LICHEN WALK

A walk to discover lichens in Edinburgh
A new perspective on the city

A 4 km walk to discover lichens in the city of Edinburgh.

The *Lichen Walk* project aims to introduce the inhabitants or any visitors of Edinburgh to the presence of lichens in the urban ecosystem. It invites participants to discover another facet of the city and to observe their surrounding environment. Cities are often seen as environments created for and by humans. However, other living beings colonise the cervices and interstices of the city, creating hidden wilderness. On this walk, we will observe these spontaneous movements of life by learning about lichens in the city.

I believe that to change cities into sustainable spaces, we must welcome more-than-human living organisms into urban space and recognise their presence and importance.

Follow this walk to learn more about what a lichen is, its importance in the urban ecosystem, its symbiosis - a close relationship between a fungus and an alga - and the mysteries this organism holds.

How does it work?

The 4 kilometer walk lasts about 3 hours, stopping at each destination. All the interactive content of the walk is available online on the WALK tab of this website. The content is formatted into blog posts and those can be read on printed document (see the PDF document below), or on your phone. The content can also be listened to thanks to the audio accessible on each post. To enable the best experience, I recommend that the participants bring a **hand lens** with them. If you have one but you don't know how to use it, you can watch this video from the British Lichen Society. Lichens are small and looking at them with the naked eye can sometimes be complicated. Otherwise, pictures will be available on the website. It is also recommended that you bring **headphones** to listen to the audios and buffer the noise of the city. I invite participants to adapt their route according to their desires and remind them that this content is only a support to stimulate discovery.

The walk has been created with everyone in mind, and is accessible for both novice and experienced naturalists.

The illustrated map (below) will help visualise the destinations where the content about lichens will be presented. If you have access to Google Map, check out the interactive map.

Who are we?

This project is the result of a collaborative project between the University of Edinburgh and Lucie Pestiaux, within the framework of the course "Creating Edinburgh: the interdisciplinary city". The website for the whole course can be accessed here.

VISION AND MISSION

The *Lichen Walk* project aims to raise awareness of the presence and importance of lichens in the formation of the urban ecosystem and their impact on our perception of the world. If we observe them carefully, lichens can allow us to step back from our everyday life and transport us to another world. In addition, the project attempts to introduce amateurs and the more experienced to lichenology - the study of lichens.

After the walk, we hope that the participants will

- Consider the city as a hub of complex interactions, of which lichens are a part.
- Have sparked their interest in urban flora.
- Learn to sense the environment around them by observing the distribution and presence of lichens.
- Be able to identify common lichen species in urban areas.

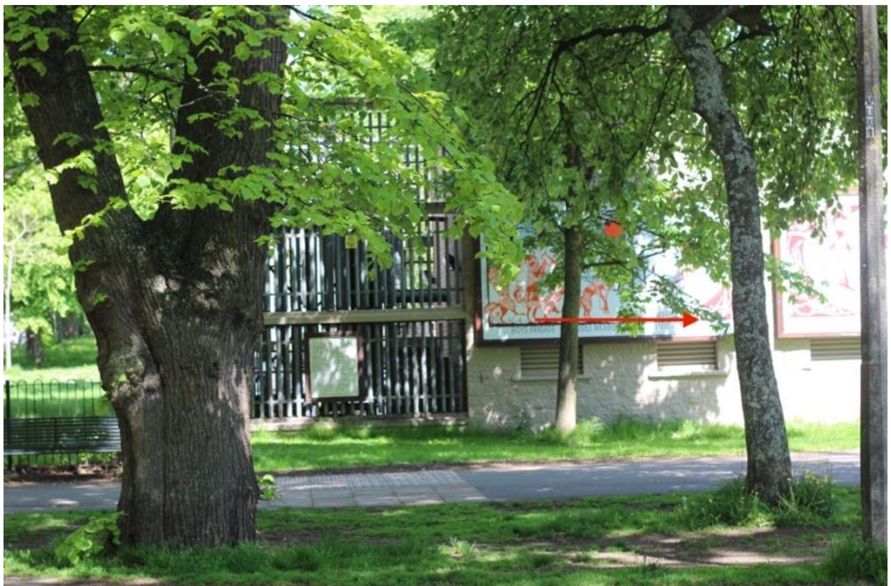
- Know what a lichen is and how the organism functions.

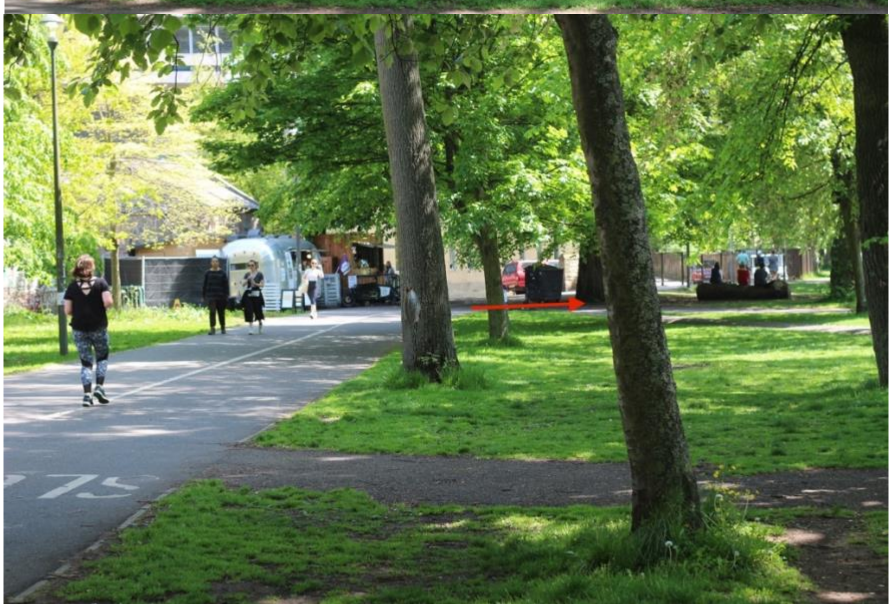
License and Copyright

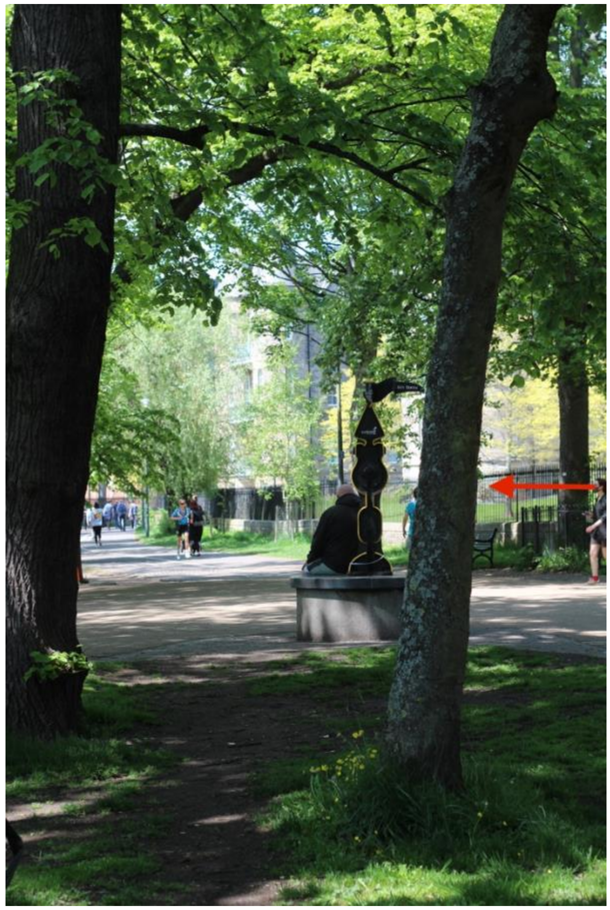
MIDDLE MEADOWS WALK

What is a lichen?

Have you found the tree we will be looking at?







“In the Western tradition there is a recognized hierarchy of beings, with, of course, the human being on top—the pinnacle of evolution, the darling of Creation—and the plants at the bottom. But in Native ways of knowing, human people are often referred to as “the younger brothers of Creation.” We say that humans have the least experience with how to live and thus the most to learn—we must look to our teachers among the other species for guidance. Their wisdom is apparent in the way that they live. They teach us by example. They’ve been on the earth far longer than we have been and have had time to figure things out.”

