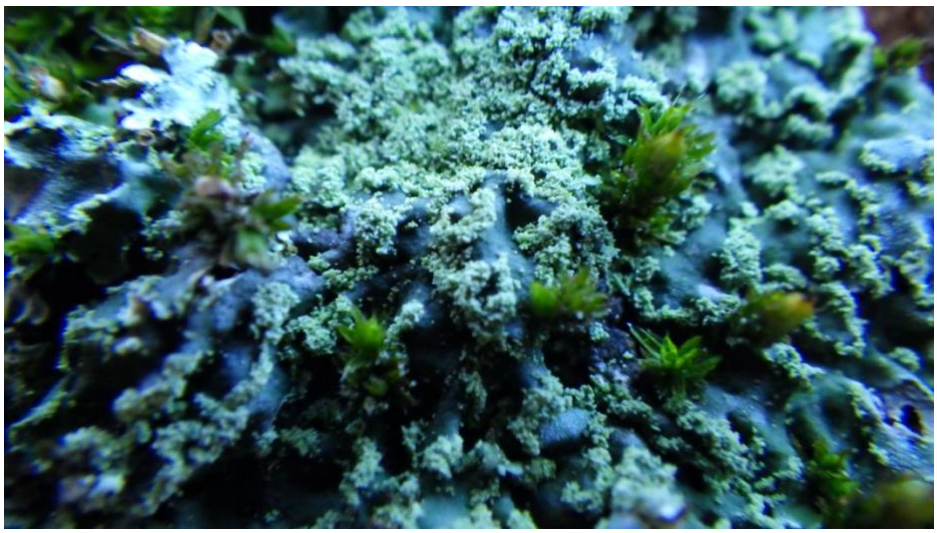
Credit: Diagram representing the isidia, created by the author (2020) under a CC BY-SA 4.0 license

Credit: *Parmelia saxatilis*, by Ed Ubel on Wikimedia CC BY-SA 3.0

Soredia, (soradium in singular) produced by soralia (soralium in singular), are small mealy or granular masses consisting of small clusters comprising an algal cell surrounded by fungal hyphae. These soralia are created as a result of interruptions in the cortex (the upper surface of the lichen thallus). Soralia can be diffuse and found all over the thallus or they can be well delimited. They are liminal when they develop on the thallus, marginal when they are formed at the margin of the thallus and terminal when they are located at the end of the lobes.



Credit: Diagram of the sorelia producing soredia (the little ball at the bottom), created by the author (2020) under a CC BY-SA 4.0 license.



Credit: Sorelia with soredia of *Punctelia subrudecta,* picture taken by Christian Thirion and used with permission, under a CC BY-SA 4.0 license.

Finally, the mycobiont (the fungus) can produce spores that are not involved in the sexual process. These spores are called conidia (or pycnospores). They are produced at the end of hyphae and vary in shape and size. The organs that contain them are called pycnidia. The pycnidia containing the conidia are dispersed without the photobiont and therefore must find an algal partner in order to reconstitute a lichenised thallus.

SEXUAL REPRODUCTION IN LICHENS

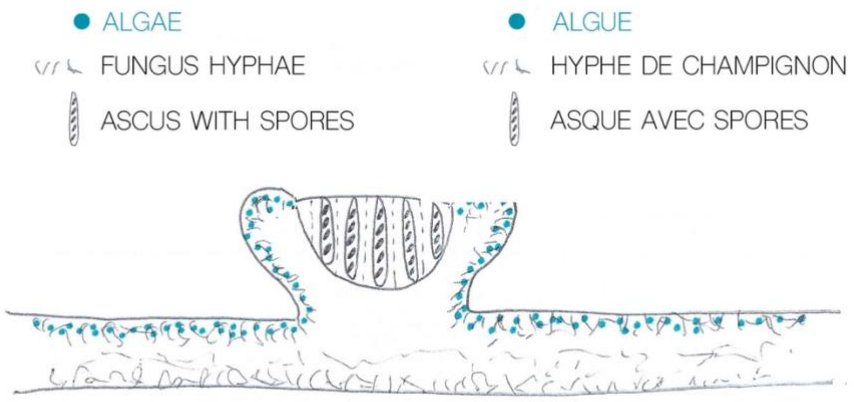
There are two main forms of sexual reproduction: apothecia and perithecia. These forms produce spores in asci (plural, ascus in singular) (see diagram). When the spores are dispersed, they must find an algal partner in order to form a lichen.

