Myco-collaboration
for a new vernacular

a mycelium informed journey

Miriam Josi

Master of Science Nature Inspired Design - Ensci les Ateliers Paris - 2021
Under the direction of Professor Carole Collet, Living Systems Lab, Central Saint Martins UAL

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Fig.1 'Matter of context' Photo: Miriam Josi, 2020

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Preface

Matter of Context

Laying randomly on a table: a pile of dirt, a block of wood, a loose key, a rubber band, a phone charger, a dried rose, a plastic fruit net, an egg carton.
Imagine you were asked to organize them from "natural" to "artificial".
Perhaps you put them in two groups. Maybe you find it difficult to separate the two. Where did you put the egg carton? The key? What makes you think that the dirt is natural? What if I told you the dry rose origins in a greenhouse monoculture on another continent and was sprayed with chemicals?

What is natural? What is artificial? A look in the dictionary reveals three definitions of artificial: man-made, false and unnatural. The word "natural" originates from Old French *naturel* and Latin *naturalis* meaning "by birth". The definitions for it are endless, everything non-artificial basically. Ultimately it could be defined as something that 'exists and evolved within the confines of an ecosystem'.
The previous questions trigger more questions. Why this separation between nature and humans? Aren't humans part of nature too? When did (or do) we stop being nature? What is human nature? Is everything human-made inevitably artificial? What about hand-made and is machine-made still human-made?
We may also ask why this tendency to fetishize the natural? Aren't we reinforcing the separation between humans and nature?

It indeed appears that we can't separate natural and artificial in a definitive way. All materials we interact with are - if not human-made - at least human-touched or human-affected.
Rather than two clear categories, it could be more useful to arrange our table in a spectrum of materials sourced from less or more abundant natural resources, less or more manipulated by humans.

We can repeat the exercise and rearrange the table, defining the criteria each time a bit differently, from least to most durable, lowest to highest environmental impact, and so on. It moreover becomes clear that we can't talk about these materials and objects in isolation of their context. Each has their own story and is part of a bigger system. Unlike often expected, when it comes to design there are no good or bad materials. There are only better or worse material choices depending on the context and the intended use of their application.

Fig.2 ‘Matter of context’ Photo: Miriam Josi, 2020

‘Matter of context’ (Fig.1,2) is a simple interactive game I came up with together with my peer Stella Lee Prowse to use on the first day of a workshop. Through a multisensory experience, the exercise is meant to provide insight into the importance of thinking about the bigger picture, asking questions and understanding the systems and context that materials exist within.

The way we make

Cutting, drilling, lathing, soldering, welding, heat pressing, sanding, plating,.. materials are typically extracted with force and go through processes that could be deemed barbaric if applied to a living being. The array of tools and machines are intimidating and often dangerous to manipulate: objects that cut, turn at high speed, melt at extreme temperatures and release toxic fumes. The fabrication of materials is practiced under precautions and requires safety equipment and protective gear. There seems to be no limitations to impose shape on inert matter and one can wonder why this relationship between humans and materials is one of domination and force.

The development of machines and the discovery of fossil fuels helped to drastically intensify our force on materials and simultaneously shaped our relationship with them, which has become, for the big majority, one of emotional and physical distance. Industrial processes have made available and affordable an ostensible abundance of materials for designers to choose from. This allows the material choice to be an afterthought in the design process. The emergence of digital technologies seems to have only increased the disconnect between designers and materials allowing designers to visualize any material within a mouse click.

The more human intervention and manipulation the better, seems to have been for a long time an unwritten rule in product design (at least that is how I experienced the first years of my undergraduate studies), reflected by an aesthetic broadly represented in mainstream media. Smooth shiny surfaces and sleek flawless shapes have dominated our perception of design. It might be needless to state that this out-of-touch attitude to materials comes hand in hand with a consumerist human-centric approach and a major environmental cost.

Our making is continuously shaping the way we perceive the world and how we interact with it. Throughout human history we have been in touch with materials, built tools to manipulate them, created artefacts from them, continuously developing new technologies to fulfill our material and emotional needs. Doing this we constantly constructed our environment and in return ourselves.
In other words: The way we make, makes our world and in return remakes us.

