



What if.. (A troubleshooter hypothesis)

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Introduction

We all know lichens as small moss-like plants growing on trees and stones, and think of them as parasites to their substrate. But that is not true! They have little in common with moss, they are no plants, and they do not parasitize on their substrate. Lichens are dual or triple organisms, consisting of fungus and algae, or fungus, algae and bacteria. (Stapper. NJ, 2013) They are parasitic but only with respect to these individual parts of the lichen organism.

Lichens are tough and fragile at the same time. They cover approximately 10% of the Earth's surface; and inhabit diverse biomes from the arctic to the desert: they (an estimated 25000 species) are virtually everywhere. (Stapper. NJ, 2013) They are autonomous life forms (i.e., not substrate-dependent) and because of that they form the basis of life for many other animals in harsh environments.

When I started my research I talked to a lichen specialist who referred to lichens as astonishing organism, as something that could save our planet. In addition he said they were able to conquer a new one, e.g., by providing an earth-like atmosphere on Mars (R. de la Torre, 2010).

I was astonished by such a strong opinion of the scholar on the abilities of that small organism, and brushed it aside as a slightly overdone viewpoint. But after an extended investigation into the world of lichens I started to rethink his words and decided to ask some more lichen specialists for their opinion.

So I asked a group of lichen-specialists the following question:

What if lichens could be/ implicate the answer to all our problems and needs?

Interestingly, my rather hypothetical question did not really surprise the experts. So I started to create some fictional concepts based on scientific facts as far I had access to them.

The next step was to collect facts, information and data about lichens, in order to support my hypothesis of an all (se-)curing, healing, sheltering composite organism (CO).

The text will follow this approach and will start with the collection of facts:

Symbiosis, thallus, metabolism, the snuggling, water supply, respiration and exchange of gases, reproduction and appendix organs Then I shall undertake a structure analyses where the observational part will lead into the constructional part of the composite organism. Finally I shall point out my hypotheses which are an essential part of the exhibition together with the illustrations of the facts and the theoretical aspects. I am starting with a subject matter that is called symbiosis, without which lichen would not even exist.

Symbiosis – or what makes it special

The term “symbiosis” was coined by German botanist Anton deBary in his monograph *Die Erscheinung der Symbiose* (Strasbourg, 1879), and describes the cohabitation of very different kinds of organisms. (Complete Dictionary of Scientific Biography, 2008) A symbiosis is an association of two or more organisms of different species live together on the benefit of all associated partner. (Munk, Katharina, 2009)

“Living beings defy neat definition. They fight, they feed, they dance, they mate, they die. At the base of the creativity of all large familiar forms of life, symbiosis generates novelty. It brings together different life-forms, always for a reason.” (Margulis, 1998, p 9)

The prior task of symbiosis is the exchange and the connection between the partners, to reinforce weaknesses and become more resistant and competitive. It is an interaction that can have more than the one form, mutualism (Munk, Katharina, 2009), to which lichens refer. More specifically, the relationship between the two elements is called mutualism, a regularly occurring relationship thought not essential for life or cohabits of either one of the constituents. The two main other forms of symbiosis are the proto-cooperation (alliance – the loosest form of interaction) and the eusymbiosis (an obligatory form of symbiosis). (Munk, Katharina, 2009) The main reason of symbiosis is an exchange and connection to reinforce weaknesses and become more resistant and/ or competitive.

The lichen symbiosis is unique. The correlation is categorized as mutualism but have parasitical features. (Schöller, 1997, p. 15) The composite organism is a being defying a clear definition, as we will see in the following.

Thallus¹, the initial body

Primarily, the fungus determines the physiognomy of the lichen. It is the symbiotic partner that is responsible for both, shape and colour of the lichen. The degree of lichenisation, which defines how far the association is advanced, influences the colouring and structure of the lichen thallus. The stock of simple structured lichens i.e., can be referred to one of the partners, the myco- or the photobiont. Further developed forms possess a more sophisticated thallus, which no longer has any similarities with the stocks of the isolated bionts (Schöller, 1997, p. 19).

The thallus can be categorized by the following growth forms:

- **foliose**, lichens with a flat, leaf-like structure
- **fruticose**, lichens with an erect or pendulous, branched structure
- **squamulose**, lichens with a thallus consisting of small scale-like structures
- **crustose**, lichens develop a flat crust on or beneath rock or tree surfaces
- **filamentous**, lichens with a hair-like structure
- **leprose**, powdery lichens
- **gelatinous lichens**, cyanobacteria lichens (Deacon, J.)

Strictly speaking, this classification is artificial and not based on any taxonomic data, but it is still founded to be of great practical use. In fact there are numerous transitions and crossbreeds between those categories.

The long held assumption that the growth-shape has no evolutionary causes has been disproved recently. The form and structure of the thallus is a functional reaction on environmental conditions of the organism (Schöller, 1997, p. 21).

Referring to foliose lichens, the typical arrangement of thallus-tissue is differentiated into the: upper cortex, photobiont (algae) layer, medulla and lower cortex.

¹ Is a term for plants that do not have leaves, stems and roots

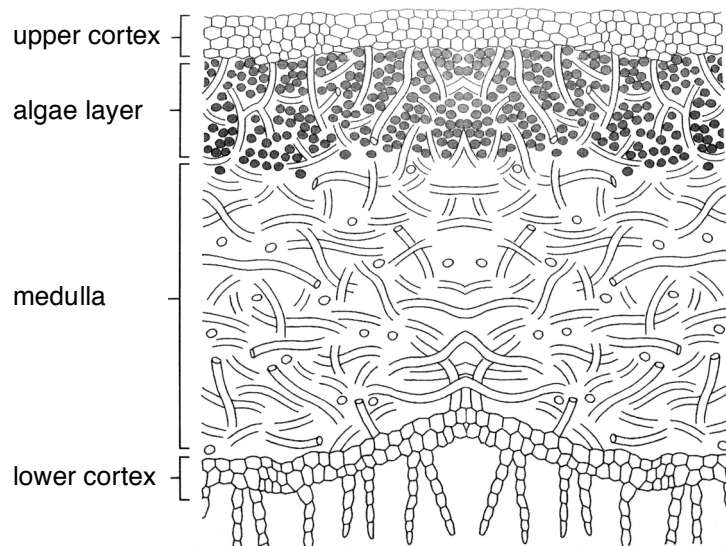


Image 1 , arrangement of thallus-tissue of foliose lichens.

Metabolism and nutrition

Lichens are becoming increasingly important because of their ability of secondary metabolism and the substances (antibiotics, vitamins, pigments, etc.) produced in that course. These metabolites are stored in the thallus, precisely in the medulla – a fact upon which the construction of the CO will be based. (Schöller, 1997, p. 49)

Due to its composite nature, consisting of two or three organisms defining the metabolism of lichens is not a trivial task. (Schöller, 1997, p. 19) Apart from the common ground, the symbiosis, the individual organisms unfold very different activities. Experiments to cultivate lichens in a sterile environment have until now have been unsuccessful: The fungal spores and the algae cells just germinated as individual elements and do not engage in a symbiotic relationship. Both need the particular environmental cues of their habitat, the moisture and drought, the alternating forces of wet and dry. (Schöller, 1997, p. 58) It is possible to cultivate them, but just under the conditions required by the particular species. Thus the actual metabolic processes remain unclear for now. However, researchers try to find out how the symbiotic elements interact and influence each other in this special symbiosis that is a lichen. (Schöller, 1997, p. 21) Considering that until now, these questions can only be tackled using hypothetical models, this opens up

a challenging and promising research field.

Although physiological measurements can be done using wild lichens extracted from their natural environment, untangling the relevant activities and processes of the individual organism in the relationship is impossible using this system.

The metabolism in lichens is unique and produces substances that are specific for lichens. Yet not all secondary produced substances are identified. (Schöller, 1997, p. 52)

Organisms produce far more substances as necessary for their survival. Basic metabolism defines substances that are essential for the survival of the cells.

Secondary Metabolism refers to substances that are not essentially used for surviving but have importance for the whole organism. (Sengbusch, Peter v., 1996-2004)

The following features are characteristic for the secondary metabolites of lichens:

- They are formed by only relatively few species.
- They are not essential for growth and reproduction.
- Their formation is extremely dependent on growing conditions, especially on the medium
- Often, different compounds with closely related structures are produced by one lichen.
- Unlike primary metabolites, production of which correlates to biomass, secondary metabolites can be produced over abundance.

(Sengbusch, Peter v., 1996-2004)

