Simbiosi

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Simbiosi

A poetical narrative on paper waste from exhibition: the metamorphosis of material through mycelium.

Note to the reader: "Simbiosi"

Simbiosi -as in the title - is the Italian translation of the term symbiosis. In the Italian renowned Enciclopedia Treccani, "simbiosi" is defined as an intimate, often obligatory, association between organisms of different species, generally involving co-evolutionary phenomena. Depending on the type of relationship established between the various organisms (symbionts), different modes of symbiosis can be defined. The one of interest for this thesis is the ectotrophic mycorrhizal. Mycorrhiza is the structural and functional combination of the mycelium of a fungus with the root of a plant. (Micorriza, n.d.) In this thesis I want to express the symbiosis among two cultural fields: museum and bio design.

Abstract

- In this research, I am exploring how to regenerate paper, so making it an endless material. I propose an approach based on transforming paper from an exhibition into soil, through the help of mycelium, a living organism.
- The thesis aims to create awareness about the development of sustainable alternatives to recycling and archiving within the museum field. It Embeds the concept of metamorphosis within the transformation of paper.
- For that, I developed a collaborative project focused on experimentation taking place in a material incubator laboratory, and on a visual translation of a design methodology.
- In this thesis, I present research on testing if mycelium can grow on paper and how it will decompose in the soil.
- The thesis proposes a "poetical narrative", as it stems from the idea that paper originated from the trees and will return to them through their roots in transferring and preserving the information of the piece of paper within the mycelium . The mycelium which has grown on paper in the laboratory, is used to create vases that will be positioned into the ground, allowing the cycle to continue endlessly.
- The thesis builds on my interests in museums and bio design, and on my professional experience in the field of exhibition organisation.





May 2023 Name: Lara Ippolito Thesis supervisor: Barbara Neves Alves Personal tutor: Márton Kabai Netherlands Words: 4320

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Figure 3. Petri trees. 2023

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Introduction

Living in an historical period characterized by a profound economic and climate crisis, and increasing social and political tensions, we cannot avoid taking everything that surrounds us into consideration when dealing with the topic of creating new projects and ideas. The issue of sustainability is increasingly intrinsic to everyday actions both on a large scale and on an individual level.

Closing Conference Working on Common Ground "Have We Met?", 2022. Triennale di Milano, Italy. Speaker K. Kuitenbrouwer.

This thesis is divided into three main parts.
First, it analyses the role of museum in relations to sustainability; second it focuses on bio design specifically exploring mycelium. Thirdly, it presents an innovative experiment with living organism in a bio-based project.
This thesis aims to bridge the two fields of knowledge: exhibition design and bio design.
Nowadays, eco-sustainability in museums is a complex issue, as museums must balance their environmental responsibilities with their educational and cultural duties. In the design field, in the last decades, a new sector emerged: "bio design", which describes the use of biological materials and processes to create new products, services, and systems.
Thus, bio design has the possibility in the museum field by

innovatively approaching waste recycle and material use. By embracing bio design, museums can make progresses towards achieving environmental sustainability in regards of the materials use after the exhibition life.

- Based on this assessment, I use paper waste from a specific exhibition, which will analyzed later in the thesis, and explore the possibility of mycelium to grow on it. In doing so, I am looking to carry out what I understand as a symbolic act that raises questions to the afterlife of exhibition and the sharing of knowledge. Thereby, I am aiming to create awareness about the development of sustainable alternatives to recycle and archive. Through the experiment, the thesis embeds the concept of metamorphosis with the transformation of a sheet of paper.
- Paper derives from the cortex of the tree and undergoes numerous steps before being ready for its most common function of gathering information. After its lifetime, paper is either discarded or archived. I want to add a step to the cycle of paper life, by letting it go back to trees by positioning mycelium in the soil. In this way, paper would naturally be absorbed by trees from their roots, thus closing the cycle. This thesis proposes a way to incentivise solutions for the sustainable use of the fraction, which is not recycled, thus making the overall consumption of paper in the exhibition field more sustainable. In creating this transformation, I discuss how to understand and regenerate the paper as an endless and symbiotic material. Exploring an innovative approach to thinking about shared

knowledge by working from transforming paper from an exhibition into soil through mycelium.