How does the fungus overcome the problem of finding a photosynthetic partner to "lichenise" ?

Different species of lichen will find different strategies to overcome this problem. Some species will have their spores agglutinated with some cells of the alga or cyanobacteria so as to have a better chance of developing. Others may survive by forming a symbiosis with other algae (which are not normally their partners) or may insert their hyphae into a neighbouring lichen to steal some of its algae (see Science Infuse file, only accessible in French).

Note: Today, one in five of all known fungi species can form a lichen. Some fungi formed lichens earlier in their evolution but have lost this ability. Other fungi have had different photosynthetic partners during their evolution. Finally, some fungus species can choose to live in symbiosis with algae or live independently (Sheldrake, 2020).

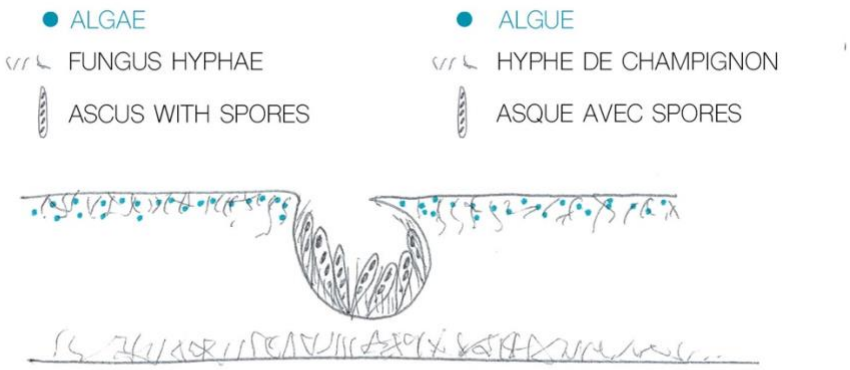
The **apothecia** are cups that can be concave, convex or flat (depending on the species). There are two types of apothecia, those called lecanorine which contain a layer of cells of the photobiont - the algae or cyanobacteria - and lecidine which do not.



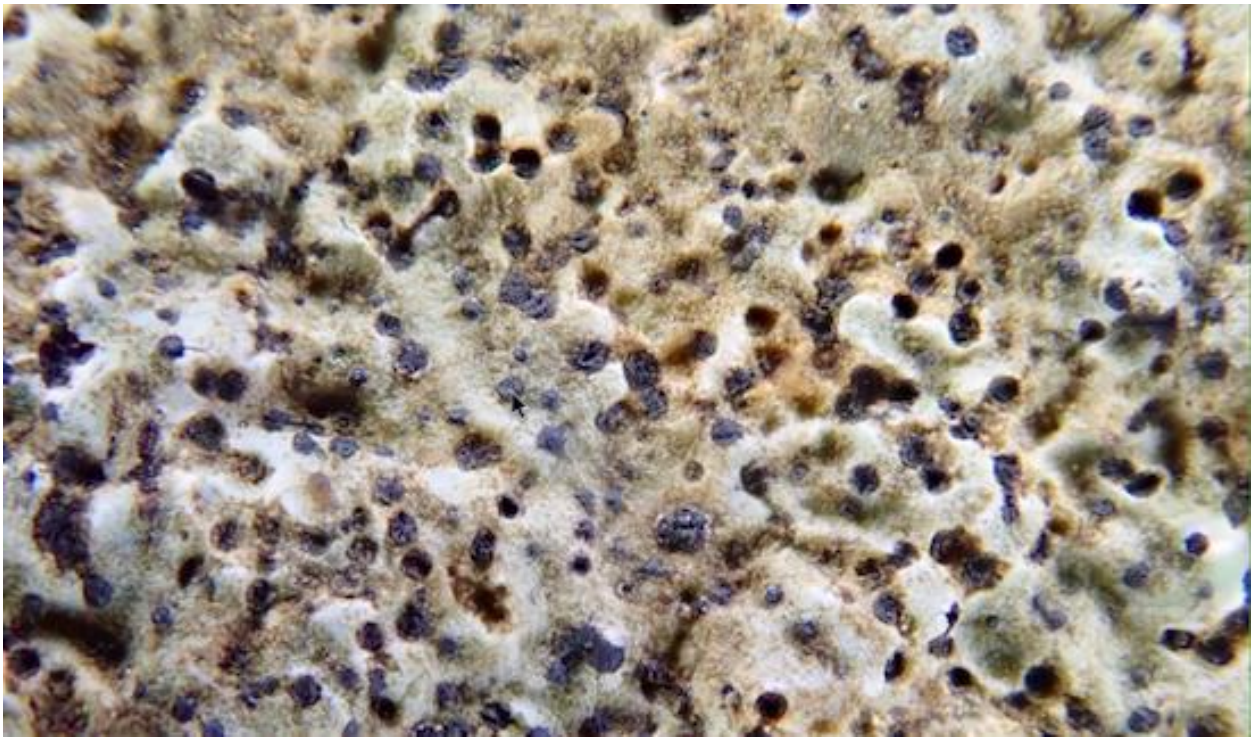
Credit: Diagram of the apothecia, created by the author (2020) under a CC BY-SA 4.0 license.