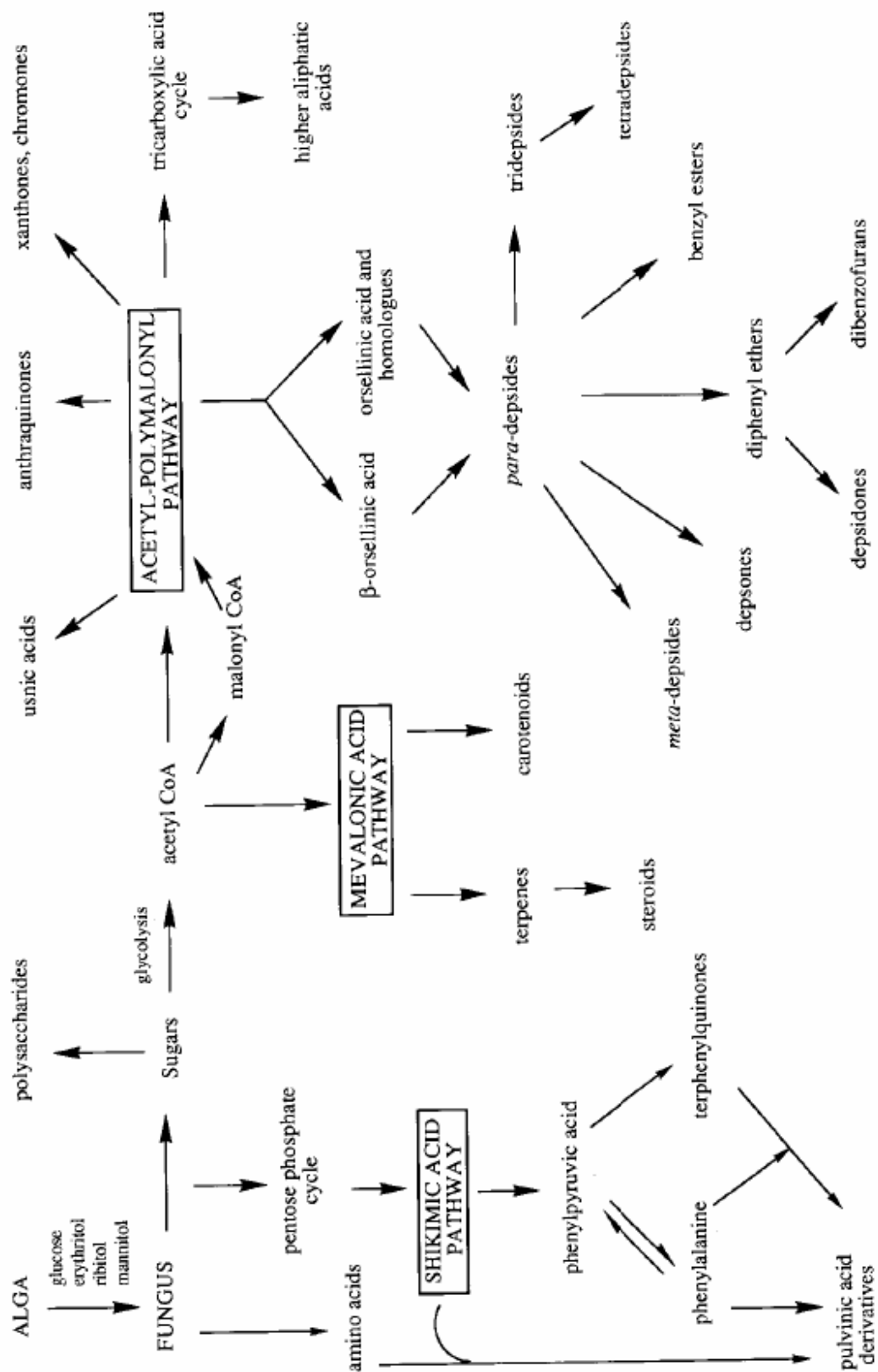


Fig. 9.1. Probable pathways leading to the major groups of lichen products.

Image 2, Probable pathway of lichen metabolism

The snuggling down into each other..

As mentioned above, photoautotrophic algae and cyanobacteria supply organic substances/nutrition for their symbiotic partner, the fungus. (Schöller, 1997, p. 19), The way they are coupled could be described as an intense snuggling of the involved elements. Given that the cells of the symbiotic partner do not merge and remain separate, that they are intrinsically linked to another life-form but are still separated from each other at the cellular level (Schöller, 1997, p. 19), the term snuggling seems applicable for their way of bonding.

To define this coupling between algae and fungus more precisely: It is a specialized feeding structure, where the parasitic fungus penetrates the tissue of algae cells using a special developed appendage called haustorium and retrieves nutrients from it. Although the algae cells are densely packed, the haustoria of the fungus do not penetrate the cells, but just dents their membranes. Due to this localization, they are called intermembranous haustoria. (Symbiosis: Mycorrhizae and Lichens, University of Hawai'i at Manoa)

Another way of structurally organizing the symbioses between algae and fungus is the intergelatinous protrusion, which primarily occurs in blue-green algae lichens (cyanobacteria lichens). There the fungal hyphae grow into the gelatinous colony of algae. (Symbiosis: Mycorrhizae and Lichens, University of Hawai'i at Manoa)

Different forms of snuggling down into each other:

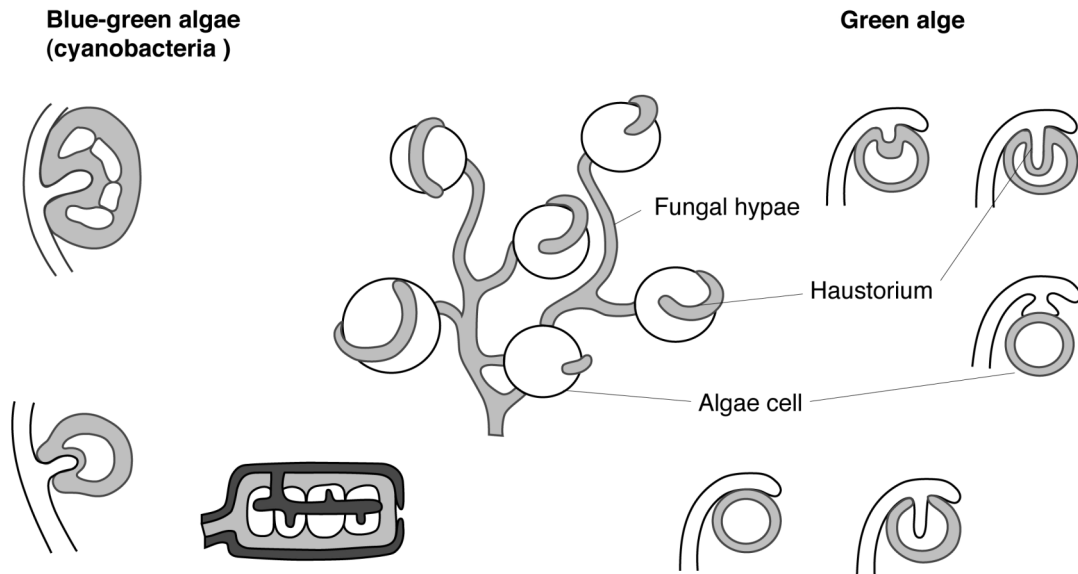


Image 3, the snuggling of the lichen partners.

Water supply

To colonize areas of different climate on earth, plants have developed two almost opposite ways of hydration systems: homoiohydrie, i.e., a consistent internal humidity as found in vascular plants, and poikilohydrie, alternating moisture which occurs in most cases of cryptogams (Schöller, 1997, p. 51).

Lichens use alternating moisture in a process called anabiosis (greek: revive) which allow the reawakening of a dry lichen by moistening (Schöller, 1997, p. 51).

The composite organism is a form of being that its lifetime as an individual cannot be measured. The ability of resting in a dried state and re-entering a proliferate state within seconds bears the potential of an eternal lifespan. (Schöller, 1997, p. 51) The process of soaking up water is comparable to rebooting the metabolic system. It is even vital for them to dry out in more or less regular intervals (Schöller, 1997, p. 51).

It is an act that can repeat several times per day (depending on the environment).

The alternation of wet and dry is determined by the microclimatic conditions.

(Schöller, 1997, p. 51) Exposure to (rain) water is the key process of how lichens retrieve water without having roots, and extract nutrition. In many lichen habitats

water is only available for a short period of time. So lichens are capable of getting water-saturated within a matter of minutes, and can lose water again as quickly. This is mostly securing protective mechanism to high levels of solar radiation, because a water-saturated thallus is much more sensitive to environmental conditions (Schöller, 1997, p. 52). In seconds the energetic level of the organism is rising and the metabolism is able resume work at the highest level of production. This holds true for both the metabolism as well as the secondary metabolism.

The main share of moisture is not stored within the cells (intercellular) - like in vascular plants and mosses but in the highly swellable walls of the fungus hyphae in the medulla. (Schöller, 1997, p. 52)

Soaking up water triggers adaptive movements where the thallus-parts are physically adjusted anew to the current environment. The cells on the lower cortex fill up with water, which makes them more elastic, and the thallus spreads. A force of friction in between the cells is the trigger of the movement of individual stands and filaments.

The content of water in the green-algae lichen thallus ranges from a minimum of 2% to 15% up to a maximum of 100% to 300% of the dry weight. Gelatinous lichen this measure can even store up to 800% and even more than 1000% of their dry weight in water (Schöller, 1997, p. 51).

They also have a strong ability to absorb water vapour from the air.

In addition to thallus moisture, the metabolic processes depend on factors such as light availability (photon flux density), thallus moisture, thallus temperature and CO₂-content of the air. Those factors vary considerably in different locations for some species (Schöller, 1997, p. 57).

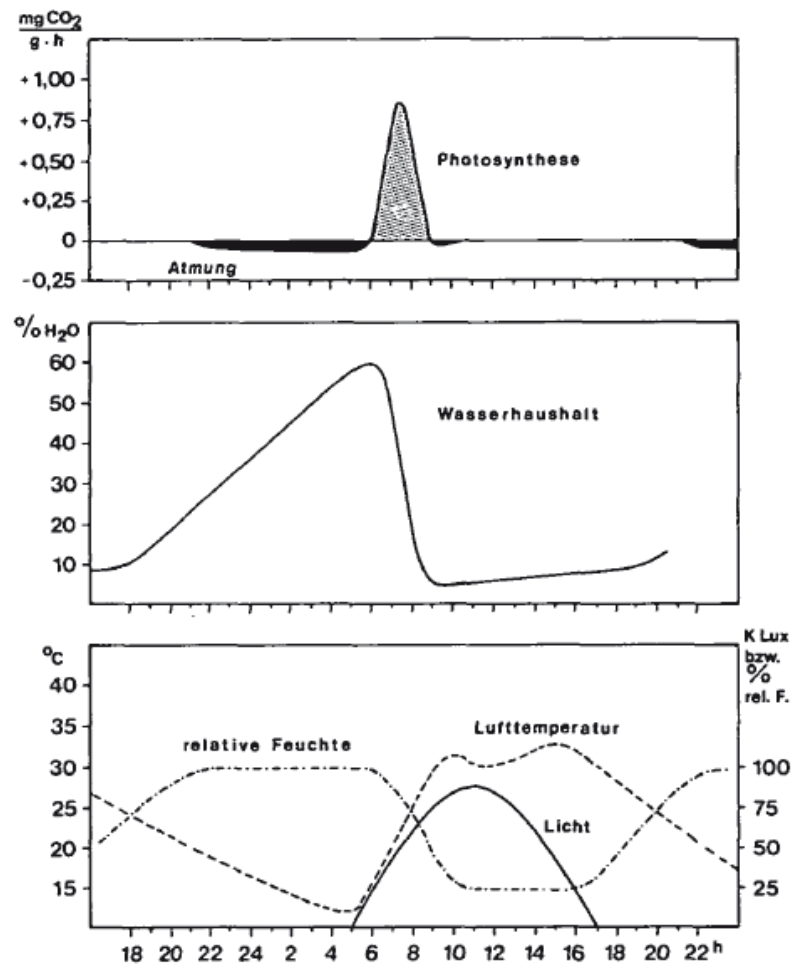


Abb. 3: Photosynthese und Dunkelatmung der Wüstenflechte *Ramalina maciformis* in Abhängigkeit von Wassergehalt, relativer Luftfeuchte, Lufttemperatur und Lichtintensität. Während der Nachtstunden nimmt die Lufttemperatur ab, die relative Feuchte steigt an und dementsprechend auch der Wassergehalt der Flechte; dadurch wird die Atmung aktiviert. Nach Sonnenaufgang wird die Photosynthese rasch in Gang gesetzt; die Erhöhung der Lufttemperatur hat eine Verminderung der relativen Feuchte zur Folge, wodurch das Lager sehr rasch an Wasser verliert und schließlich in die „Trockenstarre“ übergeht (nach LANGE und Mitarbeitern).