Today July 29th 2021, three weeks earlier than last year, marks 'Earth Overshoot Day', the date when humanity's demand for resources this year exceeded what the Earth can regenerate in the same year. (Le Monde 2021) The natural world is globally declining at an unprecedented rate due to destruction from human activity. The Living Planet Report 2020 outlines its catastrophic impacts not only on biodiversity but also on all aspects of human lives and highlights the urgent need for "a deep cultural and systemic shift". (WWF Living Report 2020:6)

Fig.3 From 'Honey, I watered the screen', an ongoing project in collaboration with Atelier 37.2 and Stella Lee Prowse, documenting discarded objects inoculated with mycelium and fruiting mushrooms. Photo by Nicolas Guiraud, 2021

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Introduction

The planetary environmental emergency, we find ourselves in, has caused a need to radically rethink design and given rise to a diversity of alternative practices, ancestral and emerging ones, that challenge prevalent linear and petroleum-based material sourcing and processing methods.

Acknowledging the vastness and complexity of the concept of sustainability, I will not be able to discuss the large and interconnected extent of environmental, economical and social justice issues in relation to design.

The objective of this inquiry is to examine other ways of physical making to seek more regenerative and resilient materials and processes that consider the more than human. My research explores biofabrication principles through an experiential journey into reconciling the role of the designer in a shared world.

I ask how collaborating with living organisms can help redefine the designer's role and relationship to materials. I will be working with mycelium, the vegetative body of the fungus, and organic waste in an ultra-local context, exploring the opportunities and limitations of this process called myco-fabrication.

Based on the experiences from personal projects and experiments, as well as workshops I taught, I will discuss the learning potential of mycelium as a pedagogical tool and the ethical questions to working with and thinking through living systems. Here, instead of seeking clear answers, the goal will be to highlight the importance of their consideration.

My exploration with mycelium-based processes will lead me to propose the potential for a new vernacular design. Outlining the parallels between vernacular design principles and myco-fabrication I will challenge the view of biofabrication as a new field and emphasize the role of localism in a globalised world.

Reflections and conversations with designer peer Stella Lee Prowse will inspire the framework for a joint practical experiment to work with mycelium and its ecosystem and design a new collaborative process to imagine more reciprocal futures.

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Background to research

I am a designer.
At least that's what I say when I get asked by people what I do. Somehow my answer is never quite satisfying neither for my conversation partner nor for myself. Indeed the title designer calls for further explanation. Usually a 'what do you design' follows. With good reason.
Yet in my opinion it is not the only question that matters. Perhaps an even more relevant question, and one I keep asking myself, would be: 'What kind of designer are you?'
My aim is to explore this question with further interrogation, without seeking definite answers but find new meanings to my practice.

My educational background in design is product based. I started as a self-taught jewelry designer, during my studies in fine arts in San Juan, Puerto Rico. As I seeked to expand my design skills and knowledge, I was lucky to receive a scholarship to continue my studies in product design at Parsons New York. The experience of going back to school unambiguously taught me much more than technical tools. It provided me with a deeper understanding of the implications of design, making sustainability a central concern in my work.
After graduation I moved to Paris and where I have been working as an independent designer since, exploring local production, temporalities of objects and materials, and open ended design. Besides my practice, I teach the courses 'Sustainable Systems' and 'Space Materiality' at Parsons Paris, as well as occasional workshops at other design schools. Both as a designer and lecturer I am interested in hands-on transformation of matter, learning by doing and embracing failure. I value constraints as a tool for creativity and seek opportunity in the unexpected, be it in abandoned objects, waste materials or fungi.
Rather than designing useful artefacts (I leave this important task to more skilled product designers) I am interested in existing objects as well as exploring low-tech processes for new ones.
While I am not a traditional product designer, my research is certainly grounded in and informed by this field, yet it aims to blur the boundaries between different disciplines of the built environment and beyond design.

Earlier this year I started to collaborate with colleagues and friends Francesca Bonesio, Nicolas Guiraud and Stella lee Prowse on a project of which I will use some images to illustrate this text. (Fig. 3,4,5)
This project originated in the middle of the pandemic leading us to find a local territory of exploration in the contradictions of an ultra-urban life that were highlighted by the lock-down. We have since documented 55 objects that have outlived their original function using them as vessels to grow oyster mushrooms. There is something deeply unsettling and at the same time satisfying about the act of watering a makeup box, table lamp or electrical board and watching them grow. Through this, a ritual develops, of care and attention to objects which are normally disregarded and considered obsolete.
After a few days, hybrid entities began to emerge, suggesting new relationships with the living world. The "ritual of care" by manipulating and interacting with these discarded objects became a way to reflect on them. The fungi kept surprising us along the process leading into an ongoing conversation between them, the objects and us. It has taught us to welcome the unpredicted, in the fungi's own will but also in the collaboration of our cross-disciplinary team.