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

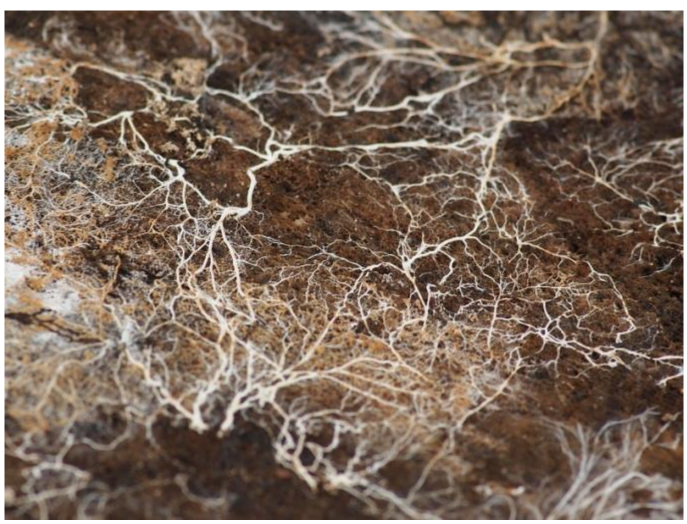
I would like to take you through a world of questions, entanglements, and connections. A world of mystery and imagination. A world where little is known. Through this adventure and journey of lichen discovery, I would like to imagine with you other stories about us, our perceptions, our beliefs and our futures… about the cities. I would like to open a door to another world, a world where we create spaces - like cities - by considering other organisms, like lichens. I would like to defy the division between nature/culture or between human/more-than-human often found in environmentalist movements by highlighting the intricately intertwined relationship between living beings through co-development/co-evolution processes. I hope that through this discovery you will feel the interconnections between all beings, even in an urban environment and will learn of other ways of being in the world by observing lichens.

Lichens (pronounced L-I-K-E-N), as we will see, push us to these reflections and point out to the fact that our bodies do not end at our skin. Lichens invite us to consider new behaviours and new sensitivities. By observing one of the multiplicities by which living organisms can experience the world around us I hope you will travel into other imaginaries.

I suggest you follow me for a few hours of discovery of an organism and another way of living and feeling the world. For this, I ask you to listen, to perceive, to open your senses.

Before you start, I could like you to close your eyes. Feel the ground below your feet, sense the breeze or the strong wind (as it often happens in Edinburgh) on your skin. Can you hear the soundscape of the place where you are standing? Is it busy? Can you hear the variety of living beings around? Some humans chatting, some birds singing, some leaves moving by the wind.

Now imagine mushroom hyphae. 🍄 If you do not know what hyphae are, let me introduce you to these incredible living structures.

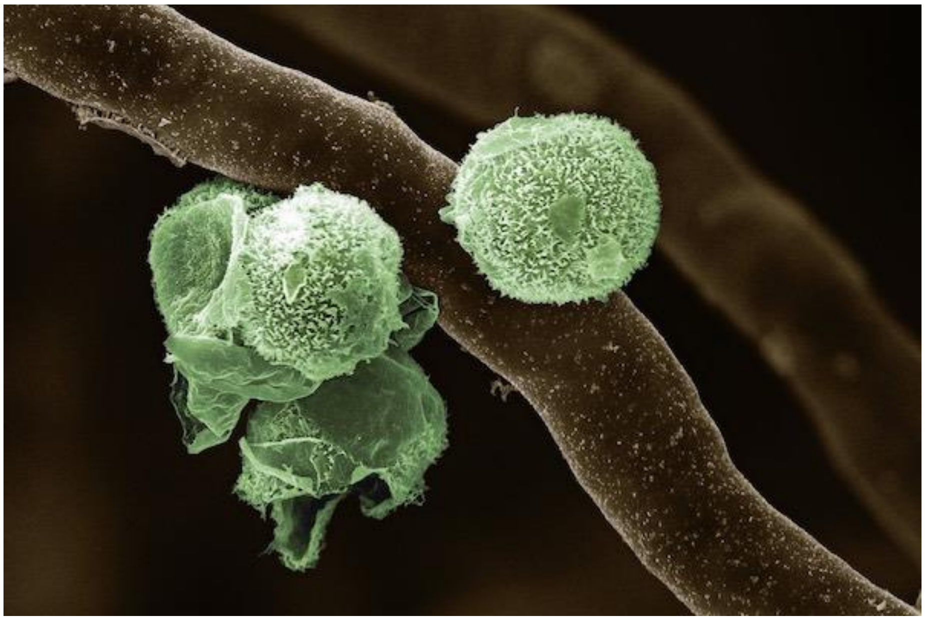


Credit: Mycelium by Kirill Ignatyev on Flickr, CC BY-NA 2.0

Hyphae are long, white, earthy filaments and form the structure of fungi. Assembled together in a decentralised and anarchic fashion, hyphae form the mycelium. The mycelium is not a thing, it is a process. It is constantly being created and in movement. You can access incredible videos of the movements in the hyphae here. Water and nutrients flow through the networks of mycelia which can be stimulated electrically. Some fungi therefore conduct electricity along their hyphae, similar to the impulses of nerve cells in animals.

Despite their delicacy, hyphae have incredible strength; they push the earth, but also sometimes cement (like *Coprinus comatus*). Imagine these hyphae in the earth, under your feet, in this bubbling ecosystem, surrounding the roots of plants. Hyphae (called mycorrhizae) often surround the plant root and create an exchange, bringing nutrients to the trees or plants and taking carbohydrates produced from photosynthesis in exchange. I suggest you watch this video by Merlin Sheldrake which is a laser analysis of the relationship between the hyphae of a fungus and a plant. The hyphae also form the structure of the mushroom we eat. And, according to some estimates, if you take a piece of mycelium found in a teaspoon of soil and stretch it out, it could be anywhere from a few hundred metres to kilometres long.

Now imagine an exchange between the hyphae of fungi that we talked about and algae. Not the algae you might see on the beach, but small cells.



Credit: Relationship between algae and mushroom hyphae. Photo appeared in a University of Michigan paper here.

In the lichen, the hyphae are not alone, they are entangled in and with alga cells or cyanobacteria. These photosynthetic structures - algae and cyanobacteria - use the energy of the sun as well as carbon dioxide (CO_2) to produce their energy. This cooperation between photosynthetic and fungal forms creates the lichen. This intimate relationship of cooperation (called a symbiosis) allows both organisms to live in places where they could not have lived alone.

Lichens are worlds, they are ecosystems. They are inhabited by hundreds if not thousands of other species including fungi and a myriad of bacteria (Pingle, 2017).

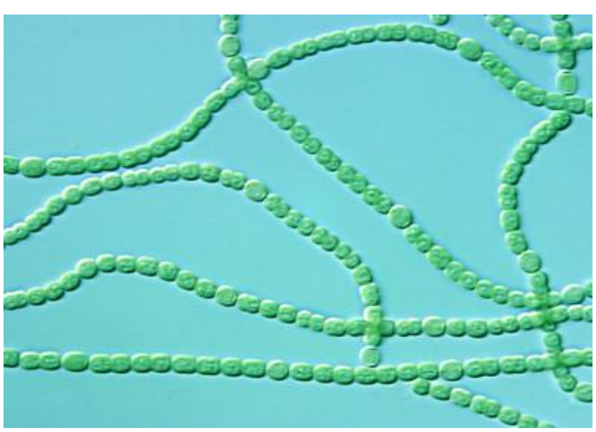
So how do we define these organisms that form an assemblage of many species, that are not "one" but are at the same time. Where is the boundary of the lichen? What is a lichen?

A lichen is a symbiotic organism. This means that it is an intimate relationship between different species where one organism is considered the host and the other is the symbiont. Symbiosis is a spectrum that contains several kinds of relationships between living organisms, including mutualism on the one hand and parasitism on the other.

Mutualism is a relationship where both organisms benefit from the association. For example, humans depend on their microbiome - which is the community of microbes in the gut and their genetic material - to digest food. Some research also shows that the microbiome in our gut can affect our immune system and moods. On the other hand, the microbes, through the symbiosis, live in an environment where they have access to food and are protected. Both organisms (human and microbe) benefit from this relationship.

In a **parasitic** relationship, one organism benefits from the relationship while the other organism loses. The SARS-CoV-2 virus is a parasite for humans and generates a disease that we all know by now: the coronavirus. The virus, on the other hand, finds a comfortable environment in humans where it can reproduce.

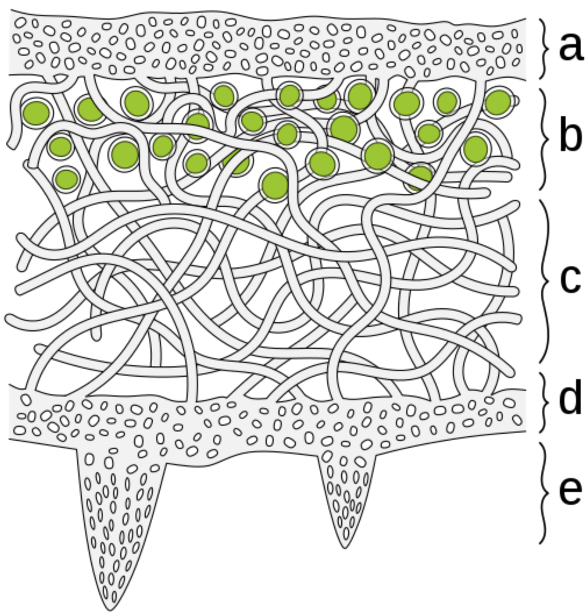
Well, back to our lichens....