Image 4, example of the process of alternating wet

Algae growing in strongly pigmented lichens are much less sensitive to high UV-radiation, heat and dryness within the protective frame of the lichen compared to individual algae organisms.

The amount of light, which reaches the algae in the thallus depends on moisture and the thickness and leads to a pigmentation of the cortex (Schöller, 1997, p. 57). The higher the amount of light in a given environment, the thicker is the cortex, the intensity of pigmentation and ultimately the photosynthetic capacity of the lichen.

Assimilation- utilization, respiration and the exchange of gases

Under control of the mycobiont, the green algae and the cyanobacteria release most of their photosynthetic products to the inner thallus. In case of the green algae it is *Ribit* (glucose alcohol) while for the cyanobacteria it is *Glucose*. Both are transformed to *Mannitol*² (a storage substance) by the fungus (Schöller, 1997, p. 57).

Producing those substances is an unusual physiological behaviour seldom observed for algae outside a symbiosis with a fungus. The fungus does not only influence the assimilation processes; it also influences the permeability of the algae cell walls, to actively facilitate the exchange of elements and photosynthetic products. (Schöller, 1997, p. 58) Fungi which live in a composite organism with green algae as well as with cyanobacteria do not just benefit from their different products, also their temperature optima for metabolism varies, i.e. they are able to use a broader range of environmental conditions effectively (Schöller, 1997, p. 58f).

The respiration process in composite organisms is - in combination with oxygen - the utilization process of the photosynthetic substances in order to make the vital energy available. Unlike the photosynthetic process, which stops when the organism is dry, respiration still continues, albeit at a much lower level than in the active organism (Schöller, 1997, p. 62).

A well functioning exchange of gas and air is a prerequisite for the metabolism of lichen in general and the ability to do photosynthesis in particular. The cortex is composed of a rigid layer of hyphae, which can exchange gases via small pores. (Schöller, 1997, p. 31) Many COs develop additional respiratory openings for a more efficient exchange with their surroundings. Cyphelles are crater-like apertures at the bottom of the thallus, built from cells of the lower cortex. Similar structures, called pseudocyphellen (by foliose and fruticose lichens), are formed like dots, patches or sometimes branched lines (Schöller, 1997, p. 31f).

In a fully dried, hibernating thallus there is no gas exchange taking place, until the

² *Mannitol* is a natural sugar alcohol that occurs mainly in salt plants, fungus, algae and animals. It is named after the manna-ash-tree. In plants, it is used to stimulate osmotic stress.

thallus moisture reaches a value of 20%, which is when the photosynthesis processes start (Schöller, 1997, p. 58).

In terms of the CO₂ a balanced respiration and gas exchange of gas leads to a fruitful production of reproductive elements.

Some cyanobacteria (Cyanophytia or blue-green algae) are even able to absorb atmospheric nitrogen (N₂), while green algae (Chlorophyta) must be supplied with nitrogen to be able to grow and reproduce. (Schöller, 1997, p. 57)

Absorbed nitrogen is an additional nutrient for the fungus, helping to grow to better protect the algae. Lichens are among the few organisms (like also certain bacteria), which have the ability to take advantage of the large existing quantities of atmospheric nitrogen. (Schöller, 1997, p. 57)

Reproduction and dispersal mechanisms

In general, there are two distinctly different reproductive pathways in lichens: generative and vegetative reproduction.

In lichen-symbiosis only the mycobiont (fungus) develops organs/ bodies for fructification (entirely asexual reproduction) and restrains the force of sexual reproduction of the photobiont (algae). Under control of the fungus, the algae is just able to vegetatively reproduction i.e., the reproduced cell is an exact copy of the mother-cell. This strongly limits the ability of adapting to changing environmental conditions, compared to generative (sexual) reproduction. (Schöller, 1997, p. 35)

The most widespread example of reproduction in composite organisms is the **generative** dissemination. By far the largest group of lichens systematically belong to the family of sac fungi. This group of fungi forms fruit-bodies (Excipulum) as reproductive organs, i.e., the ascomata or asci, to disperse the spores of the fungal partner. When these spores germinate, they need to get in contact with cells of a photosynthetic partner to establish a new lichen thallus.

Despite the fact that the generative forms of reproduction are common in lichen, some crucial developmental steps are still unknown.

Concerning on the development and construction of the fruit bodies two general types of ascomata can be described. The Lecanorien ascomata form their fruit-body out of the thallus tissue, consequently their structure is the same as that of the thallus. The second form pycnida, emerges out of sterile fruit-body tissue, so the typical layering of the stock is missing.

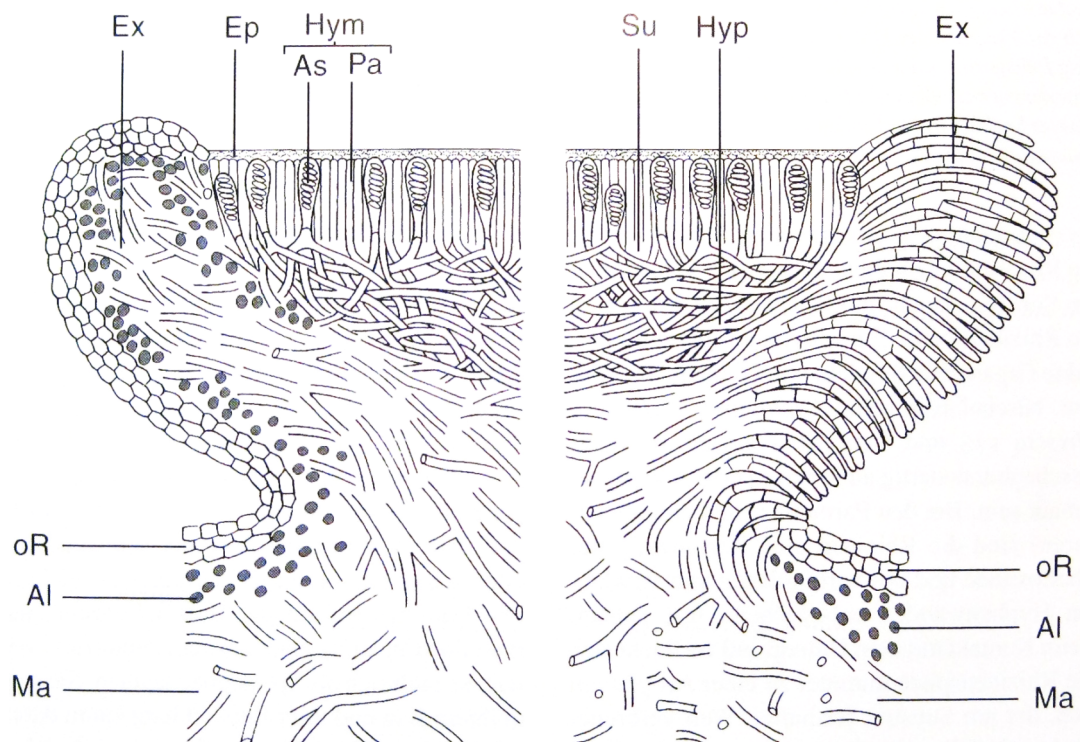


Image 5: oR – upper cortex, Al – algae layer, Ma – medulla, Ex – excipulum, Hyp – hypothecium, Ep – epihymenium, As – asci, Pa – paraphyses, Su - subhymenium

Some composite organisms have designed special features for dispersing, i.e. the *cladoniaceen* (Stecknadelflechte) which builds an erect ascomata-shaft (Podetia), that can capture most of the stock. (Schöller, 1997, p. 35ff)

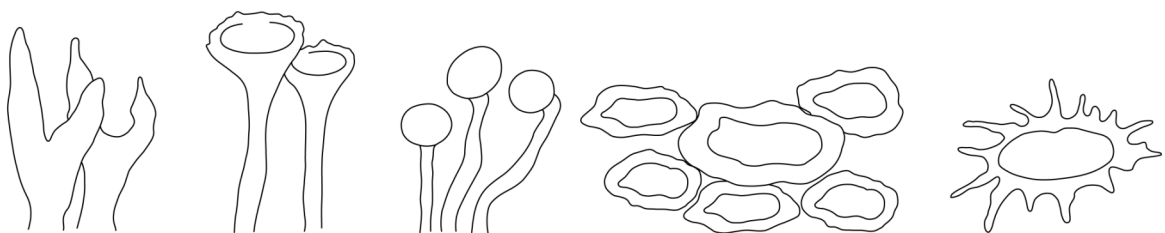


Image 6: Fruit-body, a selection of forms

Composite organisms can also be dispersed by **vegetative** dissemination. The dry

lichen thallus is brittle and fragile, so fragments break off easily when in a hibernation state. Several COs produce stalk-like or pillar-shaped structures called isidia, which are specially designed shapes to break off and dispersed e.g., by means of wind or animals (Schöller, 1997, p. 38f) (and also humans, the worlds most effective vectors).

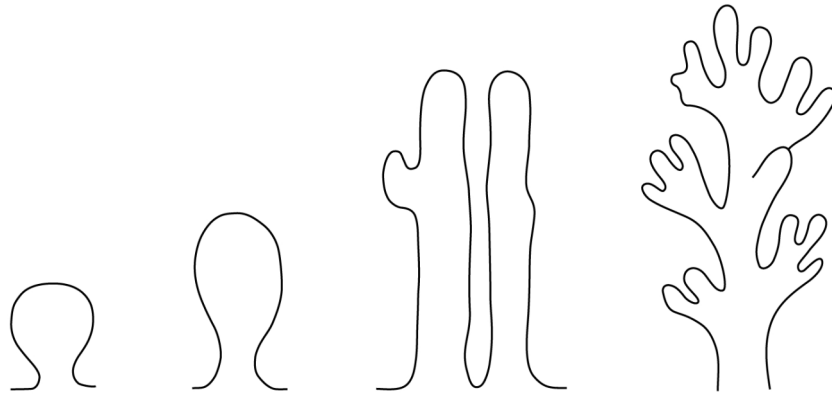


Image 7: Different shapes of isidia

A further dispersal pathway is the development of specialized dispersal units termed soredia. These are made of algae cells enveloped in fungal hyphae - algae-fungal-packages. Those packages exist as a powdery mass near the centre of a lichen thallus or at the tips of some of the thallus lobes. Soredia are commonly dispersed by wind.