Credit: Apothecia of *Xanthoria parietina*, picture taken by the author (2020) under a CC BY-SA 4.0 license.

Perithecia are small wombs embedded in the thallus. Contact with the outside environment is through a small punctiform cover at the top of the perithecia called an ostiole. The lichen in the slide show below is *Bagliettoa calciseda* (photo shared at the British Lichen Society meeting).



Credit: Diagram of the perithecia, created by the author (2020) under a CC BY-SA 4.0 license.



Credit: *Bagliettoa calciseda, picture taken by a member of the British Lichen Society, used with permission, CC BY-SA 4.0.*

The process by which the genes of the algal partner and the fungus are combined is still poorly understood despite the fact that we know the structures well.

Hopefully, this introduction will help you identify lichens as the reproductive apparatus is an important criterion. In the next step, we will discuss identification and these steps.

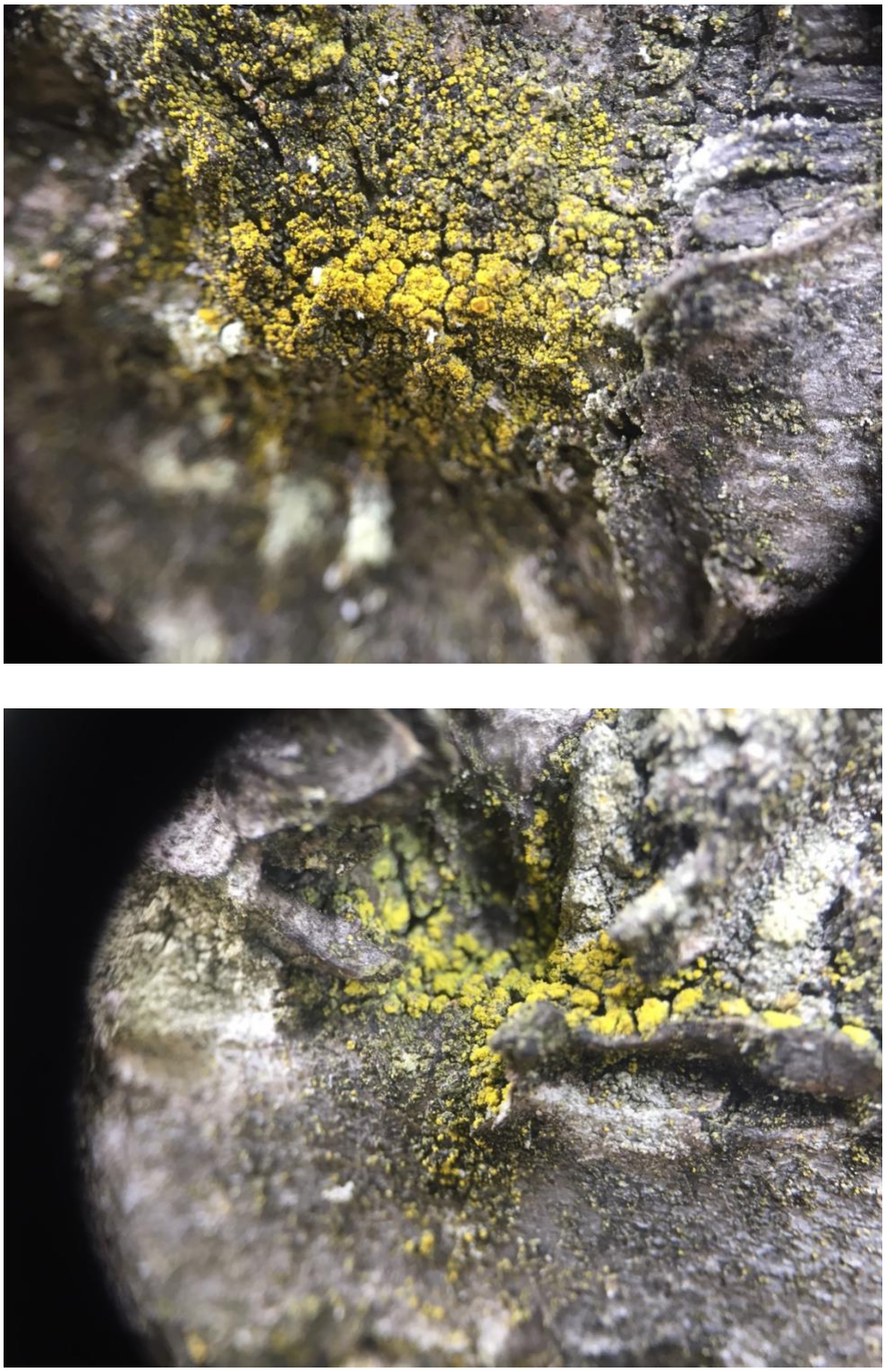
Identification activity

We will introduce new species: *Candelariella reflexa, Lepraria, Hypogymnia physodes*, a specimen from the genus *Melanohalea* and *Evernia prunastri.* Some specimens of the genus *Physcia* are also present. Can you spot them?

Credit: *Physcia spp.,* picture taken by the author, Lucie Pestiaux (2021). CC BY-SA 4.0.

Credit: *Candelariella reflexa* (the yellow lichen) and *Lepraria* (blue-green powdery lichen), picture taken by the author (2021). CC BY-SA 4.0.

Candelariella reflexa is a crustose lichen. The crustose thallus is formed of yellow to yellow-green granules. This lichen is very similar to *Candelaria concolor* and can only be differentiated if you look closer to it. The latter has small folioles (and can be categorised as a foliose lichen) compared to the former which is a crustose lichen.



Credit: *Candelariella reflexa*, picture taken by the author (2021). CC BY-SA 4.0.

We have talked about the genus *Lepraria.* The species are difficult to tell apart so we will leave that and already identify the main genus. If you want more information on the species of the genus *Lepraria*, you can check out the identification key here and more information on how to use an identification key here. On the second picture below, you can see the powdery granules (soredia) which are the reproductive apparatuses of the lichen.

Credit: *Lepraria,* picture taken by the author (2021). CC BY-SA 4.0.

At the time I did the lichen identification, I could also see the sporophytes of the moss (the reproductive apparatuses of the mosses). Can you still spot some mosses ?

Credit: Sporophytes of the mosses, picture taken by the author (2021). CC BY-SA 4.0.