Credit: Cyanobacteria by James Golden, University of San Diego California accessed in Flickr, CC BY-NA-SA 2.0

A lichen is a stable and lasting mutualistic association between fungi and an alga or cyanobacterium.

Cyanobacteria look like algae but are actually single-celled or colonial bacteria (see photo).



Credit: Cross-section of the thallus of *Nefornus* lichen found on Wikimedia, CC BY-SA 4.0.

The diagram above represents a cross section of the thallus. The algal cells are entangled in the fungal hyphae (part b). The thallus is the visible surface of the lichen and consists of several layers of cells. The *thallus* is a word I suggest you remember, as it is an essential characteristic for naming the lichen.

The upper and lower parts of the diagram represent the cortices (a, upper cortex and **d,** lower cortex) that protect lichens from their environment. These structures are primarily formed of fungal (mushroom) tissues. At the bottom of the upper cortex is the layer of algae or cyanobacteria when they are in symbiosis with the fungi (represented by the green circles in part b). Then comes the medulla, it is the layer of mushroom hyphae (part **c** on the diagram). The part **e** represents the rhizines, which lichens use to fix themselves to the surface on which they are found.

With the naked eye, we can only see the thallus as well as the lower and upper cortex. If you have access to a microscope, I suggest you take a piece of thallus and cut it in half. You will then be able to see the green layer, the algae, as well as the white medulla.

<u>Now that we know the anatomy of the lichen, let's move on to their functions!</u>

Algae (and cyanobacteria) are photosynthetic organisms. The algae and/or the cyanobacteria are called photobionts. The photobionts capture the energy from the sun, and with water and carbon dioxide (CO2) from the air, they transform it into carbohydrates. Carbohydrates are sugars that provide energy to the lichens that are partly absorbed by the fungal cells.

Algae and cyanobacteria can live without being associated with fungi, but their symbiotic association with the fungus changes them radically (structurally and morphologically).

Note: Photosynthetic organisms are autotrophic - they produce their own energy source. We, humans, get our energy from the food we eat, because we cannot photosynthesise - we are heterotrophs.

The fungus, on the other hand, provides a protected environment and gathers moisture, which prevents the algal cells from drying out. The fungus also provides the algae or cyanobacteria with nutrients. Lichens are always named after the dominant fungus. This will become important when we start learning the names of the different lichens.

Note: Normally, we think of plants as photosynthetic organisms. However, some animals produce their energy from the sun's energy. Have you ever heard of *Elysia chlorotica*? This sea slug is found on the east coast of the United States and has the ability to sequester a chloroplast - the organelle where the process of photosynthesis takes place - from its prey, an alga. This non-permanent symbiosis allows the sea slug to survive for up to 12 months thanks to the energy supply that the algae provides through photosynthesis.

Credit: *Elysia chlorotica* by Patrick Krug accessed on Flickr, CC BY 2.0.

Activity 🌸

On the tree in front of you, can you see the lichens?
Look at the pictures below to help you.

<u>The forms of lichens are very varied.</u>

Can you already differentiate between different morphological forms ? Different colours ?
We will learn a few of those as we go but below, you can find some pictures of different species.

Here are some pictures of the different individuals you might see on the tree in front of you. The name of the species can be found in the caption, below the picture, but we will go more in detail on a few of those lichens later in the walk.

Parmelia sulcata (at the front) and *Hypogymnia physodes* (the small ball at the centre of the picture). Credit: *Hypogymnnia physodes* and *Parmelia sulcata*, picture taken by the author (2021). CC BY-SA 4.0.

Close-up of *Hypogymnia physodes*. For more information on this lichen, check out the identification key created by the author. Credit: *Hypogymnnia physodes*, picture taken by the author (2021). CC BY-SA 4.0.

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

Close-up of *Evernia prunastri* (left) and *Parmelia sulcata* (right). More details on these two lichens can be found on the identification key created by the author. Credit: Close-up of *Evernia prunastri* (left) and *Parmelia sulcata* (right), picture taken by the author (2021). CC BY-SA 4.0.

Credit: *Melanohalea exasperatula* (dark green lichen in the centre of the picture) and *Parmelia sulcate* (lichens around the dark green lichen), picture taken by the author (2021).

Close-up of *Melanohalea exasperatula.* More details on this lichen can be found on the identification key created by the author. Credit: Close-up of *Melanohalea exasperatula*, picture taken by the author (2021). CC BY-SA 4.0.

A common lichen (the bright yellow one), *Xanthoria parietina,* that we will see a lot and talk more about later on this walk. Credit: *Xanthoria parietina*, picture taken by the author (2021). CC BY-SA 4.0.

Lastly, I would like to share a special discovery (already) with you. When I was looking at the lichens on this tree, I spotted a lichen of the genus *Usnea*. This genus is normally present in less polluted environments. It was a surprise to find this individual in the middle of the city. The *Usnea* spp. can be recognised by their long filaments (lobes) that can be stretched out a lot before breaking. These are fruticose lichens. We will talk about what it is at the next halt.

Credit: *Usnea*, *Parmelia sulcata* and *Physcia spp.* (small lichen above the *Usnea*), picture taken by the author (2021). CC BY-SA 4.0.

Credit: *Usnea* spp. on a piece of lobe of *Melanohalea exasperatula*, picture taken by the author (2021). CC BY-SA 4.0.

If you are already more experienced, you can look at the identification key available here and try to identify the different species.

References

- The content of this walk is very much inspired by the book of Merlin Sheldrake:

Sheldrake, M. (2020). Entangled life: how fungi make our worlds, change our minds & shape our futures. Random House.

You can also find amazing videos about fungi on his YouTube account here.

- Pringle, A. (2017). Establishing new worlds: the lichens of Petersham. Arts of Living on a Damaged Planet.

That's the end of this first halt, we meet at the next halt – at the Pavilion on the Meadows park at the pedestrian crossing on Melville Drive. The exact location can be found on the map here! 👇🏾👇🏾

THE PAVILION

The complexity of lichens and their forms

So far, we learned that a lichen is a symbiotic form between a fungus and an alga...

A nice discovery! But it is not that simple.

The world of fungi is complex, and its forms are variable and sometimes incongruous. Look at the lichens on the tree with a magnifying glass or get closer to the lichen to see them with the naked eye... Another world, isn't it ?

Credit: *Xanthoria parietina*, photo taken by the author (2021). CC BY-SA 4.0

Credit: *Xanthoria parietina*, photo taken by the author (2020). CC BY-SA 4.0

The multispecies assemblages

Researchers tried to recreate a lichen in a lab by assembling the different organisms - algae and fungi. But.... a lichen did not emerge from this combination. Further research has shown that the lichen is probably composed of a third organism, a single-celled yeast of the Basidiomycetes phylum (see Box 1).

Two fungi ? Yes... For years, lichens were thought to be an association between an Ascomycete fungus (see box 1) and an alga. This idea had already created controversy at the time in the well-founded taxonomic science. The cooperation between several organisms caused us to question ideas in evolutionary theories. Indeed, evolutionary theories are based on the natural selection of organisms that were most well-adapted to their environment. So, the idea that a species physically seen as 1 individual was, in fact, composed of many organisms was just unthinkable. We'll talk more about these issues and discoveries later in the walk.

The recent discovery of the presence of two fungi was initiated by Toby Spribille (2016) when he and his colleagues studied a yellow lichen (*Bryoria tortuosa*) that produces a poison called vulpinic acid (which helps to keep snails - including other gastropods - away) and a brown lichen (*Bryoria fremontii*) that does not produce these toxic substances. These two species had always been considered different... Yet, they are formed from the same species of algae and fungus.

Then what makes them so different ? By analysing the genes of the lichens, Toby Spribille discovered the presence of genes from Basidiomycetes fungi and when these were removed, everything related to the presence of vulpinic acid disappeared. Spribille continued to do more research analysing different types of lichens and found that this Basidiomycete fungus was present everywhere ! Since then, the definition of a lichen has changed.

For more information on Spribille's research on lichen symbiosis, here is a link to an article.

Box 1: What is the difference between Basidiomycetes and Ascomycetes?

There are five taxonomic groups of fungi (Chytridiomycetes, Zygomycetes, Glomeromycetes, the Ascomycetes and finally the Basidiomycetes). Taxonomy is the grouping of the diversity of organisms that allows them to be identified - see stop 8 of this *Lichen Walk*.