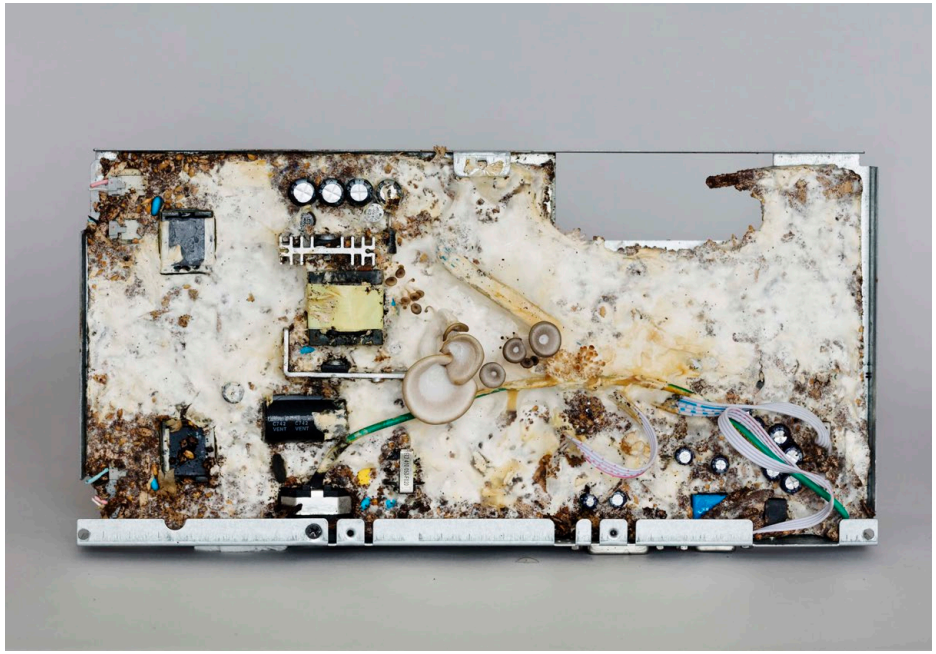

Fig.4: From "Honey, I watered the screen", an ongoing project in collaboration with Atelier 37.2 and Stella Lee Prowse. Photo: Nicolas Guiraud, 2021

Undefining the designer

What is a designer? What does it imply to design?
My reflection will focus on the designer that conceives and realizes physical things, which is where my own practice is situated. In that sense, a designer could be very broadly defined as someone who envisions a process to transform matter with the goal to anticipate or respond to specific needs and desires. But what and whose are those needs and desires we are addressing as designers? And what are the short and long-term impacts of the realized processes?

Let's just first acknowledge that recent advances in design and technology have taken us to a level of comfort indispensable for contemporary life and allowed for important societal progress that we tend to take for granted.
Yet, design is basic to and interwoven with all human activities and we can not deny its detrimental impacts on the environment that have defined the era we now live in, widely referred to as the Anthropocene. (Cruzen 2002) There is countless scientifically proven and often visible evidence on how the earth has been altered and disturbed by human activity, and thus by design.
However, the term Anthropocene itself is also contested, as it refers to humans as species as a whole. In fact the planetary-scale impacts are mostly caused by very recent human activity (most notably since the Industrial Revolution) and by the most privileged while the least favored suffer from them the most. There has been a rise in compelling debates on the Anthropocene's beginnings (ranging from the neolithic revolution, to colonialism ultimately leading to capitalism) and proposed alternative terms, such as Capitalocene, Plantationocene, Chthulucene. (Haraway 2015) Anna Lowenhaupt Tsing states that "the most convincing Anthropocene timeline begins not with our species but rather with the advent of modern capitalism, which has directed long-distance destruction of landscape and ecologies." (Tsing, 2015:19)