All these fragments can resume growth in a new environment after they are rewetted. (Schöller, 1997, p. 39f)

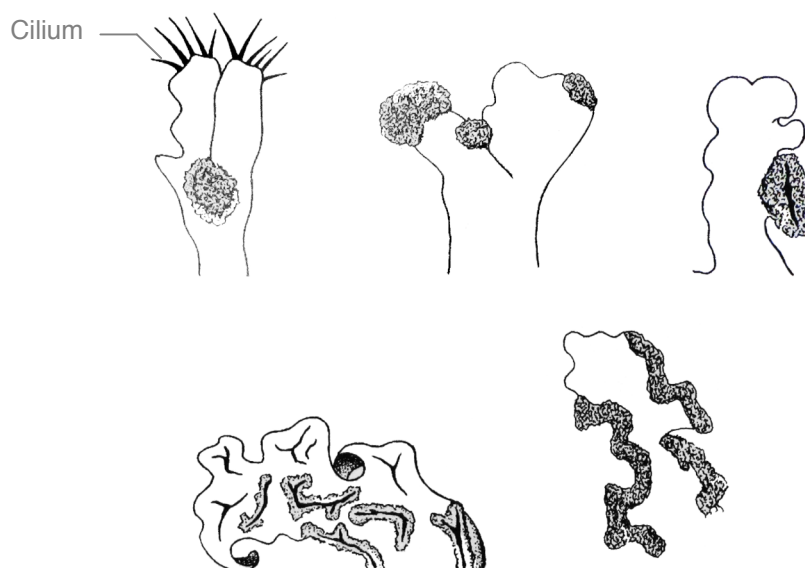


Image 8: Different shapes of soredia

Some scientists believe that the reduction of sexual reproduction, even if disadvantageous from an evolutionary point of view, is less energy-intensive and a major adjustment to the symbiotic way of life in lichen (Schöller, 1997, p. 35).

Adherence/ appendix organs

In order to being able to stick to various surfaces composite organisms have developed a rane of appendix organs, called rhizine or cilium. Foliose lichens, for instance, have rhizine on the lower side of their leafs, to attach themselves to the subsoil/ground. Rhizine are not single threads, but rather a bunch of hyphae forming a compact organ. In contact with the substrate they can spread like a brush or form a foot-like compact anchor.

The second widespread organs are cilium. In structure they are similar to rhizine, but they are not located on the lower side of the leafs. They grow like slim fingers out of the borders of lichen tissue to adhere to the sideways, like extensions of the lobes (Schöller, 1997, p. 32f).

Both of them are very flexible in form and structure, and adaptively reaction to their surroundings. Also tomentum, a hairy-felted clothing of sterile surfaces, is a widely spread form of appendix organs found in lichens.

Structural analysis or what the composite organism will be formed by

Starting from the assumption that the structural features of the lichen are not primarily driven by evolutionary processes, but rather are a functional response to specific environmental conditions, it can be described as flexible and adaptive to individual situations and environments. In contrast to higher plants, their dependence on alternating wet-dry cycles and their thermal inertia makes lichens strongly dependent on the microclimate; they are thus really opportunistic to their natural environmental conditions.

The form-giving aspect of the CO is also open and adaptive to the specific needs of the healing and sheltering organism. Because of their adaptability and structural flexibility, lichens are more often called aggregates than species (Schöller, 1997, p. 180).

The following analysis of some structurally different types (or as mentioned in the chapter about the thallus; classifications) of lichens is an observatory analysis to distinguish some formal types of how the outer shell of a composite organism might be structured.

The crustose lichens form a thallus like a crust over the substrate that is firmly attached to it. The lower cortex and the medulla are directly connected to the substrate and grow partly into it. In its structure, it looks like a map, with small islands of heightened thallus on an underlying prothallus or hypothallus. These islands can vary greatly in their form. Exactly this growth form enables the lichen to colonize some of the most extreme habitats.

As the thallus is directly associated with the substrate/subsurface/skin, it can function as a protecting organic layer.

Lichenometry is a technique using crustose lichens to determine the age of exposed rock surfaces based on the size and the centrifugal growth patterns of the thallus.

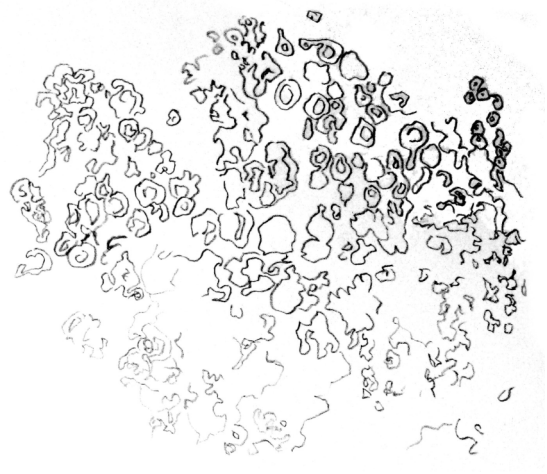
Flat, dorsiventral bodied lobes form the thallus of foliose lichens, which may adhere more or less firmly to the substrate. The size and shape of the lobes can vary greatly between different species, but most have radiating growth patterns.

Owing to their high morphological diversity foliose lichens are able to colonize many different habitats.

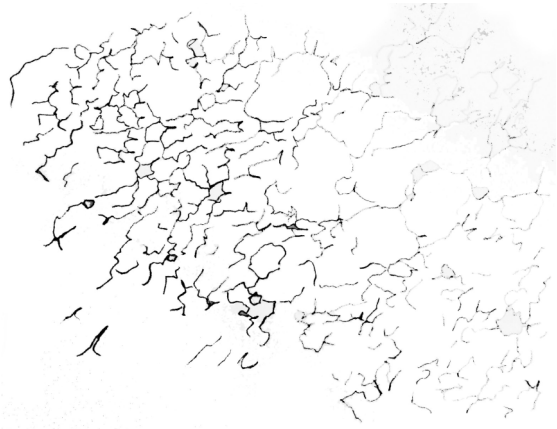
The lower cortex of the lobes is often coloured differently than the upper cortex, frequently darker brown or black, and carries the rhizinies. Characteristic is also their wide variety of appendix organs.

The fruticose and filamentous lichens are characterized by their different growth orientation. This leads to different mechanical loads on the thalli: therefore upright standing thalli have a tubular supporting tissue, which gives them the necessary resistance. In contrast, hanging shrub lichen are primarily exposed to tensile stress, therefore one or more centrally located fibre threads are formed. Most of them are anchored to the substrate, usually with a basal adherence disc. Certain erect-growing shrub lichen have a dual-formed thallus; the primary thallus as a crust and the dominant secondary thallus as the erect one.

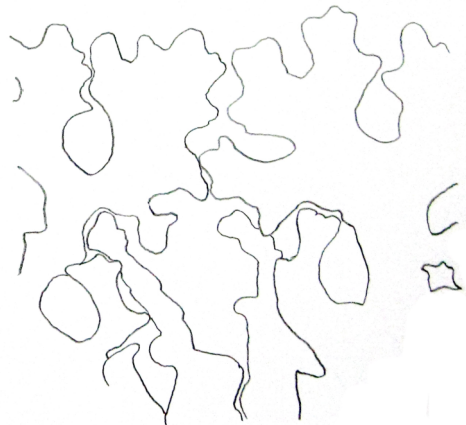
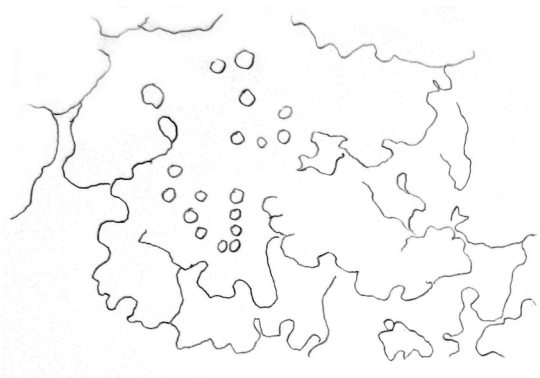
The colour and consistency of gelatinous lichens is mainly determined by the photobiont, the blue-green algae or cyanobacteria. They have a homeomorphic thallus, which is coloured blackish to dark olive and, when moistened, sometimes reddish. The jelly-parts of cyanobacteria swell by water absorption and give the thallus its characteristic gelatinous, slimy consistency.



Structure of crustose and gelatinous lichen



Structure of fruticose and crustose lichens



Structure of foliose lichens

The composite organism (troubleshooter) build-up

To construct something, the main part is to analyse and deconstruct it to the core and afterwards start to rebuild it bottom up. Three prominent parts evolved by deconstructing the system of the composite organism. So the initial build-up plan of the composite organism is structured in core (the fabric), skin (the protector) and net (the nurturer and supplier).

Core, location of metabolism and secondary metabolism:

Practically, it is the "factory" of the composite organism, where nutrition and light is transformed into valuable substances. Some of these are used for means of protection, adaptation and nutrition, the basic function. Others are not important for survival. As it seems they are produced just because the composite organism is able to produce them, without any intrinsic use.

The algae and bacteria cells are basically located in the core, in the algae layer and partly in the medulla. The medulla is characterized by its large hollow spaces, which serve the gas-exchange, act as air reservoirs and are absorbing water. A crystal layer of lichen-substances mainly covers the fungal hyphae in that area. Most of the secondary metabolism substances are produced and stored here - a long list of acids, vitamins, minerals, toxins etc.

The interaction between the fungus hyphae cells and the algae cells is mainly shaped by haustoria, small extensions of the fungal hyphae, which penetrate the algae cell. The location of the algae layer directly beneath the upper cortex is necessary for photosyntheses. The upper cortex is a fungal protection layer for the algae cells, to not let them dry out completely. In addition, through the pigments out of secondary metabolism in the core, which are stored in the fungal upper cortex, it is also a sun-blocker against high UV-radiation.

Every individual CO has somehow an individually constructed thallus, which is in

principal based on the interaction between the lichen, the substrate and the environment. For example, foliose lichens have a lower cortex with appendix organs to stick on a surface or crustose lichens have their medulla rooted at the surface of the substrate. Fructose lichens (beard lichen/ *Usnea*) with their root-like structure are developing a central core (a cord) where the medulla is binding, surrounded by the algae layer and the cortex.

The core structure is a dense scaffold in the centre of the medulla that guides the individual forming of the composite organism. It is the inner structure of the CO and is covered by a gelatinous mass, the skin.