- In terms of methodology, this thesis includes collecting material; working in the laboratory; digitally writing the process and print it in a final publication; reporting the process with photographs made with the analogue cameras Olympus OM10 and Praktica 700 with 100 films both coloured and black and white; the creation of representative objects, in this case vases, but this process can be applied to many other items.
- Why paper? As I am passionate for printed books and for tiny natural details. In choosing this approach to my research, I am relating to my love for books, for reading, for printed matter. I am a loyal book reader, a lover of the ink's perfume on the paper, the feeling, and the gesture of opening a book and entering in another dimension. I am that type of person who collect any kind of paper, poster, flyer from exhibitions. Some of those I hang in my house, some other I use to create collages. At the same time, I am the type of person who can be mesmerised by small details, like a droplet running down a leaf or a tiny mushroom sprouting on a branch. Everything for me is worthy of attention. With this simplicity, I am aiming to draw the best from the elements that surround me, thinking about how to give a new meaning to what already exists. With this awareness, I am connecting two field I am passionate about, exhibition design and bio design.







Museum

In September 2022, I started my internship in the agency department at Nieuwe Instituut, Museum of Architecture, Design and Digital Culture in Rotterdam. This museum promotes sustainability within the building itself, the exhibitions, and the program. It shares intrinsic values based on sustainability and cooperation. These ideals have always been intrinsic into my practice. Also due a compelling educational role played by my mother who nurtured in me the passion towards cultural occasions. Since I have memory, I remember visiting every weekend a different museum or an archive or a cultural event in my home country, Italy. Ever since, I always collected any kind of paper from there, namely flyers, cards, posters, brochures, and books. I still do it and keep most of this material with me.

When I started moving from place to place to study and work, I have always brought some of these papers along. I hang these memories on the walls of my new room as my first ritual when I enter it. This makes me feel home. The lightness and the small dimension of the paper allow me to always carry them with me.



Figure 8. Nieuwe Instituut entrance. 2022

These little gestures are backbones of my practice. I combine it with the exploration of exhibitions due to the curiosity that these sparks in my mind. Exhibitions are places where I can always get in contact with new ideas, be inspired by them, and have always helped me to develop a critique point of view toward a topic. In these places it is possible to experience while learning and to discover while being in contact with others.

- In positioning myself in this way, I choose to focus my work around the exhibition "Archives at Risk" (Archives at Risk, 2022) that took place at the Dutch Design Week (Dutch Design Week, 2022) in Eindhoven between 21 and 29 October 2022 and it is now exposed at Nieuwe Instituut in Rotterdam.
- It was the first exhibition I collaborated with during my internship. I had the chance to observed people interaction and reaction to the space, by pending a lot of time there during the buildup and almost every day of the exposition.
- As the title suggests, "Archives at risks", the theme was connected to the practice of archiving and the urge of preserving them. Thus, the materiality of paper was truly present. The exhibition was bounded by panels with hanging photographs depicting the archives and the central area had five shredders. Long rolls of paper falling from the ceiling and chopped by five shredders working with a different timing and diverse durations. These papers illustrate



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Figure 10. Archives at Risks. 2022

some of the most powerful phrases extracted from conversations with designers and archivists during various interviews that took part during the research.

The purpose of this paper sheered was to raise awareness towards the need to act in response to the loss of numerous archives in the fields of design and architecture due to a lack of attention, space, or interest in design projects. However, the process of eliciting such desperate emotion resulted in a sizable amount of paper waste, which made me reconsider the circularity of its life. This gave me a huge inspiration regarding the whole project since it makes me relate to an afterlife of exhibition components.

Regarding museum practice, I am keen on the process of the afterlife of the exhibition, and new alternatives of reselling, archiving, or throwing away the components. Thus, my research begins with an investigation on studio, cooperatives and any kind of realities that collect and reuse materials from exhibitions, the most functional examples are: REbienale (REbiennale, 2008) and StudioSuperniche (StudioSuperniche, 2011).