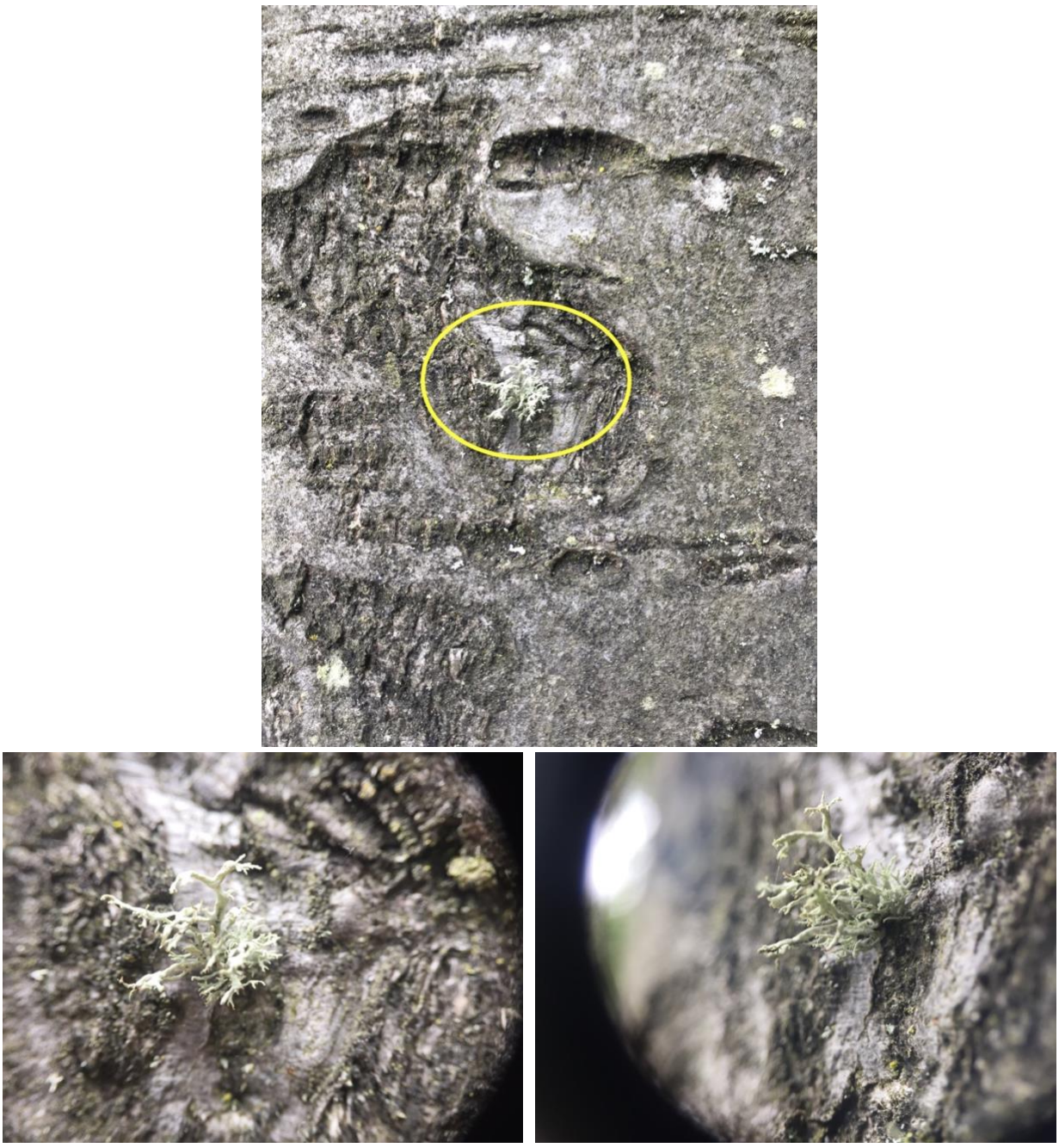
We have briefly talked about *Hypogymnia physodes* but I will introduce this specimen a bit more just now.

Hypogymia physodes is a foliose lichen and has a shiny grey-green with narrow swollen and hollow lobes. The under-surface of the lichen is light brown at the margin and dark brown to black in the centre. The lobe ends are turned up and have soredia on the underside. This genus is known to not have any rhizine and is thus attached directly to the substrate by patches of fungal hyphae. This species is common on trees, mosses, and rocks and in places polluted with SO_2 (sulphur dioxide).

Credit: *Hypogymnia physodes*, picture taken by the author, Lucie Pestiaux (2021). CC BY-SA 4.0.

Credit: Close-up of *Hypogymnia physodes*, picture taken by the author, Lucie Pestiaux (2021). CC BY-SA 4.0.

Evernia prunastri. This species is often confused with fruticose lichens as it is attached at one point, however, the distribution of the algal layer makes it belong to the group of foliose lichens. The thallus is strap-shaped and is yellow to green grey on the upper cortex. The lower part of the thallus is much paler with white patches due to the lack of algal layer underneath.



Credit: *Evernia prunastri*, picture taken by the author, Lucie Pestiaux (2021). CC BY-SA 4.0.

Lastly, I want to show you the spark of colour when a fungus attacks a lichen. This type of fungus is called a lichenicolous fungus. On the picture, these are the small orange dots on the powdery *Lepraria* spp.

Credit: Lichenicolous fungus on *Lepraria*, picture taken by the author, Lucie Pestiaux (2021). CC BY-SA 4.0.

References

For more detailed information on lichens, as well as to have access to a determination key, I recommend you check the references (only accessible in French):

Sérusiaux, E., Diederich, P., & Lambinon, J. (2004). The macrolichens of Belgium, Luxembourg and northern France. Keys to identification. Work from “Musée national d’histoire naturelle Luxembourg.