Skin:

The skin is a gelatinous mass, in colour and texture mainly determined by the blue-green algae (cyanobacteria). It is a strong skin that, when moistened, soaks water and becomes gelatinous (jellylike and elastic). It appears like an indefinable viscous mass with the ability to expand.

The fungus, in this case, plays the role of the outer protector and collector of the system.

The skin is the prior part of absorbing nutrients from air, water and the surrounding and further transports it to the inner core, the factory. One of the great questions is: what sorts of substances are able to sneak into the composite organism? And how they affect the processes in there, how they influence the secondary metabolism/the outcome. Air pollution might play a major role in the field of the production of secondary metabolites.

Net:

The shape can be compared with self-constructing tentacles (tentacles in that context is an attempt to describe the shape of an extended form of thallus), which embrace the inner body and the sheltered matter (i.e. organic tissue material). The

filtering of air for nourishment, moisture and pollution is also a property of the net. Its special feature is the skill to adjust its tentacles in seconds to a perfect alignment for filtering. The dry net just takes a few seconds - when moistured - to come back to life and start the inner factory. An amazing process that starts at a minimal energy level and rises up to the metabolic action. The composite organism fills up the cells on the lower cortex and the medulla with water. The adjusting of the thallus shapes and the change of the colouring/pigmentation visually amplifies this impressive metamorphosis. It gets a brighter and more intense pigmentation out of a greyish dried out colour.

The pigmentation is a protection against high UV- radiation - the stronger the lighting the more intense is the colouring. A second duty of the pigmentation is the shielding of the composite organism against different enemies. Special acids like the vulpin acid i.e. are toxic to carnivorous animals like wolves or foxes. (More of these and other significant acids in the list attached)

The troubleshooter concept – the composite organism

In the ability of secondary metabolism composite organism are able to be used for securing and recovering matters. More specialised studies on composite organisms will have a big influence on medicine, technology, ecology, reproduction and a general way of looking on small things - like lichens - and the power of symbiosis.

The concept and the form of the troubleshooter is adaptable to the individual usage.

CO could be implanted into pieces of clothing like protectors that react in a protective way to the condition of our environment as there is e.g. humidity, temperature, radiation, volatile or solid substances, mechanical factors.

CO could serve as a second skin, or an implant, like a “patch” on/in the skin, that is accelerating the wound healing process

CO could grow to a cocoon in which you sleep and recover, something that gives shelter. In this The CO could then produce the secondary substances our body needs to compensate stress of the day.

Another domain could be an artificial womb, where embryos were raised for a certain period of time: a cocoon that is nourishing itself and built as closed system that complements the embryonic tissue inside.

CO could establish a cocoon that provides tissue material to grow organs.

Finally, CO could provide organic food and nutritional supplements that may help to protect humans and animals from mal- or undernourishment.

The idea conceptualizes the universal troubleshooter as a self-generating symbiotic natural system, that does not dependent on technology. It is considered

as an independent life-form (creature), that adapts to massive environmental stress factors. The idea of a composite organism that gives shelter and provides cure for all kind of diseases, is a theoretical frame for human wishful thinking. However, the abilities of lichens are ubiquitous instances of a composite organism, which help to imagine respective responses.

Even the most basic descriptions of lichens (in books, papers, etc) provokes thought into the direction of a CO. Digging deeper into the complex system - the symbiosis – this possibility seems to be backed up.

After bringing together all scientific facts it is just a simple step of creating a universal troubleshooter (the CO) that might be a solution for recovering processes. The CO's secondary metabolism could play a leading role in future science. The chemical compositions of those more than 1500 (now known) secondary products are an inspiring list of substances and their effects.

The construction of the composite organism the lichen as a universal troubleshooter leads some conceptual ideas of how it could look like - the IF constructions!

Artificial womb - ectogenese

The artificial womb or incubator might be seen as an absolutely fictional concept for a lichen-troubleshooter. The self-sustaining composite organism is - as independent as it is - the perfect system for such a concept.

The development of the ongoing incubator goes in line with the development of the cells and the later on embryo. The fungus-algae-package constructs composite organisms during the first days - meanwhile the first cells divide. After the habituation phase both grow mutually (as a symbiosis) to become the artificial womb.

Going into detail, the in-vitro-fertilisation follows the steps of injecting the recently fertilized egg into the prepared fungus-algae-package. During the first days in the association, it can be stored in a breeder - just for a higher rate of success. The

breeder is not absolutely necessary, because basically the organism supplies itself from the first day on and could be directly placed/planted on the prepared substrate.

Additionally, the prepared substrate supports the growth of the composite organism in the first period of growth, to create a stable microsystem for the fertilized egg.

It might be useful to keep an eye on the alternating humidity of the system during the initial breeding process.

The whole process is designed to be absolutely self-securing, recovering and protecting from the moment of the injection of the fertilized egg. The system is developed to an overall self-sustaining organism that could face hardest environmental changes. During periods of absolute dryness, the composite organism keeps the humidity inside the system on a constant level until the next humidification.

Tissue material for organs

By using the same method of injecting fertilized egg cells into the fungus-algae-package, also tissue material of human (or nonhuman) organs could be cultured. Under the same conditions the future transplant will also grow in line with the composite organism. Beside the nutrition and sustaining of the tissue, the CO will also take enhance the organ by producing substances, tailored to the patient's needs. The organs will be designed after the individual disease pattern of every patient. So the chance of rejection of the transplant is actually negligible. For those purpose, the CO is cultured on a biodegradable scaffold giving the organ's shape. Which will dissolve throughout the growth phase. When the organ is fully developed the CO starts to crumble off. Those crumbled pieces can be reprocessed and reused as fungus-algae-packages.

The CO turns into an organic bioreactor for the organs and the embryo during the period of becoming a fully functional organ that is constructed after the building-plan of individual patients or a fully viable new human (nonhuman) being.

Recovering capsule or cocoon

As the name already suggests, the recovering capsule is a cocoon-shaped form, where the human body will be recovered after spending a certain time inside. How long is individual to the special needs of the body. The person will feel when the CO attention is turning fading. The system could be seen as an independent intelligence that considers the human body lying inside, as a part of itself during the recovering process and turns away as soon as that process is fulfilled. It brings the lack and the abundance back in balance and regulates the humidity level and the stress-factor. It adapts to the prevailing needs and feeds the body individually.

Implants and patches

A more localized and flexible usage for the CO are patches for quickly curing wounds and injuries. The CO is just placed on the skin and with its adherence organs it will stick itself. After the healing it falls off.

For a long-term-treatment or chronic symptoms those patches can function as a sort of an implant. It is a special sort of lichens - a crustose lichen, that is directly connected to the skin. The supply of substances like antibiotics, painkillers etc. would work much more efficiently and directly as compared to traditional methods of drug administration.

Some of the implants could integrate into the bodys system (especially in case of recurrent pain or infections, and also in case of chronic troubles i.e. with the spine or organs). Those will stay in/on the body and start to grow exuberantly when it senses a pain stimulus and forms back when the pain is gone again.

A further step could be, that it becomes a part of the blood circulation and starts to grow where needed.

Nutrition

The produced lichen substances, like antibiotics, vitamins, pigments (as a special

one: scytonemin, act as sunscreen; see list attached) etc., could be compressed to pills or supplied as an extracted serum that would act according to the needs of the patient. A concentrated food supplement that brings the whole body into balance, and operates preventive i.e., in cases of upcoming bacterial infections.

Ecological/biological indicator

As a bioindicator lichens are going to be observed, measured, dated and mapped to get a more detailed image of microclimatic changes in areas of ongoing climatic transformations. Their ability to conquer new habitats is a necessary feature to transform contaminated land or deforested soils. The composite organism creates a protective coat that secures the soil of erosion and enriches it with nutrients in a self-dependent process and also by rotting.

Using COs for matter of microclimate, they employ in areas of high air contamination. Fungus-algae-packages will be planted next to the source of the pollution, to adapt to particular needs while growing. The CO will develop according to the required features to transform the contaminants into vital substances for the surrounding.

Those concepts are not just designed on single usage of the composite organism, which means that those concepts (the artificial womb and the cocoon) can also be seen multiple – like farms.

In their natural environment, thalli of different composite organism species can parasite and harm each other, but none of them is going to be displaced by others. Together they build a stable equilibrium. They develop very successful survival strategies and are well adapted to the particular conditions of life. They are always cloning and reproducing itself during the process of growing. So every CO could be seen as a colony of its own.

The IF construction/ artwork

What if ..? A question, that seems to be as old as mankind. We are always aspiring higher things, whatever that is or however that looks like. The concept of the troubleshooter is nothing divine. It is down on earth, but acting on two levels - one level of reality/of fact and a second level of fiction.

During the analyses and constructions of the hypothesis, those two parts start to overlap and become blurry. Enlightenment is needed. In this context two ways of displaying the hypothesis are used. The first, the facts, will be visible under normal light conditions. To visualize the fictional some different means will be used to decode it. In the text, those means are easy ones, like different naming or shortcuts to describe. In the installation, a different lighting - UV-light.³, is the means of choice.

The dual nature of the lichen is incorporated into the artwork - the adaptable extroverted and the sensitive introverted sides. The UV-light highlights the second layer, the fictional sensitive part. But it does not fade out the first layer, the one that has the facts. So it always remains visible where the hypothesis comes from. By switching back to normal light, there is just the first layer (the facts) visible again. To switch between those two light conditions an IF-button is installed. A button that is placed in the room of the exhibition, which let the visitor himself switch between the two layers.

The first layer – the real or fact – will display the processes, the thallus, structure analyses etc. that were described before in the text, by sketching them on the walls of the exhibition room. Those drawings, descriptions and graphs illustrate the base of the construction – the proven facts.

³ Beside lots of other applications, UV-light is used as way of visualizing in microscopy to differentiate, or as one part of the C-P-K spot-test. A special test for lichens to verify species by the produced substances, which react by changing colour or fluoresce under UV-light.

K - Kalilauge -> bark is reacting yellow because of the substance Atranorin

C - Natriumhypochloritlösung -> mark is reacting pink or red

P - Paraphenylendiamin -> no reaction or fluorescent glowing under UV- Light

http://www.blam-hp.eu/allglich_blam.html

http://nhc.asu.edu/lherbarium/lichen_info/tlc.php

As I was told by one, lichen investigators love it to make night hiking tours through the woods with UV-flashlights to observe the glowing lichens.

The second layer will show the fiction. On that layer the hypotheses are displayed - drawn with transparent, blue glowing colour.