At the same time the study shift to the topic of sustainability regarding the museum itself. By analyzing the PhD research conducted by Michela Rota in the publication "Musei per la sostenibilità integrata" (Rota, 2019) it is possible to conclude that museums are at a crucial moment in terms of the role and relevance they want to bring within contemporary society. Museum spaces have always made me feel safe and reminded me about the feeling of home and belonging that I refer to my childhood life. Museums play an important role in the society, not only regarding its life in the inside, but also its function in relation with the outside. Moreover, considering the SDGs for sustainable development of the UN's Agenda 2030 (Rota, 2019), sustainability, with its implications in the cultural, environmental, economic, and social spheres, is an open challenge that many museums have yet to systematically confront. This research provides an enormous range of professional tools in this area, orienting technical competences on the various activities, and supporting the involved museum directors and operators to be active witnesses. As a result, Rota's book has been essential to the research's goals of raising awareness of the world of museums in relation to sustainability. It intends to propose a range of possible approaches to start the path towards sustainability of the numerous and heterogeneous museum experiences. The goal is to build a green management that works both on current management and on the implementation of projects for the transformation and redevelopment of the existing. To inspire actions that are consistent with the urgency and importance of using cutting-edge tools to address the issue, it wants to engage with the various publics.

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Figure 11. Archives at Risks paper. 2022



Figure 12. Archives at Risks detail. 2022



Figure 13. Mushroom.





Eio-design

- Bio design means exploring design methodologies with a biological viewpoint or viceversa, researching at the same time with living organism.
- Based on this definition, the thesis merges bio design and exhibition design, make them working in symbiosis toward a more sustainable future in the design and artistic world. The aim is to give an afterlife to the paper from the exhibition with a non-canonical method, by working with a living organism: mycelium. The thesis proves a small-scale example.

2.1 What is Mycelium?

- Mycelium is a network of fungal threads or hyphae. It often grows underground but can also thrive in other places such as rotting tree trunks. The fruiting bodies of fungi, such as mushrooms, can sprout from a mycelium. A single spore can develop into a mycelium. Mycelia gives a vital importance to the soil. (Mycelium, 2023)
- Mycelium is able to break down organic material, by making it raw material which is useful again for the ecosystem.



Figure 15. Growing fungi on the book Entangled life. 2020



Figure 16. Still from performative video of Merlin Sheldrake eating his own book. 2020

re 17 Ganodesema Resinaceum in The Netherlands. 2023

This incredible network of fungi roots is composed by filaments called hyphae. Hyphae facilitate the decomposition of organic matter, the breakdown of toxic substances, such as pesticides and petroleum products and the exchange of nutrients.

- Moreover, they prevent the soil from erosion and retain water, by merging with the roots of trees and plants. Mycelium is a fungus like yeast, but unlike most yeast cells, which grow as a single cell, mycelium is multicellular and can grow into macro-size structures. These are often recognized as mushrooms, but not only mycelium produce small molecules, but assembles them into complex, precise and very small structures invisible to the human eye. Since mycelium works very similar to single-celled yeast, it takes in small molecules of food, namely sugar which often comes from wood or plant waste sources.
- This occurs because of the excreting enzymes break these materials down into digestible morsels. As the mycelium grows it assembles a dense network of long microscopic fibers that grow through the substrate, the hyphae. (Sheldrake, 2020)
- Once the mycelium has fully built its network, it transitions to its next stage which is the building of the mushroom. In this phase humans can intervene. Rather than letting a mushroom pop up out of the substrate, the mycelium can be coaxed to build predictable structures by controlling temperature, CO2, humidity, and airflow to influence its growth.