The Ascomycetes represent most of the fungi that are in symbiosis with algae or cyanobacteria in a lichen - 98% (Honegger, 1991) and are in general the largest group of fungi. This type of fungi like yeast, truffles or molds and Penicillin are among the fungi that have asexual reproduction. This reproduction occurs by mitosis (the division of spores) or by budding (e.g. yeast). An important characteristic of this group is the asci, a sac in which eight spores (in general) are found. This is an important group as a source of antibiotics and decomposers. You will have more details on ascus in stop 7 of this *Lichen Walk*.

The Basidiomycetes include most of the fungi we eat, and some plant pathogens. Their reproductive structure, the basidium, is external unlike the Ascomycetes.

Lichens contain many mysteries that we are just beginning to discover thanks to the current genetic technologies. For example, we know that the bacteria that form the thallus certainly have an important function in the functioning of the lichen.

Activity

In front of this tree, what do you see ?

A trunk with some lichens. Different shapes. Various colours.

The trunk is the substrate on which the lichen grows. The lichen does not have a negative effect on the tree as lichens do not have roots. They have rhizines which are small attachments made up of fungal cells that allow the lichen to attach to the substrate. Rhizines are one of the ways to identify different species of lichens, as they can have different shapes - they can be single or double.

Credit: Rhizines of a lichen in the genus *Peltigera*. Credit: *Peltigera praetextata* by Ed Uebel on Wikimedia. CC BY-SA 3.0

The forms of lichens

The thallus can have very different shapes. This characteristic is the first important step to differentiate and identify the species.

- **Crustose lichens**: these are lichens that form a crust on the substrate and that can hardly be detached from this surface because the rhizines are so deeply embedded. This type is the most common, but also the most difficult to identify because of their various shapes. To take the lichen with you, you would have to take a piece of the substrate: the rhizines of the crustose lichens can go into the substrate, both trunk and stone. The photo below is of a lichen often observed in polluted environments. The name of the lichen is *Lecanora chlarotera.*

Credit: *Lecanora chlarotera*, photo taken by the author (2021). CC BY-SA 4.0.

- **Leprose lichens:** these are lichens that have their crust (similar to crustose lichens) entirely formed of small mealy granules. These leprose lichens form a kind of leprosy on their substrate and are characteristic of a habitat sheltered from rain.

Credit: *Phlyctis argena* surrounded by *Parmelia sulcata* (green-grey on the sides) and a *Lepraria spp.* photo taken by the author (2021). CC BY-SA 4.0.

- **Foliose lichens:** these are leaf-shaped lichens. These lichens can be detached from their substrate relatively easily. You can run a fingernail under the lobe to check. The lobe is the outer part of the lichen thallus, shaped like a leaf. The upper cortex of foliose lichens has a different colour than the lower cortex. This difference in colour is due to a different distribution of algae as the lower cortex has no algal layer.

Credit: *Physconia grisea* (whitish-grey lichen) and *Xanthoria parietina* (yellow lichen), photo taken by the author (2021). CC BY-SA 4.0.

- **Fruticose lichens:** these are shrubby (shrub-like) lichens. These lichens have radial symmetry, from all their sides the lichen looks the same. Because of the homogeneous distribution of the algal layers, the lower and upper cortexes have the same colour.

Credit: *Ramalina farinacea,* photo taken by the author (2020). CC BY-SA 4.0.

There are still many different lichen forms, but for now you have enough information to differentiate a few types.

Activity

Can you differentiate between the different forms of lichens on this tree ?
Are there different coloured lichens ?

To look at lichens, you need a magnifying glass. If you don't have a magnifying glass, you can admire the lichens with the pictures below. If you have a magnifying glass but don't know how to use it, I recommend this video from the British Lichen Society.

Can you spot some lichens that we briefly mention at the last halt ?
We will introduce a common lichen species. The name of the lichen is *Xanthoria parietina*. The lichens of this genus (it is like the family, *Xanthoria*) are yellow as you can see on the specimen on the tree. Sometimes these lichens are blue and have yellow edges. Their characteristic is their yellow or blue colour. Their reproductive systems, which are like small yellow mushrooms (see photo) are also another important feature to identify lichens. We will learn more about these structures, called apothecia, later in the walk. They are structures that allow sexual reproduction and contain spores in sacs called asci - structures that define one of the types of fungi that form the lichen, the Ascomycetes.

Xanthoria parietina, photo taken by the author (2021). CC BY-SA 4.0.

On the way to our third halt, think about the question below :
Why do you care about lichens ? Why should we care about lichens ?

We'll meet on Leamington Walk next to the Brunstfield Links at the exact location shown here
👇👇

BRUNSTFIELD LINKS

The importance of lichens

Why are lichens important?

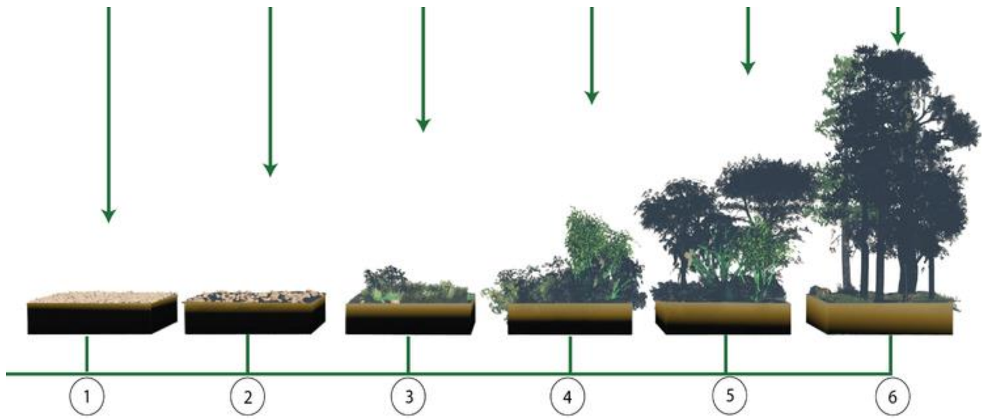
Lichens are pioneer species - they are a link between the animate and the inanimate.

Every environment is constantly changing, this is due in part to climatic conditions, but also to the communities of organisms that make up the environment. Each living being is active in its habitat, it changes it and is changed by it. In environments devoid of vegetation, such as ancient volcanoes or mountain peaks or even cities, pioneer species such as lichens, mosses or grasses create space for other species to colonise.

<u>But how?</u>

Lichens' penchant for rocks has literally changed our planet. Lichen erosion of rocks occurs in two ways. First, lichens, along with the roots of mosses and grasses, create crevices in rocks as they grow and develop. Second, lichens use their arsenal of chemicals to digest the rock. The lichen's ability to erode rock puts it in the category of physical forces. But more than that, lichens as they die and decompose create nitrogen-rich humus and shape the first soils for other plants to grow. Lichens transform the inanimate, like rocks, by including them in the metabolic cycle of life. These symbiotic organisms are the links between what is animate and what is not, what lives and what does not live.

Lichens allow environments to form and prepare a habitat for other plants to colonize. This can be observed in any environment in a dynamic succession phase (see diagram below).



Credit: Ecological succession. Lichens and mosses create habitat for a forest to grow over time. Photo by LucasMartinFrey on Wikimedia, CC BY 3.0.

Lichens, inhabitants of extreme environments. They change the way we see space and the earth.

{Sound of a spacecraft and astronauts}

June 18, 2016, a module from a spacecraft lands in the steppes of Kazakhstan. The astronauts get out, but not alone. Below their seats are a hundred organisms in a box. Among the samples sent into space for a year and a half, there are several species tolerant to extreme conditions including bacterial spores, algae and tardigrades (Box 3) and some species of lichens. This experiment was part of the international astrobiology consortium named "Biology and Mars Experiment" (BIOMEX). The astronauts incubated the organisms outside the International Space Station under extra-terrestrial conditions. A few of these organisms can survive if they are protected from solar radiation, but few - apart from a few species of lichen - can live in space conditions, exposed to cosmic ray radiation. Indeed, when the lichens returned from space, they showed no sign of physiological changes nor in their photosynthetic activity, which they resumed 24 hours after being rehydrated.

Box 3: What is a tardigrade?

Tardigrades are 0.1-1 mm animals and are extremophiles. They can survive in extremely hostile environments such as temperatures of -272 to 150°C and pressures of up to 6000 bar. Deprived of water and food, they enter in cryptobiosis, which means that their metabolic processes are reduced. This state can last up to 30 years.

Credit: Micrograph of an adult Tardigrade from Goldstein Lab on Wikimedia. CC BY-SA 2.0.

But how can these small organisms live in such inhospitable environments?