The semicircular window of the room is covered and functions as a projection surface, where a video of one lichen (island moss) during the process of irrigating is shown. Repetitive water is drizzled on the lichen, so it performs a slow movement and changes its colour from grey to green. It is the initial process of lichen revival out of the dry rig it by soaking water and starting the inner factory. This video is also the footage for a program that codes/raster the images and changes, like the changing of the colour and the movements, to convert it into sound.



Visualization of the two layers of the installation,

Reflection

The work is the creation of a hypothesis. The lichen as a metaphor stays for an all surviving and curing organic form. Because it is autonomous the lichen is able to cure and sustain others.

The "IF" in the concept of the composite organism as a possible universal troubleshooter referring changes/problems/complications that need attention. From this perspective the concept might not be so far from reality. To create such a hypothesis is by far not a new way of thinking, neither in art nor in science.

Lichens actually are composite organisms - COs. In the hypothesis the lichen becomes more the composite organism, step by step through the naming of the construction/the hypothesis itself/the universal troubleshooter. Instead inventing a new name, the already existing suitable fictional name is used.

Lichens have been historically used as food plants and primarily as medical plant. Beside that it was one of the most important and valuable resources for dyeing (Orcein, lithmus). (Casselmann, Karen Diadick, 2001) Until today they are used as a base element for soaps, perfumes and after shaves. (Schöller, 1997, p. 192) They also found great appeal in alchemy, mostly to cover wounds or in creams like the *Waffensalbe* (Paracelsus, 16th Ct) (Dilg, P. & Rudolf, H. 1991) or in the liniment *Urgentum armarium* - a highly recommended beneficial elixir for the treatment of various diseases (i.e. epilepsy). It was made out of different lichen species growing on the skull of an executed criminal. (Parmelia (lichen) -- Britannica Online Encyclopedia)

The hypothesis has to be seen as a desirable concept. It might be a promising idea of a universal troubleshooter. The lichen perfectly fits with its abilities and its adaptability. One thing, that could be seen as a problem-solving approach. Something that is there, available always and everywhere for what reason ever you might want to use it.

Installation views (Photos by Iuliam Moise)