- Mycelium is the nature's biggest recycler; it is able to breakdown toxins such as plastic or oil and turn them into available nourishment to help other living organism thrive (Solving the Issue of Single-Use Plastic, 2023.).
- The ability of fungi to flourish in an enormous variety of habitats depends on their diverse metabolic abilities. Metabolism is the art of chemical transformation, and no plant grown in a natural environment has ever been discovered without this mycelium network. The only other organism that can explore, scavenge, and salvage as cleverly as fungi is bacteria. Fungi can break down some of the hardest substances on earth, including rock, crude oil, polyurethane plastics, and the explosive TNT, by combining powerful enzymes and acids.
- Fungi can grow basically everywhere, with just few exceptions, but the species isolated from mining waste is one of the most radiationresistant organisms ever discovered and may help to clean up nuclear waste sites. The most extraordinary example is the blasted nuclear reactor at Chernobyl which hosts a broad culture of fungi. These types of fungi are called radio trophic. It has been asserted by the research on the book "Fungi in Extreme Environments: Ecological Role and Biotechnological Significance", (Tiquia-Arashiro & Grube, 2019) these fungi can carry out the hypothetical biological process known as radiosynthesis, which entails using ionizing radiation as an energy source to drive metabolism. Indeed, a



Figure 18. Mycelium detail. 2020



m Rumming, 2023

number of these radio-tolerant species even grow toward radioactive particles and appear to be able to harness radiation as a source of energy, as plants use the energy in sunlight.

In exploring the field of bio design and up-cycling, in this section, I start by describing what mycelium and its substrate are, to then talk about mycoremediation and the toxicity of the ink on the paper. This is important to my project as it grounds designing with living organism. In this thesis I will concentrate on experimenting if mycelium is able to grow on paper and how it will depredate end decompose in the soil.

I am choosing to work with Mycelium as I am inspired the non-fiction book on mycology "Entangled life" (Sheldrake, 2020) written by the British biologist Merlin Sheldrake. With this book, the author created a performance in which he cooks and eats mushrooms that have been planted by him on his publication. He enacts the concept of eating his own words. What has come out of his mind returns to it by the act of eating his text. A fascinating action that leads me towards a circular concept and make me wonder if paper can be seen as an endless material; and if paper can have a circular life while being a vehicle of knowledge among the human and non-human.

2.3 Paper as substrate: what is the substrate?

In this project paper will act as the substrate of mycelium. The substrate is the surface or material from which an organism grows or obtains its nourishment. In biochemistry, the substances with which the enzymes react are known as substrates. In ecology, the substrate is known as the foundation to which an immobile substance is attached (Biology Online, 2022). It provides nutrition for mycelium. Agricultural fiber residue is commonly used as substrate, namely hemp, straw, and sawdust. Due to their cellular structure composed of cellulose content embedded in a lignin and hemicellulose matrix enable them to bind strongly and form composite material. Temperature and light are compelling factors to its growth (Abdelhady et al., 2023).

Then, mushrooms, if compared as a plant, can be associated as the flower and the mycelium is its body, its roots. A above mentioned, mycelium naturally decomposes organic matter by binding onto surface rich in carbon to form a three-dimensional network. Once the network is formed, the structure is strong and light and, in this phase, it is possible to guide it and create different shapes. In this project I design a vase, which, by decomposing later, will enrich the soil.



Figure 20. Mycelium detail. 2023



Figure 21. Mycelium detail, again. 2023

2.3 Mycoremediation as a solution for the degradation of the ink toxicity.

In designing the vase, I take into consideration the toxicity of the paper and I address it so that it does not harm the soil I will introduce the vase after creationg it. The only toxic part of the paper is the ink used to print on it. Thus, I researched on the ability of mycelium to break the toxin of many materials which is known in mycology as mycoremediation. (Kulshreshtha et al., 2013)