Let's meet at the Dalry cemetery…. Some spooky discoveries await! As always, more details on the location on the map 👇👇

DALRY CEMETERY

End of the walk

Credit: Dalry cemetery, picture taken by the author, Lucie Pestiaux (2021). CC BY-SA 4.0.

We are at the Dalry cemetery. The last time I came, I was astonished by the wilderness of this place. The disorganised orchestra of flowers and plants, of fallen stones and names of dead. I

imagined the souls and the ashes of the dead growing into wild plants. I could see life cycling from death to life. I could feel the interconnections between all beings, between the animate – the plants - and the inanimate – the dead buried and the stones. I touched lichens eroding the stones, highlighting the always changing cycles of life. Wilderness is in the interstices of the over-built environment, where life finds a place to grow and thrive. Learning to observe this life within the cement, this emergence of colour in the grey requires to pay attention to the details and to other more-than-humans. I found peace with the dead, and the bees, with the lichens and the flowers.

This stroll in Dalry Cemetery made me think of the study carried out by Anne Pringle studying the demography of lichens in Petersham Cemetery, Massachusetts. She is looking at the demography of lichens to answer this question: Why do organisms age?

This is especially interesting as it is thought that the vast majority of mycelial fungi (thus, excluding single-celled organisms such as yeast) are immortal (Osiewacz, 2002). What Anne Pringle (2018) found is that what was considered an individual (lichen) does not seem to age and senesce, but some parts might detach. The question thus is not if the lichen ages but what is an individual and what enables organismal behaviours and coherence?

Credit: Wild in the graves, picture taken by the author, Lucie Pestiaux (2021). CC BY-SA 4.0.

Credit: Lichens transforming the graves, picture taken by the author, Lucie Pestiaux (2021). CC BY-SA 4.0.

Credit: Lichens in MEMORY, picture taken by the author, Lucie Pestiaux (2021). CC BY-SA 4.0.

Credit: Where is the death? Where is the life?, pictures taken by the author, Lucie Pestiaux (2021). CC BY-SA 4.0.

Such mysteries show how much is unknown right below our feet. It highlights the connections between all beings. The ashes of a dead human enable the growth of a plant. The stone of the grave became the support on which the lichen grows.

It also shows other ways by which organisms live in the world. Lichens might be immortal, always changing and growing.

We have reached the end of the walk. Thank you for participating and joining until the end of this adventure. Thanks also for having opened your ears and your eyes to discover this peculiar organism and its diversity.

I hope this walk has made you think about the presence and importance of lichens in the urban ecosystem and in our understanding of natural phenomena. You will have noticed that our ideologies influence what we see and what we want to see (like Schwendener who talked about the alga being the "slave" of the fungus - see information at the Leopold Park on symbiosis).

Current discoveries about fungi and other organisms, such as lichens, reveal ways in which beings live on our planet. Perhaps the crises that are coming (social, ecological, and political) will trigger changes in our perception of the world, deconstructing a nature/culture dualism, and rethinking the place of human in a world made of complex networks of interactions.

In any case, I hope this walk is a step towards discovering the city in another way, decolonising urban spaces from anthropocentric ideas and seeing them not as only human spaces, but as complex interactions of different species.

References

Osiewacz, H. D. (2002). Aging in fungi: role of mitochondria in Podospora anserina. *Mechanisms of ageing and development*, *123*(7), 755-764.

For more information on Anne Pringle's research, check out this video or the article:
Pringle, A. (2017). Establishing new worlds: the lichens of Petersham. *Arts of Living on a Damaged Planet: Ghosts and Monsters of the Anthropocene*, G157-G167.