Factual room







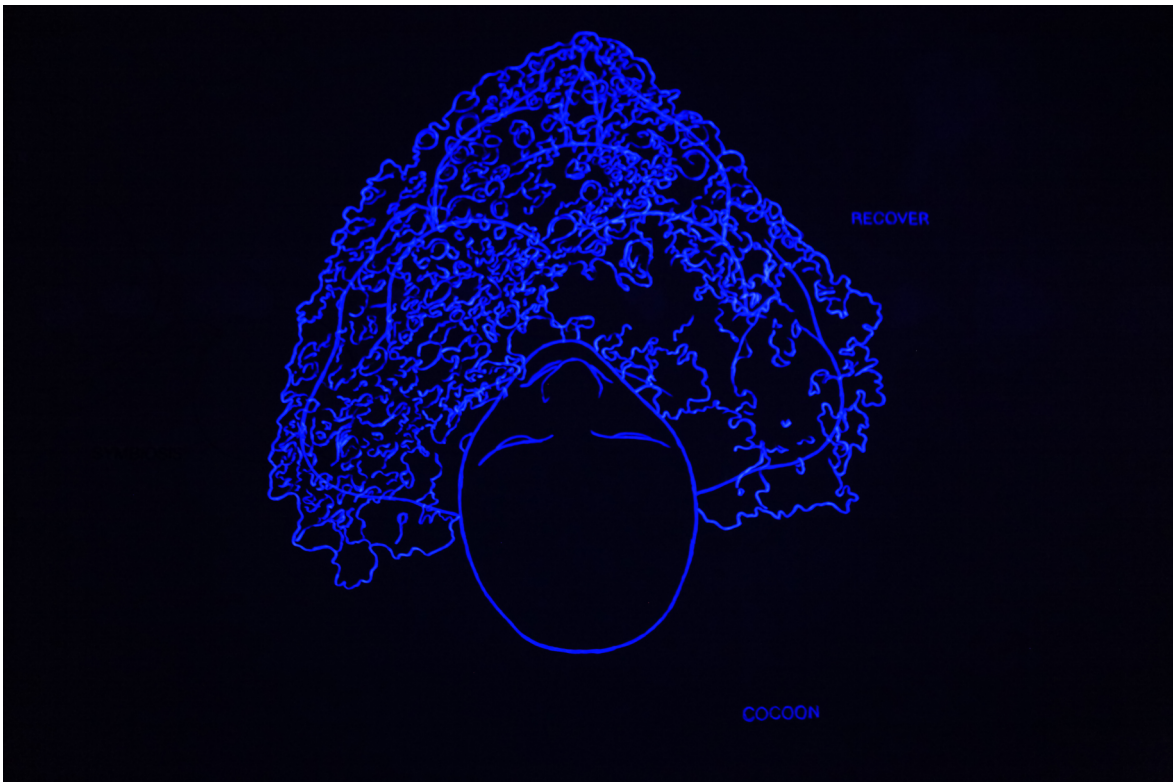


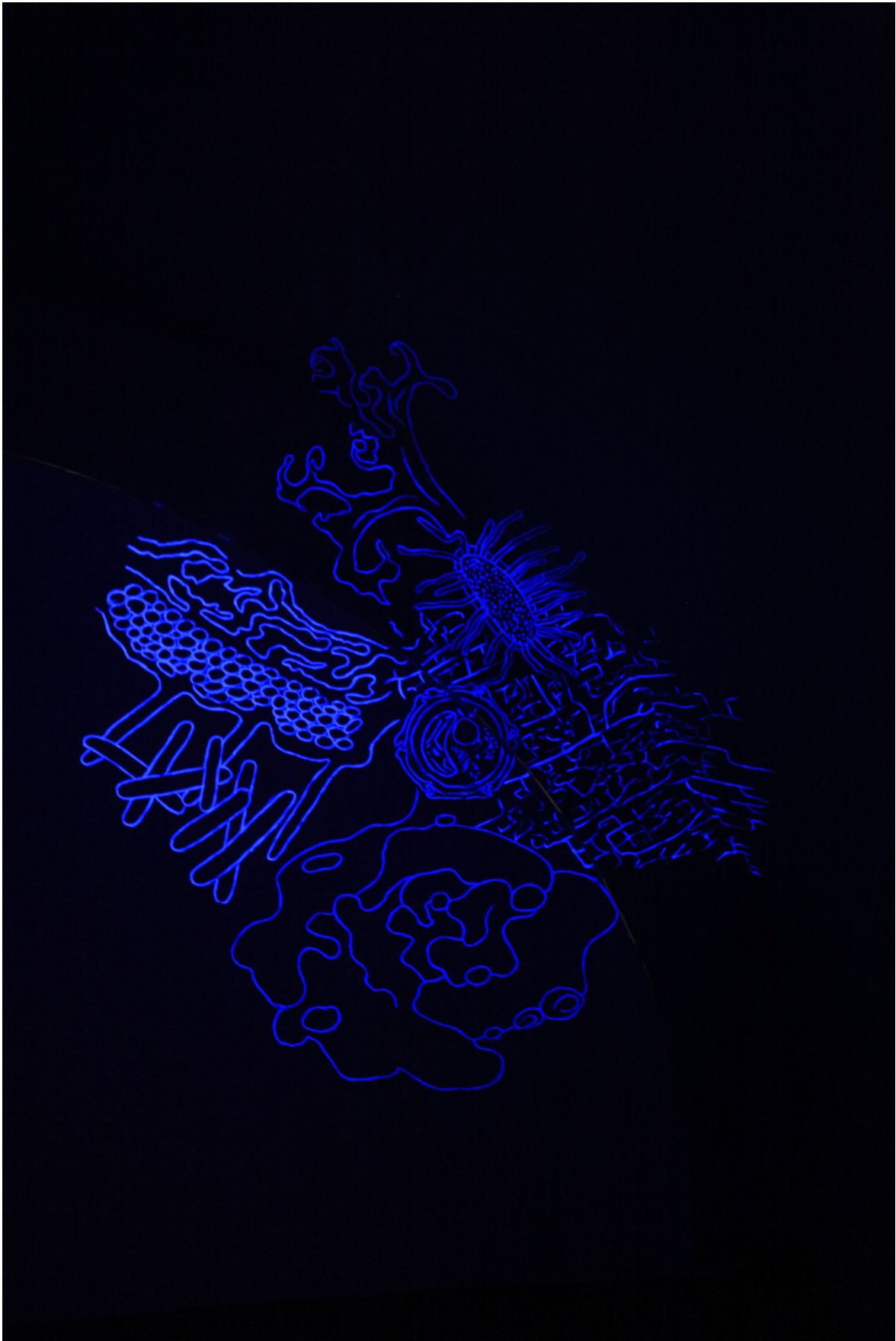


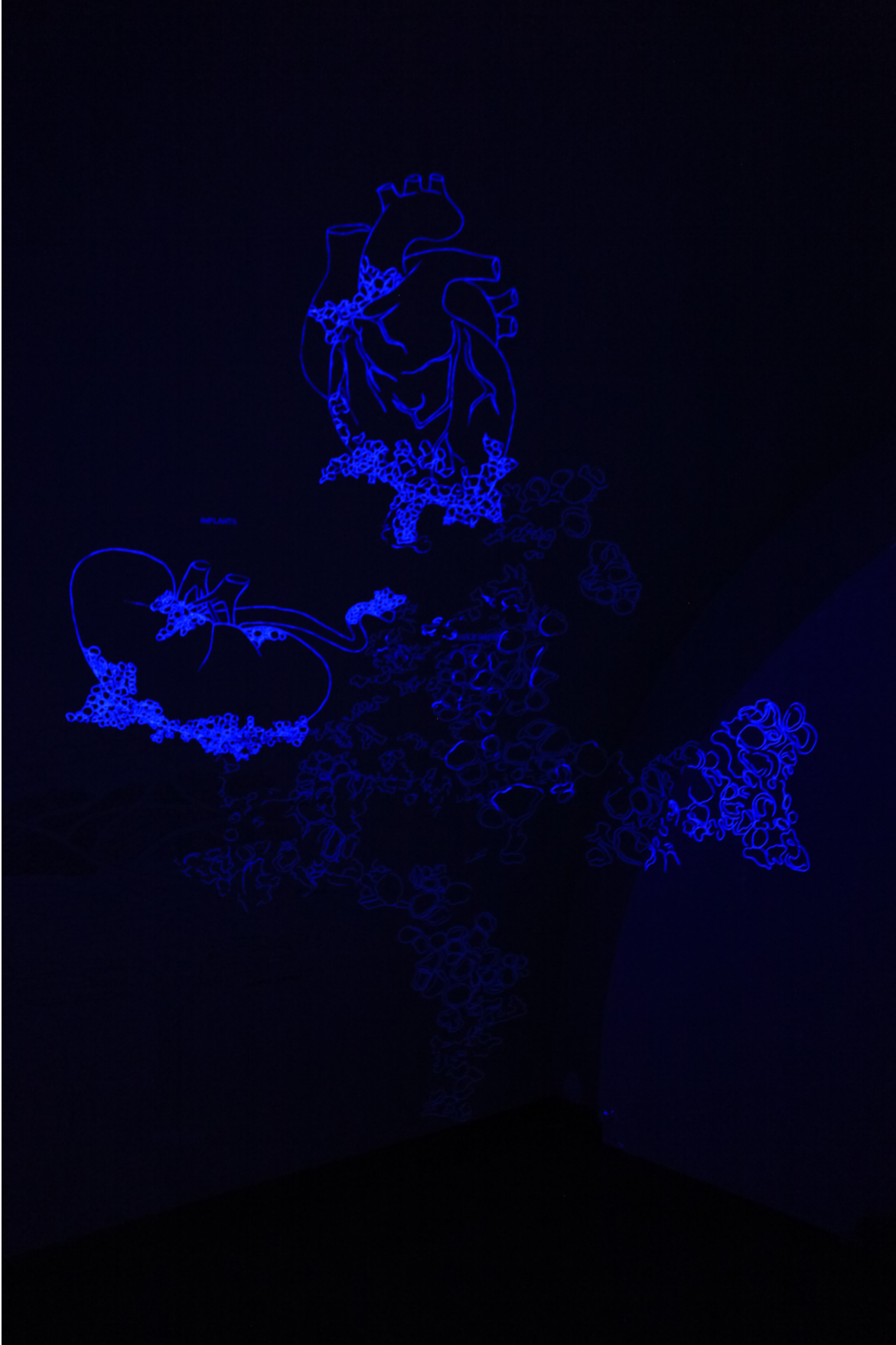


Fictional room



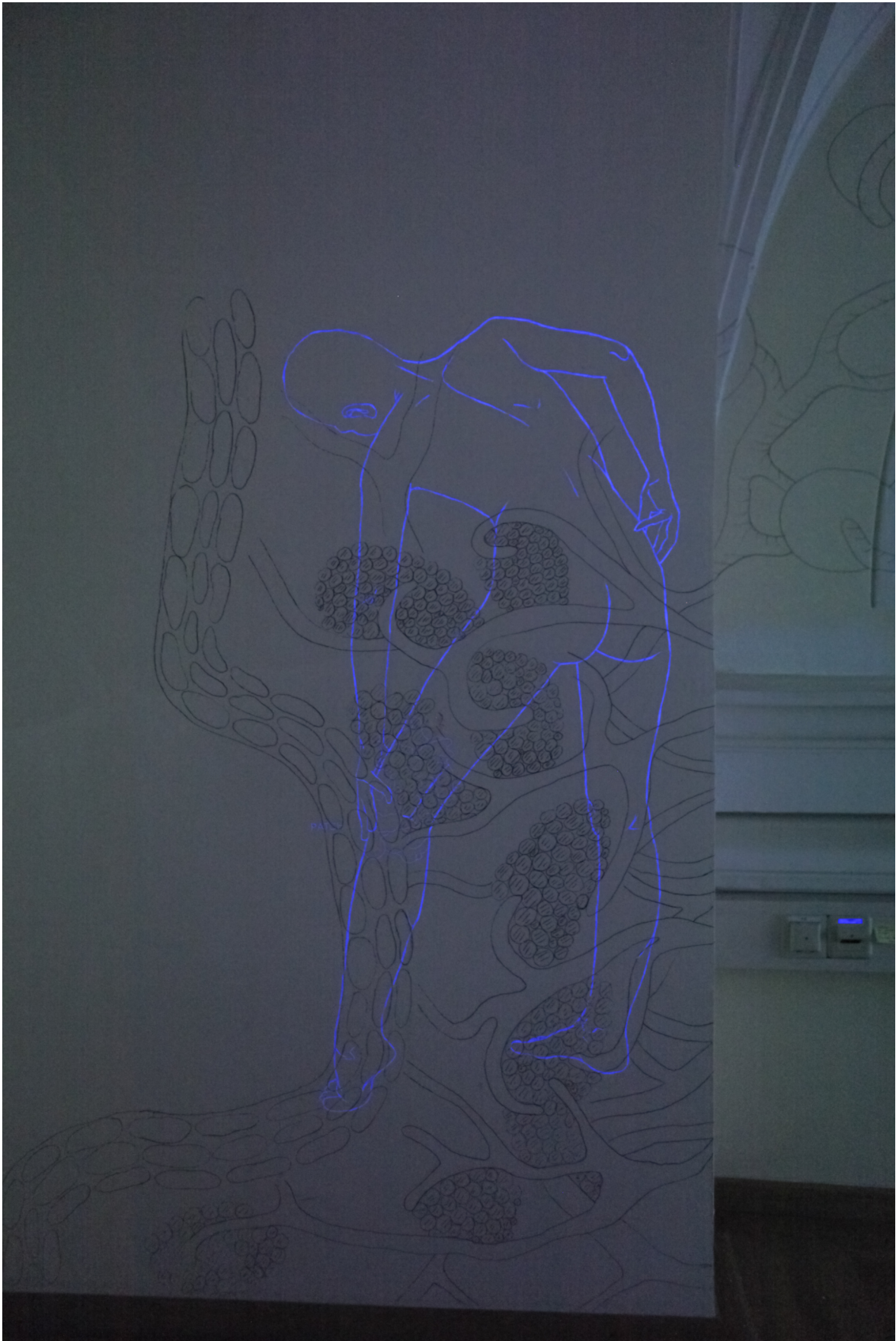


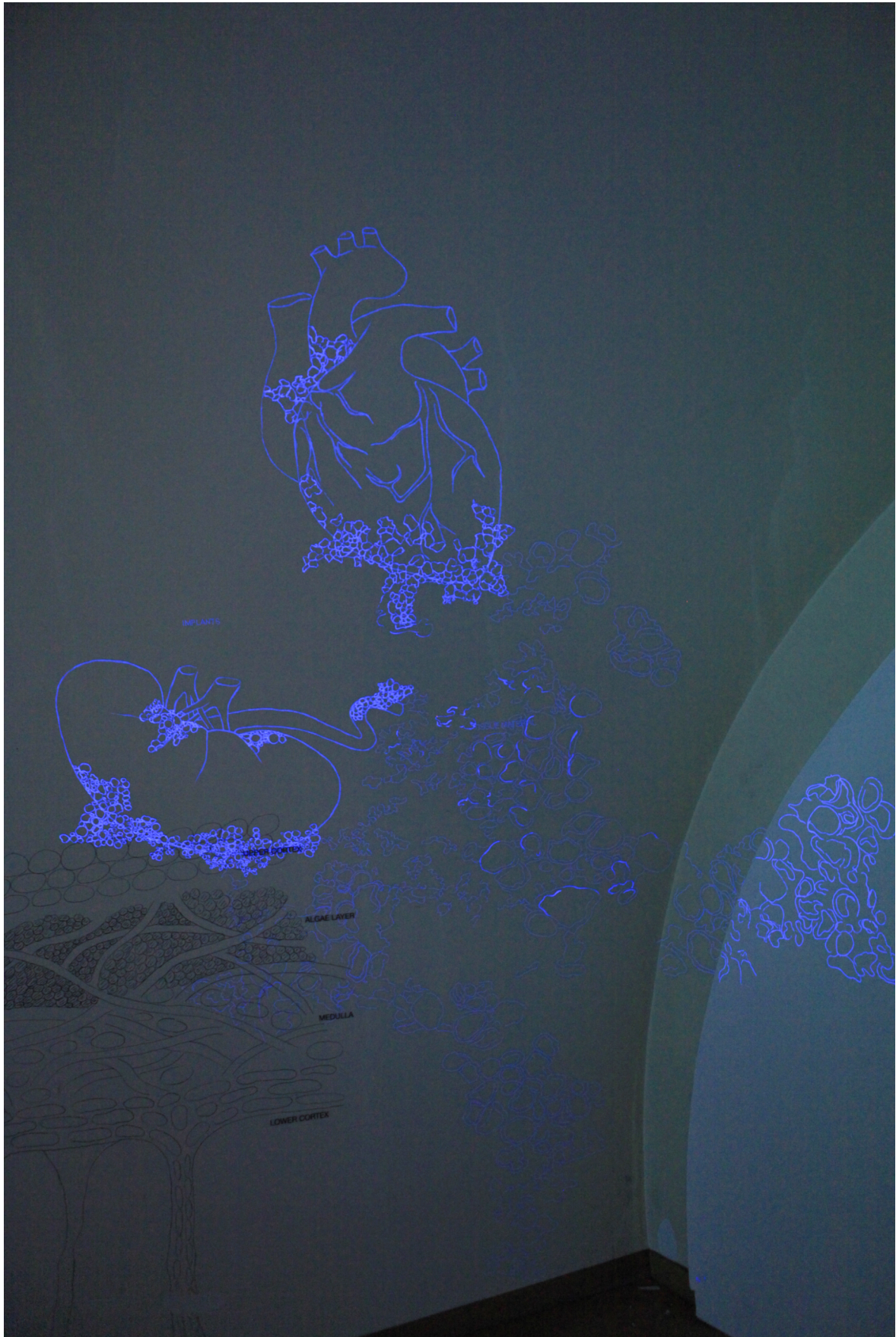




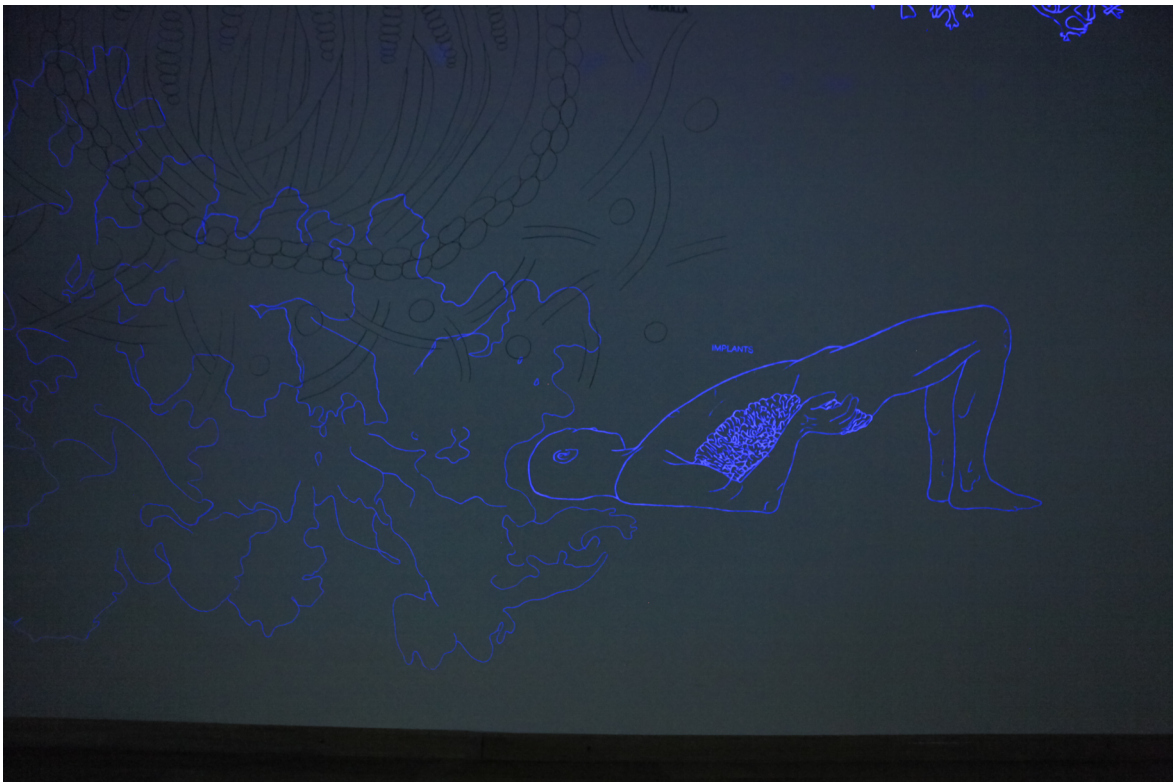


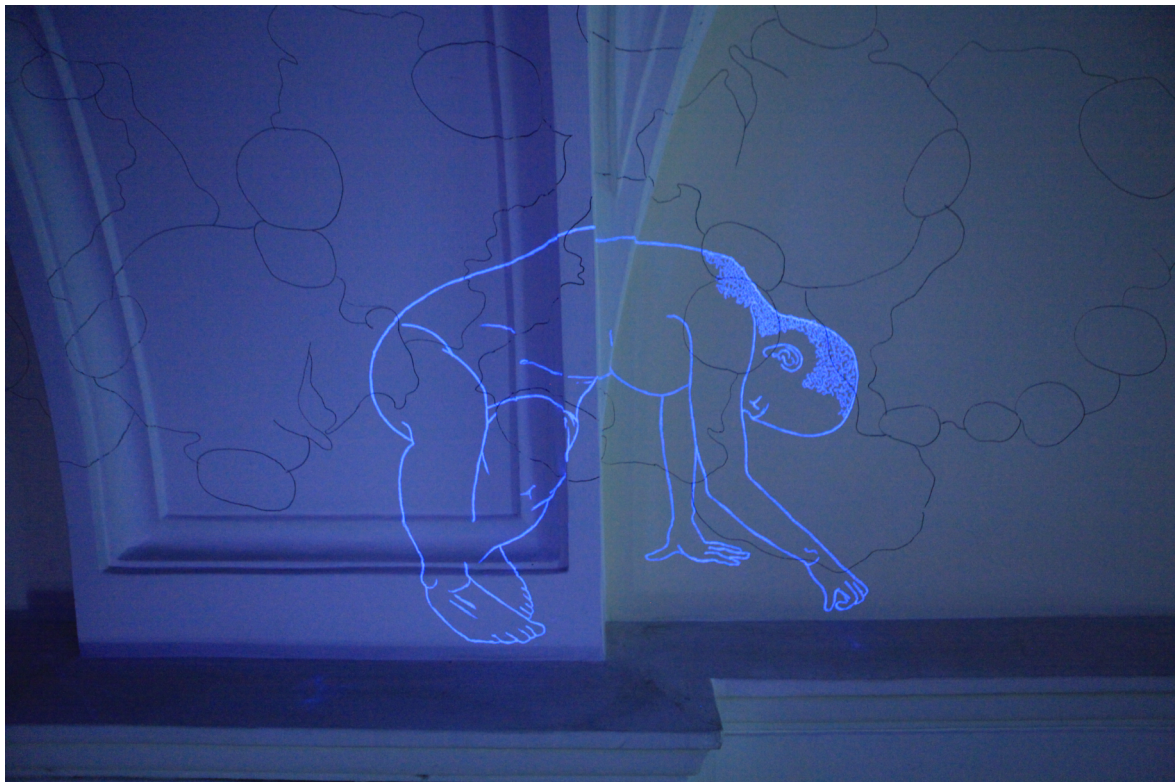












Selection of lichen substances:

primary intracellular metabolites of lichens:
are proteins, amino acids, polys, carotenoids, polysaccharides and vitamins.

Secondary metabolites (extracellular) produces over 1000 lichen substances
broadly speaking, there are three major types of lichen substances based on their
biosynthetic pathways („Lichenes: a chemically important Biota" J. Natn.Sci.Foundation Sri Lanka
2005 33(3): 169-186):

- a) depsides, depsidones and dibenzofurans
- b) two major (biosynthesized) groups of pigmented compounds, occur in the cortex:
pulvinic acid derivatives and terphenyl quinones
- c) terpenes and steroids

ad a) acetyl- polymalonyl lichen products derived from two or more polyketide chains	Lecanoric acid (<i>para</i>-Depside) Alectorialic Acid (Benzyl depside) Gyrophoric acid (Tri depside) Sekikaic acid (<i>meta</i>-Depside) Micareic acid (Diphenyl ether) Didymic acid (Dibenzofuran) Picrolichenic acid (Depside) Usnic acid Virensic acid (Depsidone) Contortin (Biphenyl)	
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ad b) acetyl-polymalonyl lichen products drived from single polyketide chain	Aliphatic acids: (+)-Protolichesterinic acid Roccellic acid Mononuclear phenolic compounds: Orsellinic acid β-Orsellinic acid Siphulin (Chromone) Lichexanthone (Xanthone) Haemoventosin (Naphthaquinone) Averythrin (Anthraquinone) Pulvinic acid derivatives: Pulvinic acid Calycin Terphenyl quinones: Polyporic acid Thelephoric acid Indolyl-3-acetic acid Ambewelamide A, B	
ad c) typical lichen products derived from the mevalonic acid pathway	Terpenoids: (-)-β-Thujone (Monoterpenoid) Fukinanolide (Sesquiterpenoid) (-)-Sandaracopimaric acid (Diterpenoid) Hopan-6α,7α,22-triol (Triterpenoid) Ergosterol (Steroid) γ-Carotene (Carotenoid)	
Usnea, Usnea barbata (Bartflechte), Ramalina menziesii	Usnic acid	Traditional Uses: cleanses lungs, resolves phlegm, controls bleeding, removes toxin Applications: headache, ocular irritation, cough, profuse phlegm, malaria, scrofula, leukorrhea, functional bleeding, wound bleeding, carbuncle, toxic snake bite. Now mostly synthetically made, also used as a steroid

Parmelia	Depsidone salazinic acid atranorin, chloroatranorin	antioxidant, antimicrobial and anticancer activities it was believed to be an effective treatment for epilepsy if found growing on an old skull, especially that of an executed criminal.