Lichens living in these extreme regions have a number of adaptations that allow them to survive. They can continue to use photosynthesis as an energy source while enduring temperatures near -20°C. Lichens can absorb water from a saturated, snow-covered habitat. The trick of lichens is the dormant, inactive state they enter when conditions are not good. They stop photosynthesis and can start again when conditions are favourable again.

The impressive tolerance of lichens to sunlight and other stars, to drought, to heat and to extreme changes between freezing, thawing and heating is due to their protection and repair mechanisms at the cellular level. These adaptation methods are not yet well known. Moreover, their symbiosis allows the organisms inhabiting the lichen to be more resistant.

Another experiment on a species known to be very tolerant - *Circinaria gyrosa* - showed that even exposure to a UV radiation dose 12,000 times lethal to humans (6 kilograys of gamma radiation) has no effect on the species. When the dose is doubled (12 kilograys of gamma radiation - 2.5 times the lethal dose for tardigrades), the ability of the lichens to reproduce is impaired, but the species can continue to photosynthesise and survive. This experiment shown that this species is tolerant to Mars atmosphere, temperature, pressure and UV radiation.

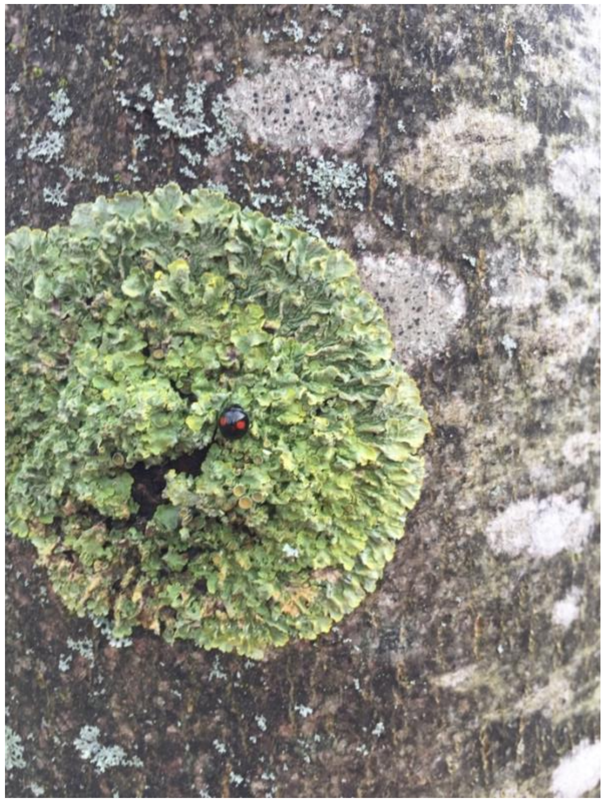
Credit: the thallus of *Circinaria gyrosa,* a vagrant lichen collected in central Spain and resistant to high level of radiation (photo by Sánchez *et al.*, 2012)

Lichens at the base of the food web

In the extreme environments they inhabit, lichens are the primary producers of the food chain and are sources of food for many herbivores like reindeer. Their absence or disappearance could cause the extinction of many individuals.

In our regions, lichens are inhabited by many species such as ladybugs and springtails. If you observe carefully you may see some insects (spiders, aphids amongst others). Even birds use the thallus of lichens to form their nests. Gastropods also feed on the lichen thallus (see photo below).

Credit: *Xanthoria parietina* eaten by a gastropod*,* photo taken by the author (2020). CC BY-SA 4.0.



Credit: *Xanthoria parietina* with a ladybird, photo taken by the author (2020). CC BY-SA 4.0.

Lichens store carbon

Lichens cover 8% of the earth's surface (Ahmadjian, 1995). Through the process of photosynthesis, lichens store carbon and release oxygen changing the composition of the atmosphere. Lichens do not represent a carbon capture as great as trees, which are larger and more massive, but they do store a significant proportion of carbon in cities. New research indicates that lichens (along with mosses) take up about 3.9 petagrams Pg (corresponding to 3900,000,000,000 kg) of carbon per year, which is similar in magnitude to the annual carbon releases from biomass-forest burning (3.6 Pg/yr) and fossil fuel burning (7 Pg/yr) (Elbert et al., 2012).

In addition, lichens play a major role in the biogeochemical cycles of carbon and nitrogen. Climate change and changing land uses will influence the geographic distribution and metabolic activity of these organisms. A feedback effect could have unknown unintended consequences.

Lichens have an intrinsic value; they matter just because they exist.

In total, there are about 20,000 identified species of lichens. And there are still many species to be discovered. For example, in the tropics on the island of Sri Lanka, more than 3,000 different species of a single genus, *Graphidacea*, have been recorded (information from a conference of the British Lichen Society). In Texas, 7000 species have been identified while 200 are recorded at the

Mexican border. This is certainly due to the number of lichenologists - people who study lichens - in the country, which leaves an incredible space for new discoveries (information from a British Lichen Society conference).

We can find lichens of all shapes and colours and on - almost - all substrates. Some lichens live on the east side of the substrate, others on the west side, some are competitive, others live on the ruins of dead lichens. Their diversity is impressive and at the same time frustrating. The probability that the identified species has a twin, but with a different chemistry is very high .... There is thus always something to learn from !

Lichens have an intrinsic value. We regularly try to put a value on living things and on the organisms surrounding us. These methods giving a value (monetary or other) to living beings is important for acknowledging them and for managing natural resources. Nevertheless, these methods consider organisms as passive beings. Lichens deserve their place in the ecosystem as much as humans do.

Activity

Think about the environment in which these lichens are found. What are the important factors ? Access to sunlight, humidity, air quality.

What type of habitat are you in ? Is there any infrastructure that could shade the substrate on which the lichens are found ? Are there roads ? What is the source of pollution emissions ? Is this source close or far away ?
We will talk about the effects of air pollution on lichens later on in this walk, here.

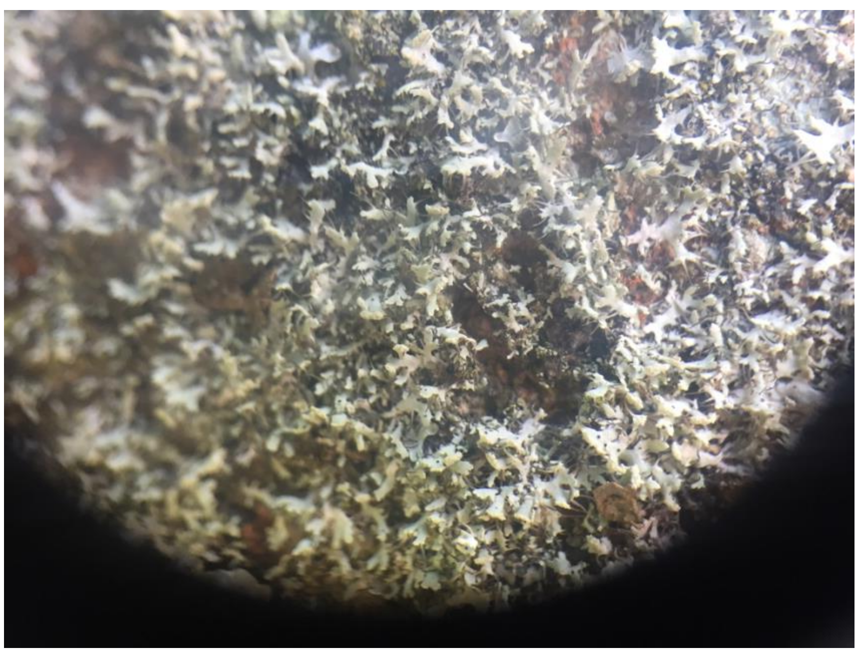
What type of tree are you looking at ?
The tree species can have an effect on lichen communities. For example, ash trees tend to be basic (in their chemistry) while other trees such as birches or oaks are more acidic. With increased atmospheric pollution in cities, the bark is becoming more basic and richer in nitrogen, so we only see species that tolerate these conditions.

Introduction to the lichen of the genus *Physcia*, species a*dscendens*

We now know the lichen *Xanthoria*. Can you spot the species *Xanthoria parietina* on this tree ?

Xanthoria parietina, Parmelia sulcata Physconia grisea and *Melanelixia spp.* , photo taken by the author (2021).

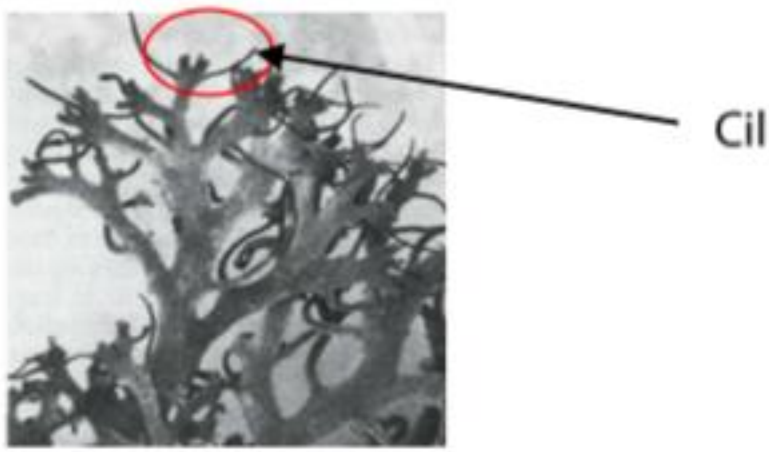
I would like to introduce you to lichens of the genus *Physcia*. It is a blue-green lichen that is very common in the city.