Extra content for the curious

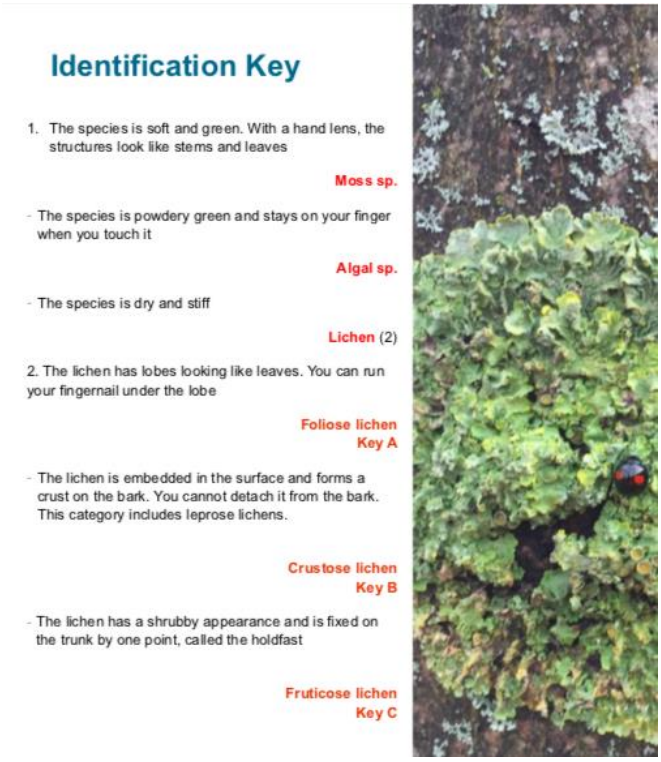
The identification of lichens

To identify lichens, two criteria are important:
- The forms of the lichen (foliose, crustose, fruticose, leprose, see here for more info)
- The reproduction methods (see here for more info)

Other details are important such as the colour of the lower surface of the lichen, the type of rhizines (which are the attachments that allow the lichen to hold onto the surface). The rhizines can be single or double (among others).

What is an identification key?

It is a tool that allows you to identify a living species (animal or plant). The key (document) contains a series of questions that allow you to find the name of the organism in front of you, based on observable morphological features. Below is an example of some questions found in an identification key. I will refer to an identification key as ID key in this text. A full ID key that I created based on the urban lichens I found in Edinburgh and in Brussels can be found here.



Credit: Screenshot of an ID key created by the author (2021), under a CC BY-SA license.

How does an ID key work?

In an ID key, you read the first statement. If it matches (one of) the morphological traits you see on the organism you are trying to identify, you continue on to the next statement referred to with a number. You continue following the numbered statements until you find the name of the lichen (or other organism) you are trying to identify.

What is taxonomy ? How do you name a species ?

Taxonomy is a way of naming and recognising species. It is a similar process to naming humans with their first name and their last name. For example, your family name indicates the larger family to which you belong, and the first name represents your individuality within that family.

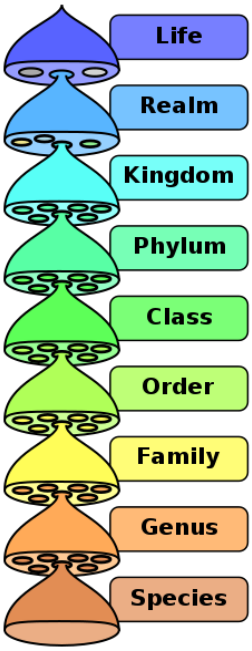
Remember the species we saw: *Xanthoria parietina, Physcia adscendens, Candelariella reflexa*. In general, the first part of the name is the genus (like the family name for humans), indicating the family to which the individual under study belongs. Then, *parietina*, the second part of the word indicates the species. This is more unique - like your first name.

Before 1753 (in the early 18^{e} century), plants were differentiated based on a description. For humans that would be like saying: "the person with a pointy nose".

What's wrong with this kind of description?
It is too long and complicated to use in everyday life.

In 1753, Linnaeus started to use (Latin) names to differentiate plants... which is much easier. There are several taxonomic ranks, which are classifications ranging from broader families to the most precise (the species name).

Here is an example of the different ranks of life:
Kingdom > Division/Phylum/Branch > Class > Order > Family > Genus > Species



Credit: Classification ranks used in taxonomy. Credit: Taxonomic ranks, by Awkwafaba found on Wikimedia under a CC BY-SA 4.0 license

For example for *Xanthoria parietina*, its taxonomy would be:
Fungus > Ascomycete > Lecanoromycetes > Teloschistales > Teloschistaceae > Xanthoria > parietina

As you can see, these are mainly Latin words.

Now that you know some common species in the urban ecosystem, you will be able to identify them when you walk down the street! How fun is it to greet other organisms!?

This is the end! Thank you for joining me on this journey.

Your feedback

I would appreciate your feedback - positive and/or negative - on the walk. You can access a questionnaire on the website (Contact page). It won't take you more than 5 minutes! Thank you in advance.

Contacts

Thank you again for your participation. If you find other lichen species that you have identified, or would like help with identification, please contact me at lichenwalk@gmail.com.