- Mycoremediation (Stamets, 2011) is a term coined by Paul Stamets to express the method of using fungi for bioremediation of contaminated soil. Through this process, fungi use some of their harmful toxins as a natural fertilizer and convert them to simpler segmented forms. Mycoremediation is crucial in the breakdown of a broad range of toxic substances including petroleum hydrocarbons, polychlorinated biphenyls, heavy metals, phenolic derivatives, persistent pesticides, and many others.
- Moreover, the scientific paper "Mycoremediation, an Eco-friendly Approach for the Degradation of Cellulosic Wastes from Paper Industry" (Singh & Sharma, 2013) elaborates on how fungi can break the toxins of the ink. In fact, the enzymes that are effective bio-reagent, called hemicellulose, can achieve bleaching. They are used to guarantee brightness in the manufacture of high-quality paper products, and they are used as an alternative to poisonous

chlorine. This means that, by being able to bleach, they can break the toxins of the inks.
The thesis assesses if mycelium incorporates the ink inside or the toxins are being disintegrated completely and will not harm the soil. This issue will be explored as a future step in the research and will be integrated later on in this thesis.
In conclusion, with this information I begin the practical research in the Material Laboratory where I test if mycelium can grow on paper and how to reintegrate it back to the soil.



Figure 22. Mushroom.





Project

In this section I will present the process and the experiments related to the project to put into practice the research presented above. I worked in the Material Laboratory of Avans University, combining paper with a living organism with the guidance of the Laboratory coordinator Serena Buscone and the tutors Emma van der Leest and Emma Luitjens.

- Since I am working about materiand knowledge from exhibitions which will have another life and become parts of trees and in this way, I am exploring a poetic approach on the afterlife of a material wasted from an exhibition. In this case paper, that comes from trees, returns to them by positioning mycelium in the soil. With this project I want to express a circular idea. In this paragraph I am describing the process of mycelium growth with paper as its substrate.
- I started my empirical project with three experiments, in which I combined two different kinds of paper, 80 grams white paper with black ink and 120 grams laminated black and white paper, collected from the exhibition "Archives at risk" (Archives at Risk,



Figure 24. Material laborator Avans. 2023



Figure 25. Material laboratory Avans. 2023





Figure 27. Petri dish with Ganodesema Resinaceum. 2023



igure 28. Petri dish with 80g white paper and black ink combined with the fungus. 2023



Figure 29. Petri dish with 120g white and black paper combined with the fungus. 2023

2022) with the fungus ganodesema resinaceum. This specific type of fungi, originated from The Netherlands, is very interesting in regards of this project since they grow on trees.

This fungus has been reacting positively with the paper as their substrate.

3.1 The experiments

- I carried out three laboratory experiments. The first one tested the possibility of using paper as substrate for mycelium; the second is a 2D craft creation through collages and the last one is the creation of two vases. I wanted to explore both the flat dimension and the tridimensional potential of the material. The three experiments are described below:
- 1) Testing the possibility of using paper as substrate for mycelium

Using paper as substrate of mycelium Testing the paper in petri dishes! used two types of paper for the experiments: white 80 grams paper with black ink writes and laminated black and white paper 100 grams. In the laboratory I first tested in two transparent sterilized petri dishes if mycelium could grow on it.

- 2) 2D craft creation through collages
- The first three experiment have been done with positioning mycelium on single sheet of written paper. One is composed only by the thin normal paper with written words which the same kind of paper

that has been chopped from the shredder. The others are collages of the laminated paper flayer (both sides) and a sheet of thick, rough, cream-colored cardboard derived from hemp. Collages is a medium of narrating the story of the project and the research directly with the material.

- 3) Ereation of two vases
- The final phase of the experiment is a combination of paper and hemp as the substrate. It is preserved in two bags with the dimension of 60x40 centimeters. The mycelium which has grown in the laboratory, is used to create vases that will be positioned into the ground. I usedsecondhand vases and designed organic shape with clay in order to mold the mycelium and create the final prototype.

3.2 The steps in the laboratory

In developing these experiments, the procedure to follow in the laboratory to grow mycelium is simple, but meticulous. I have conceived a weekly lab journal, which will be attached later to this thesis, to keep track of every procedure and observation during the process in the laboratory. This journal supports me in collecting all the information and procedures in the laboratory and accounts for the development of the hypothesis, the process, and the results.