Credit: *Physcia spp.,* photo taken by the author (2021).

The characteristics of *Physcia adscendens* are quite simple:

- The tip of the thallus (called a lobe) is shaped like a small hat or helmet.
- If you have the opportunity to look at the lichen with a magnifying glass, you will see small hairs coming out of the tip of the thallus, these are called cilia. The surface is ciliated. We do not know exactly the function of these hairs, but they represent one of the characteristics of this genus *Physcia*.



(d'après Kirschbaum et Wirth, 1997)

Credit: Image found on the website of Science Infuse and used with permission document accessible [here](#).

Credit: *Cilia of Physcia spp.,* photo taken by the author (2020).

- If you get even closer with the magnifying glass, you can see the macules. These are the white coloured parts on the thallus. This colour change is created by a heterogeneous distribution of algae. The white parts are the medulla (the fungal part) because in some places the algal layer is absent.

Credit: *Physcia spp.,* photo taken by the author (2020).

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In our next step we will keep our eyes open to spot the hidden lichens in the city👇🏾👇🏾

LEAMINGTON WALK

The hidden lichens

<u>Challenge and Scavenger hunt for lichens</u>

Can you find the most hidden lichens? They can be anywhere…. Where have you found them?

Have you seen the post indicating the street name “Leamington walk”? If you get closer, you will see peculiar organisms invading the sign…

On Leamington Walk, you can find lichens on the light poste. Can you see the beautiful *Xanthoria parietina*? This is a lichen we have already identify before.

Credit: *Xanthoria parietina* on cement, photo taken by the author (2021). CC BY-SA 4.0.

The presence of the lichens in these peculiar places gives you an idea of the ubiquity of these organisms.

Lichens can grow on different surfaces. For example, some lichens (*Pristoderus chloreus*) live on beetles that depend on it for camouflage. Lichens can also grow on soil (lichens of the genus *Peltigera*) or be vagrant (without attaching itself to any substrate such as *Aspicilia fruticulosa* found in deserts like the Namib or in the Artic). Lichens can live anywhere and closer to us that we think

– on benches, branches, trunks, paving stones. The essential elements that are necessary for lichens are the quality of the air for certain species, the accessibility to water or humidity and light to photosynthesize. When the conditions are unfavourable to the lichens, they can go into a dormant state and function normally again when the conditions improve. When the conditions deteriorate, you will regularly see the highly fertile reproductive apparatuses of lichens (we will talk about those later on this walk). This is because the lichens are quickly dispersing before – potentially – dying.

Lastly, lichens even exist in our mouths. These lichens are called lichen planus. Their presence is due to the immune system that turns against itself by attacking its own cells. Researchers have also found lichens 400 km from the South Pole and they can therefore live in the Arctic and Antarctic.

Let's continue our adventure… Keep your eyes open on the way. Lichens can be anywhere.
On Leamington Terrace, in front of the church, you will find some lichens on the stone wall.

Credit: Street view on the church stone wall and the lichens on it, picture taken by the author (2021). CC BY-SA 4.0.

Lichens on the stone wall of a church. We can already two different species (the white-orange lichen at the top of the picture) and the white powdery one at the bottom of the picture.
Credit: Lichens on the stone wall of a church, picture taken by the author (2021).

WESTHALL GARDENS

Symbiosis

"Lichens tell us things about life, they inform us"
Trevor Goward in the book *Entlangled Life: How Fungi make our worlds, change our minds and shape our future by Merlin Sheldrake* (2020, p.89)

What happens when human exceptionalism and the idea of individualism limited by a few (physical) boundaries is turned upside down by scientific discoveries on lichens ?

Biology has always had immense power to ferment moral notions about life on Earth and has done so since the imperialism of the 18^{e} century (Haraway, 2010).

Lichens are among those organisms that have shaken our beliefs not only about the idea of individuality, but also about sexual reproduction and heteronormative dogmas (Griffiths, 2015). The concept of symbiosis elicited by lichens has long been polemical and has stimulated many existential questions. Lichens thus continually challenge us to question and re-examine our relationship to the world around us.

I would like to introduce you to a few things that symbiosis tells us about and the role that lichens have played in the discovery of this concept.

Entangled, a lichen is not one, nor two, but multiple. Lichens are composed of two types of fungi, algae, and many bacteria. In addition to this assemblage of several species, lichens are sometimes attacked by lichenicolous fungi. The photos below show different lichens (yellow, *Xanthoria parietina* and blue *Physcia tenella*) being attacked by lichenicolous fungi, creating a pink and/or orange colour (due to the chemical reactions happening).

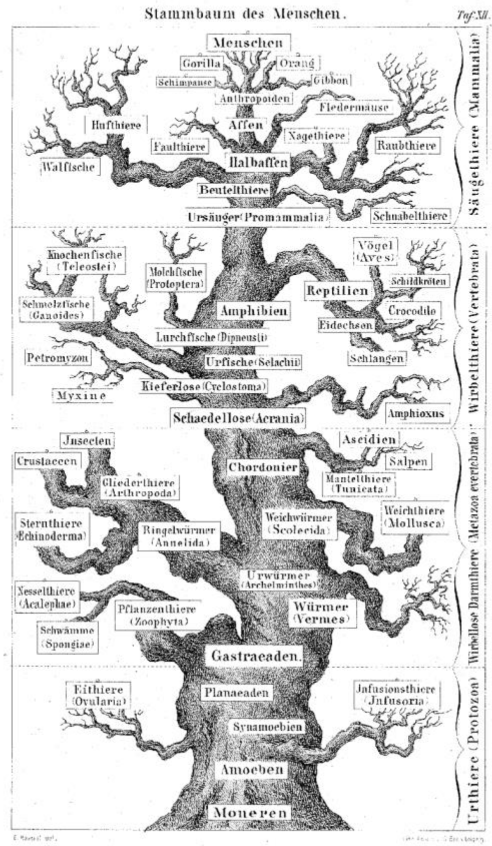
Credit: *Physcia spp.* reacting to a lichenicolous fungus, picture taken by the author (2020) under a CC BY-SA 4.0 license.

How did the idea of symbiosis come about?

It was in 1869 (three years after Ernst Haeckel coined the term ecology) that a Swiss botanist, Simon Schwendener, published an article introducing the double hypothesis of lichen.

In his article, Schwendener introduces the notion, radical at the time, that the lichen is not one organism but many. According to Schwendener, in the lichen, the alga is the slave of the fungus and is forced to serve it (this conception of natural phenomena reflected the political ideologies of the time). This hypothesis was refuted by lichenologists - people who study lichens - and was seen as shocking. One could not imagine two organisms living in such a close relationship and creating such a different form.

Moreover, based on the idea of evolution by natural selection developed by Charles Darwin, in 1859, new species were created by the divergence of species from each other. Evolution was seen as coming from competition (an interpretation of the people at the time, because Darwin's writings do not ONLY speak of competition) instead of cooperation. Schwendener's idea amounted to creating links between different evolutionary lineages (see photo of phylogenetic tree), which did not fit into the understanding of taxonomy at the time. The idea of the emergence of new species by the convergence of several species seemed impossible.



Credit: Tree of life, illustration created by Ernst Haeckel in 1874. Humans (Menselen) are at the top of the tree and bacteria (Amoeba) are at the bottom. The idea of symbiosis challenges these categories and links species that seemed to have nothing to do with each other. Image found on Wikipedia in the Public Domain.

It was in 1877 that the German botanist Albert Frank introduced the idea of symbiosis as the close relationship between a species of algae and a type of fungus forming a lichen. Later, the term symbiosis would be used to describe a spectrum of interactions ranging from mutualism to parasitism (see content for Middle Meadows Walk (1) for more information on these terms).

The lichen became a symbol of symbiosis and a biological principle when scientists discovered that symbiosis is not the exception, but the rule. Examples include the complex relationships in corals, or bacteria and/or other organisms in the functioning processes of living organisms.

As a result, the process of evolution could no longer be seen as a race to compete - a theory that had stemmed from the misinterpretation of Darwinian thinking - but as the collaboration between organisms of several taxonomic groups. This forced many scientists to rethink their ideologies and the processes of evolution.