Wolfsflechte (Letharia vulpina)	Vulpinic acid	Neurotoxin Carnivores - toxic bait for wolves and foxes According to a report by the wolf hunter Nicholas Nilsson dies a wolf within 24 hours, if not shortly takes fresh blood to him thereafter, which allows him to recover. The poison acts stronger the older the lichen is.
Lecanora	Mannitol, Depside, Fumarprotocetrarsäure	Fumarprotocetrarsäure: light shield and have antibiotic effect; these could also contribute to resistance towards metal ions, such as Mangan.
Icelandmoss	Fumaric acid or trans-butenedioic acid (non toxic)	antibacterial effects, a popular cough medicine Fumaric acid multiple sclerosis (medicin) Psoriasis (Schuppenflechte) food additive E297, also used for backing powder and beverages occasionally in place of citric acid.
Cladonia rangiformis	<i>Protocetrarsäure,</i> <i>Atranorin,</i> <i>Rangiformsäure,</i> <i>Norrangiformsäure,</i> <i>Bourgeansäure,</i>	aromatic lichen acids Atranorin Antinociceptive and antiinflammatory actions have been reported, and the use of atranorin-enriched lichen extracts in folk medicine is widespread.

Selection of lichen substances used as pigments:

primary deep yellow to orange (Parietin), green and yellow tones (e.g. using acid, vulpine acid); shades of blue are very rare.

Lithmus <i>Lackmus</i> (<i>Azolitmin</i>)	Main sources today: <i>Rocella montagnei</i> (Mozambique) and <i>Dendrographa leucophaea</i> (California).	Lithmus paper, pH-indicator (red at 4.5, blue at 8.3) to test if a solution is acidic or basic.
Orseille (Orcein) or: <i>Lecanorsäure</i> , <i>Dorsellinsäure</i>	Most obtained from the lichen species of the genus <i>Rocella</i> and <i>Lecanora</i>	solution of acetic acid for coloring chromosomes or Chromatids in microscopic preparations used in alcoholic solution with ferric chloride - colored purple, with chlorinated lime - colored blood red; emits first orsellinic acid by boiling with water or alkalis, then orcin and carbonic acid. In ammoniacal solution it turns red in air.
Parietin	is the predominant cortical pigment of lichens in the genus <i>Caloplaca</i> , a secondary product of the lichen <i>Xanthoria parietina</i> , and a pigment found in the roots of Curled Dock (<i>Rumex crispus</i>).	It has an orangy-yellow color and absorbs blue light. It reacts with KOH to form a deep, reddish-magenta compound.
Scytonemin	a biological pigment synthesized by many strains of cyanobacteria, including <i>Calothrix</i> sp., <i>Lyngbya</i> <i>aestuarii</i> , and others. It was originally discovered in 1849, although the structure remained unsolved until 1993.	Scytonemin is believed to act as a bacterial sunscreen with a broad absorption from 325-425 nm and a separate maxima at 250 nm, and its biosynthesis triggered by exposure to UV light.

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Image 4

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