Hereby is an extract of the method I have been following during the



Figure 30. Modified picture of petri dish with the fungus Ganodesema Resinaceum, 2023



Figure 31. Modified picture of petri dish with 80g white paper and black ink combined with the fungus. 2023



Figure 32. Modified picture of petri dish with 120g white and black paper combined with the fungus. 2023



Figure 33. Setting of the process in the Material Laboratory of Avans University. 2023



Figure 34. The two types of paper in the Material Laboratory of Avans University. 2023



Figure 35. Setting of the process in the Material Laboratory of Avans University. 2023

experimentation. The method includes five steps: incubation, inoculation, growing period, molding and drying. It is compelling to follow all the safety and cleaning procedure when entering the lab, then sterilizing the material chosen to let mycelium grow is mandatory to avoid other kind of bacteria or fungi to grow and contaminate the mycelium. The first step entails sterilizing all the paper material and is called incubation.

The incubation is a sterile procedure that avoid the conta mination of the biological culture which in the common laboratory language means the growing of living organism. The machine used is the autoclave and the process last for two hours. The autoclave uses steam heat to kill any microbial life that may be present on a contaminated load. A load is considered sterile once it has undergone a full sterilization cycle. Once a load is sterile, it can be used without fear of introducing foreign microorganisms into a sensitive environment, such as a laboratory (Gupta, 2023).

After the incubation, the substrate has been sterilized and the fungus ganodesema resinaceum is combined by inoculation.

Inoculation is the process of introducing an element, in this case grain spawn of the fungus, into a culture, and incubating them. The process of inoculation happens in the biological safety cabinet which provides environmental, personal and product protection and limits the possibility of contamination. The first step is cleaning the surface and tools, namely tape, cutter, spoon, gloves. Then the most delicate part is to add the fungus which must be the 10% of the substrate. The fungus has been inoculated in the petri dish and close it carefully with tape. The final step is to position the samples in the material incubator which has a temperature of 28.8° and a humidity of 70%. After two weeks, mycelium has been fully formed and it is ready to be molded and dried in the oven at a temperature of 65° for 12 hours. This procedure is enacted to stop the growth of the mycelium and preserve the result obtained. In this way the craft is totally degradable, and the craft is 60% lighter.

3.4 Results

The result of the experiment in the laboratory has been positive since the mycelium has been growing on both kinds of paper and has been functional in both bidimensional and tridimensional use. It is still possible to see the traces of the paper, meaning that mycelium has not completely absorbed the paper and the ink. More time is needed to analyze and see what will happen during its life as a vase half positioned into the ground and half on the soil. One vase will be dried, the other will be free to grow in order to see its reaction and degradation with the soil. Through this process, I explored an example of recycling and transferring knowledge, both crucial for guaranteeing a more sustainable future in a resource-constrained world.



Figure 36. Inoculation process. 2023



Figure 37. Setting of the inoculation process. 2023



Figure 39. Setting of the incubation process. 2023



Figure 40. Ganodesema Resinaceum growing on the 120g B&W laminated paper, Material Laboratory of Avans University. 2023



Figure 41. Ganodesema Resinaceum growing on the 80g white paper with black ink. 2023



Figure 38. Setting of the process in the Material Laboratory of Avans University. 2023





Figure 42. Setting of the collage process. 2023



Figure 43. Collage. 2023



Figure 45. Another collage. 2023



Figure 46. Detail of Ganodesema Resinaceum growing on the 80g white paper with black ink.2023



Figure 47.Detail of molding the mycelium in a vase shape. 2023







Conclusion

- The thesis developed a collaborative project combined experimentation in a material incubator laboratory and a visual translation of a design methodology.
- It built on my professional experience in the field of exhibition organization and my studies and research field of designing with living organism.
- The thesis brought closer museums and bio design in the name of sustainability. It showed how a small act, like producing vase from exhibition paper through mycelium, can be integrated in the museum practice as a way of recycling paper waste. The choice of a vase should be intended as a mere example. Further research should follow to properly assess the molecular evolution of the vase.





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