Cooperation as the source of diversity of living forms on earth

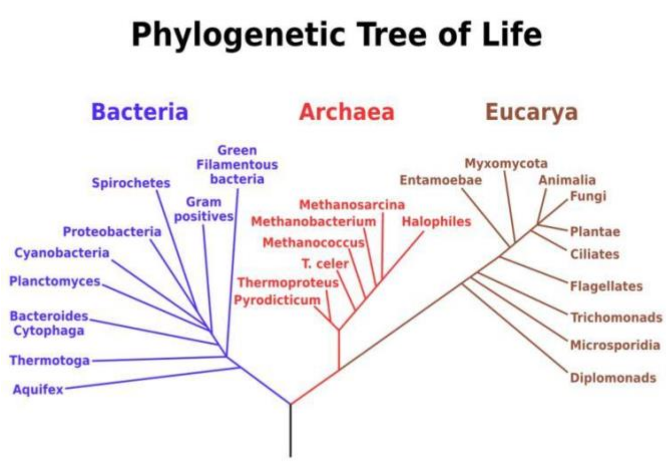
In Europe and the United States in the 1990s, evolutionary theories were influenced by the discoveries of Gregor Mendel, who opened the door to genetics. The main explanation for the variation and diversity of organisms on Earth was related to genetics (e.g. genetic mutations). Natural selection acts over time on the phenotypes - the observable traits of an organism, such as blue eyes in humans - that are most adapted in the environment. This is the main idea of what is called the modern synthesis of evolution.

Meanwhile in Russia, researchers were studying lichens and their symbioses. According to them, competition and genetics could not be the only source of diversity (in parts due to the different political ideologies at the time). Cooperation in nature was emphasised through symbiosis which could and does create new forms of life.

This idea of symbiosis as a source of variation came to Europe in the 1970s thanks to a woman (it is important to point it out because it is uncommon), the American biologist Lynn Margulis.

How did new life form on earth?

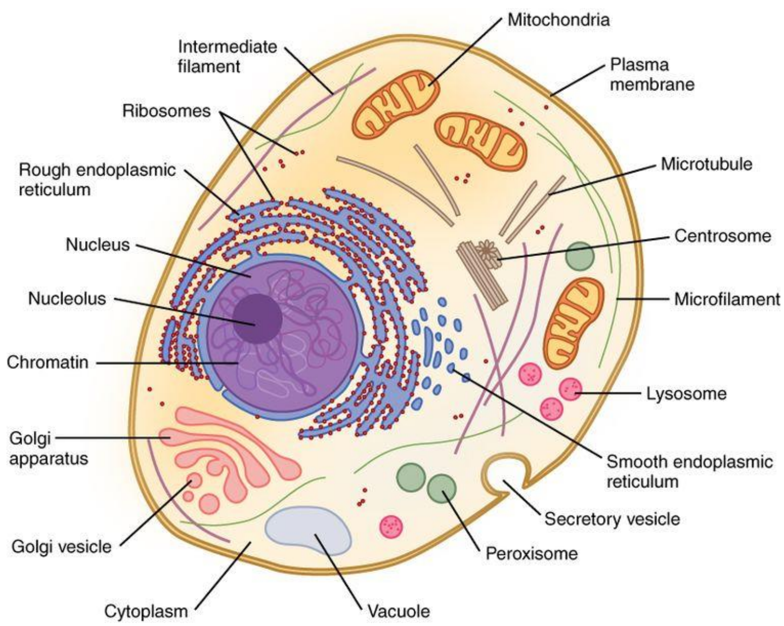
Living organisms are separated into three areas: bacteria, archaea (unicellular organisms that have a different membrane from bacteria) and eukaryotes. Animals, fungi and plants are eukaryotes. The cells of eukaryotes are larger than those of bacteria and archaea and have specialized structures (such as the nucleus or mitochondria). Plants have other specialized cells such as the chloroplast (where photosynthesis takes place).



Phylogenetic tree with three main groups - Archaea, Bacteria, Eukaryotes. Credit: Phylogenetic tree of the living world from Woese et al, 1990 on Wikimedia, Public Domain.

The Russians' discovery that Lynn Margulis brought to Europe, is that the first eukaryotic cell forming the body of animals today would have been created through symbiosis. A eukaryote with a very simple structure would have engulfed a bacterium.

This engulfed bacterium would have remained in the host. And over time this symbiosis would have become permanent - surely, because it was beneficial to both cells - allowing the evolution (later on) of multicellular organisms. The bacterium would be the descendant form of the mitochondria (see cell diagram) which is the part of the eukaryotic cell allowing it to produce energy. The same process would have happened for the chloroplast in plants with a photosynthetic bacterium that came to be enclosed by a eukaryote.



Credit: Diagram of a eukaryotic cell with the different organelles (parts). The mitochondrion (top) is an ancient bacterium engulfed by the single eukaryotic cell. Credit: Cell by OpenStax found on Wikimedia. CC BY 4.0.

This theory, which emphasises the importance of symbiosis in evolution, was initially denied for several years before being confirmed by scientific evidence in 1970. Lynn Margulis said that "the first eukaryotic cells were analogous to lichens". This idea of endosymbiosis - symbiosis that lasts and creates new forms - has revolutionized our understanding of the natural world and has called into question the time required for the creation of new forms. Rapidly, through symbiosis, new adaptations and life forms can be created.

Today, several authors (Haraway, 2010; Gilbert, 2012) argue that every organism is a lichen, meaning symbiotic. For example, a squid (*Euprymna scolopes*) that lives in coastal and shallow waters in the Hawaiian archipelago, depends on its symbiosis with bacteria (*Vibrio fischeri*) that it acquires at birth to develop a luminescent organ in its head. This organ is essential to prevent the light of the stars and the moon from producing a shade. The luminescent organ of the squid thus enables it to hide from predators. This type of symbiotic relationship can actually be observed everywhere. Every tree depends on its fungal network to absorb nutrients from the soil through the roots. Cows could not digest the grass they eat without the anaerobic bacteria in their rumen.

Euprymna scolopes, a Hawaiian bobtail squid that, thanks to its symbiosis with *Vibrio fischeri* bacteria develops a luminous organ that allows it to hide from its predators (as it prevents the creation of a shadow in the moonlight). Credit: Hawaiian Bobtail squid by Chris Frazee and Margaret McFall-Ngai on Wikimedia. CC BY 4.0.

But then, who is the individual ? Where is the limit if every organism depends on others ?

I'll leave you to ponder that question !

Lichens are changing our perceptions of the world. Recently, David Griffiths wrote an article called "Queer Theory for Lichens" where he questions our ideas of individuality through the findings on lichens.

He writes: "*There are no universal, transcendent traits that define the individual (human or otherwise); instead, the self or individual is always contingent and context-dependent*". Indeed, the human gut microbiome (communities of microbes) - on which we depend to digest our food - is highly dependent on the environment in which we live. The individual is thus dynamic and changes according to the context and the environment.

Griffiths goes further and assumes that this symbiotic view questions the way we see the body not as "clean, healthy, and pure or infected, sick, and impure" but as an assemblage of many species. Bacteria inhabit us and enable us to function.

These new ideas may have an effect on how we view ourselves and how we view infected bodies, especially today. Furthermore, in these times of environmental and social change, this new symbiotic approach to the world helps us realize and "feel" the connections and subtleties that we, humans, have with other organisms, without whom we cannot live.

Finally, while from a certain perspective, the idea of "individual" is a concept and a category that helps humans, their behaviour and ideas, the notion of the organism boundaries is more complex. As one developmental biology researcher puts it, "we are all lichens".

I hope this idea of symbiosis inspires you!

Activity

We will introduce three new species, called *Punctelia subrudecta*.

Punctelia subrudecta is blue grey in colour and has small dots on its thallus. These dots are called pseudocyphellae. They are holes in the upper cortex, which let us see the underlying medulla (the part with the mushroom hyphae, more info here, at the beginning of this walk). Coming out of the medulla are soredia - clusters of algae and fungal hyphae that disperse and allow new lichens to settle. The soredia are coming out of the sorelia and are granular, like a small powder. This kind of lichen is called *Punctelia* for its small dots on the thallus.

Credit: *Punctelia subrudecta* (with a close up of the sorelia), picture taken by the author (2020) under a CC BY-SA 4.0 license.

Lepraria spp. (species) This is a leprose lichen. The leprose thallus is made of a network of fungal hyphae with algal cells entangled among them. These lichens can be found in environment sheltered from the rain. This is the lichen on the right on the picture below. The organism on the left (apple green) are unicellular forms of algae. This is the alga without symbiosis with the fungal partner. When you pass your finger over it, you will be left with some particles.

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


One side is full of alga, showing the difference in habitat (maybe in the way water flows on the tree trunk). Credit: Alga, picture taken by the author (2021). CC BY-SA 4.0.

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For more information on Lynn Margulis (one of the rare women in science in her time), check out this article: Gray, M. W. (2017). Lynn Margulis and the endosymbiont hypothesis: 50 years later. Molecular biology of the cell, 28(10), 1285-1287.

Let's meet a little further on near the canal on Fountainbridge Green, you find the exact location on the map below👇🏾👇🏾

Fountainbridge Green

Air pollution and lichens

Credit: *Flowers blooming through cement,* picture taken by the author (2021) under a CC BY-SA 4.0 license.

On your way to the canal, did you see flowers blooming through the crevices of the cement? Wilderness can be observed everywhere.

What do you think is the link between lichens and air pollution?

As we said earlier an organism is affected by its environment and in turn alters its habitat. This is what ecologists study, the relationship between organisms and their environment. Thus, by recording the absence or presence of certain lichen species, we can get an idea of the state of the habitat.

Lichens, "like mosses, incorporate the material effects of urban ecologies across time and space and therefore form a process of bioindication in the city, capturing pollutants and transforming them into resources accessible to other organisms."

Jennifer Gabrys, 2012 in "*Becoming urban: sitework from a moss eye view*".

But what is bioindication?

Bio-indication is a process whereby environmental pollution becomes embedded in the bodies of and the relationships between organisms. These organisms express the accumulation of pollution through physiological or other observable changes.

Lichens are interesting for assessing pollution levels because they are sensitive to the air composition. The reasons are as follows:

- Lichens do not have roots - they have rhizines that allow them to attach to substrates - and therefore absorb the water and the solute substances from the air.

- Lichens do not have a protective layer - a cuticle - which means that pollutants can easily enter into the fungal and algae cells. In fact, unlike plants that have stomata, lichens do not have a system for regulating the entry and exit of gases and water in the thallus. As a result, lichens indiscriminately absorb all substances that reach them, both toxic and nutritious.

- Lichens are continuously active. All year round, from summer to winter, they are able to photosynthesise, even when temperatures are below -10°C. In winter, lichens are subject to increased pollution (e.g. increased use of electric heating) but still remain active.

- In addition, lichens grow very slowly so that any injury cannot be easily repaired. To give you an extreme example, the growth rate of lichens in harsh environments, such as continental Antarctica, is 1 cm per 1000 years.

The effects of pollution on lichens can be seen in their morphologies. We can therefore assess the quality and composition of the habitat by observing the presence and/or absence of certain lichen species as well as changes in their forms. For example, in an old forest in Scotland where the air is clean, you will find many lichens of the genus *Usnea* (see photo) because these lichens are extremely sensitive to air pollutants such as nitrogen dioxide (mainly emitted by fuel combustion).

Lichen of the genus *Usnea*, a species sensitive to air pollution. Credit: *Usnea filipendula* by Bernd Haynold on Wikimedia. CC BY-SA 3.0.

In cities, on the other hand, we find lichen species that are more tolerant to air pollution. The species that we have seen up until now are all tolerant to nitrogen dioxide (*Xanthoria parietina*, *Punctelia subrudecta* as well as others such as *Physcia adscendens* and *Physcia tenella*, *Physconia grisea*). What's more, these species have varied tolerance to pollutants. For example, when *Physconia grisea* or *Melanohalea* lichens are present, the air quality will be intermediate. When *Evernia prunastri* or generally foliose species are present, the air quality is good.

The assessment of air quality through studying changes in the distribution and diversity of lichens is increasingly used in cities. If this is done regularly, one can even observe the potential changes in the air composition in the city over time.

For example, before 1990, sulphur dioxide (SO_2), a pollutant emitted mainly by industries, was prevalent in many cities. In 1990, the Clean Air Act and an international treaty - similar to the Kyoto

Protocol, a trade in carbon dioxide - were created to decrease the concentration of sulphur dioxide in the air. It worked seeing the change in lichen distribution in the cities around the world. Lichens that thrived in an environment with SO_2 gradually disappeared and other more sensitive lichens repopulated the cities. It is also interesting to think about the impact that reduced pollution has on more-than-human species and the legitimacy of valuing these non-polluted environments at the expense of other species.

Lichens can be affected by changes in their habitat on several levels. For example, temperature change, storms, heavy rainfall can affect lichen communities, as can the surface of a tree trunk. If a crack is created in certain places, it can change the way water flows down the trunk and affect the distribution of lichens. Small details matter.

For example, a study in England showed that lichen communities are different at the top of a church compared to its bottom, such as in the cemetery. This is partly due to the different air currents. Closer to the ground, the atmospheric pollution is captured by the buildings increasing the air pollution levels. The open flow of air at the top of the church creates a greater dilution of the atmospheric pollution which is thus less localised.

Lichens and citizen science

In the UK, the Natural History Museum in London created a project called OPAL (Open Air Laboratory based on Lichens). The project was based on citizen science. This means that citizens were involved in the data collection and were invited to record and observe lichen species in the area where they lived.

One of the benefits of citizen science is that it creates a huge database and a better understanding of the dynamics of our surrounding environment. Citizen science also allows citizens to be involved in understanding and observing their environment and learning from it.

This study, OPAL (Open Air Laboratory based on Lichens) allowed to observe several changes. Firstly, the fact that lichen species tolerant to NO_2 (nitrogen dioxide) have become widespread throughout the UK, in cities and in the countryside. This could be caused by traffic, but also by the fertilisers used in fields for intensive agriculture. Some so-called intermediate lichens - which can live in more than one environment - have also been found in towns and cities and therefore have a widespread distribution.

Environmental pollution and its effects on humans

Air pollution has an impact on lichens but also on our health. Human exposure to pollution leads to respiratory and cardiovascular diseases; pollutant particles have also been found lodged in the heart and brain (Loxham et al., 2019). In Europe, 800,000 people die each year from pollution-related causes (Lelieveld et al., 2019). Pollution is a problem of environmental health as much as it is a problem of the health of our bodies (Gabrys, 2020).

This can lead us to rethink urban spaces and their infrastructure to make room for other organisms. We know that lichens, among other organisms, are impacted by changes in the infrastructure and management of the city. Hence, how can we, as urban residents, recognise the presence of other organisms in the city?

"It takes learning to recognise and be interrupted by the presence, strengths and forms of organisms of other species than humans and to notice the role they play in the construction and disruption of public places."
Jennifer Gabrys, 2018

Identification

I would like to introduce you to two common lichens of the type crustose: *Lecanora chlarotera* and *Lecidella elaechroma*. You will also see *Xanthoria parietina* that we have already identified and the species of the genus *Physcia* (see photo below for all the species together).

Credit: *Xanthoria parietina, Physcia* species (*adscendens* and *tenella*), *Lecidella elaechroma* and *Lecanora chlarotera,* picture taken by the author (2020) under a CC BY-SA 4.0 license.

Lecidella elaeochroma: This lichen is crustose and has black apothecia (reproductive apparatuses that we will talk about later on in the walk) on an almost transparent white or greenish thallus. The lichen is often confused with *Amandinea punctata.* The two lichens can only be distinguished using chemical tests. The black lines that you see determined the separation between the different individuals. These structures are only made of fungal particles. This lichen is often found, along with *Lecanora chlarotera* (the white lichen next to *Lecidella elaechroma*) in polluted environments.

Credit: *Lecidella elaechroma* and *Lecanora chlarotera,* picture taken by the author (2021) under a CC BY-SA 4.0 license.

The picture below shows different crustose lichens close to one another. The small lichen with black dots (apothecia) and a white thallus is called *Arthonia radiata*. We can also see the apothecia of *Lecanora chlarotera* and an individual of *Lecidella elaeochroma*. Can you see those on the tree trunk?

Credit: *Lecidella elaechroma*, *Lecanora chlarotera* and *Arthonia radiata,* picture taken by the author (2021) under a CC BY-SA 4.0 license.

Lecanora chlarotera is another crustose lichen. It has a white thallus and apothecia (the reproductive apparatuses) that look like pie with borders (compared to the apothecia of *Lecidella elaeochroma* which are more rounded) and are brown inside. When the organism is very wet the apothecia can change shape due to the saturation with water. Apothecia are the structure that we can see going out of the thallus. We will talk about those later on this walk.

Credit: *Lecanora chlarotera* and *Lecidella elaechroma* with *Xanthoria parietina*, picture taken by the author (2021) under a CC BY-SA 4.0 license.

Activity

Are you motivated to try and explore the environment which you live in ? Let's get started... There are plenty of tools at your disposal even if you know nothing about lichens.
Check out this Air Survey booklet that was created for the OPAL Survey. More information on the OPAL project can be found here.

Let's rethink the city together... How can we create cities that are inspired by and responsive to wildlife ? This is a challenge for all of us, city dwellers !

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Let's meet on Dalry Park👇🏾👇🏾