This also brings up the important question of gender in relation to design and human control. Arturo Escobar asserts that design emerges from "patriarchal capitalist modernity". (Escobar, 2018:3) Patriarchal culture is characterized by values such as competition, hierarchies, power, growth, procreation, domination, and appropriation of resources. In contrast, historical matristic cultures were defined by inclusion, participation, collaboration, understanding, respect, sacredness, and the always-recurrent cyclic renovation of life. (Escobar 2018)
Contemporary design is embedded in our relationship to nature, which is marked by Western philosophy that emerged since the Scientific Revolution and influenced the age of Enlightenment and rationalist thought.(St. Pierre 2019)

Before the 1500s Europe was guided by other belief systems such as Organicism defined by intimate and non-hierarchical interrelations between humans and nature. (Merchant 1990) In fact during most of our species existence, humans have lived in balance with the rest of the living world.
The Scientific Revolution and its technological innovations have gradually shaped a new worldview, which in the name of progress and culture has resulted in exploitation of human and natural resources. With the rise of rationalism, nature along with emotion, spirit and the female were increasingly devalued (Merchant 1990) and ultimately separated humans from nature.
Design remains largely associated with innovation, mastery, technology, and progress. (St. Pierre 2019) The dominating image of a designer is still shaped by a Western rationalist and colonialist worldview, defined by absolute control over the medium, often characterized by a star designer coming up with genius solutions and desirable perfect products.
To change that we need to "peel away the underlying elitism in the humanist tradition, allowing for new narratives for design and nature, a nature that has agency and is a partner in our own re-learning".(Fletcher, St. Pierre, Tham 2019:10)

In order to review the current design paradigm and potentially contribute pointing it into an alternative direction, one I mean to engage in, I suggest to begin with re-thinking the designer. What follows is an attempt to undefine the perceived and predominant role of the designer, by proposing alternative notions and approaches, to be practiced and explored by a new generation of designers with the aim to 'de-anthropocizing' human making.

Star designer	-	Collaborative
Independent	-	Interdependent
Consumer-centered	-	Relationship-centered
Male-dominated	-	Feminist & egalitarian
Outcome-driven	-	Process-driven
Perfect product	-	Ever-evolving product
Sleek aesthetics	-	Beauty of the imperfect
High-tech	-	Hands-on
Machine-made	-	'Grow-made'*
Ocularcentric	-	Multisensory
Planned	-	Experimental
Problem-solving	-	Inquiry-driven
Human-centric	-	Bio-inclusive**
Confidence	-	Humility
Mastery & control	-	Letting go
Nature as Resource	-	Integrated & Regenerative
Durability	-	Impermanence

**(Collet, 2017), **(Mathews, 2011)*

The Cambridge Dictionary defines a designer as someone “who imagines how something could be made, or what it would look like, and makes plans for it.”
But is design always planned, inevitably intentional? What does design look like when it leaves space for the unexpected?

It seems that making is an inherent human instinct. The controversial question of what is human nature has been occupying philosophers and artists for centuries. I am interested in our inherent desire to continuously make things that often go beyond what we need for pure survival.
Acknowledging this longing to make, combined with the awareness of the impacts of our making, creates a duality for the contemporary designer.

What is the role of the designer in a world damaged by human activity? How can I reconcile being a product designer in a world with already too many products and finite resources? What happens when we recognize that the possibility to fulfill basic human needs deeply depends on the health of the rest of the living world? What if we direct design to address the climate and biodiversity crisis?
Ambitious questions like these are helpful when reconsidering what kind of designers we would like to be. They aim to open up a conversation on the potential of design as a tool for change but also remind us to acknowledge its limitations.

Learning about mycelium, and physically engaging with it, has turned out to be helpful in this inquiry as it allows for a shift of perspective. Discovering the world of fungi has been, and continues to be, a valuable lesson in humility and multispecies interdependence.

Fig.5: “Honey, I watered the screen”, ongoing project in collaboration with Atelier 37.2 and Stella Lee Prowse. Photo: Nicolas Guiraud, 2021

Fig.6:
Gondwanaagaricites Magnificus: World's oldest fossil mushroom found by humans https://doi.org/10.1371/journal.pone.0178327.g001

Fig.7: Miniature stone mushrooms, metates and manos from Guatemala suggest the use of metates to grind sacred hallucinatory mushrooms for ceremonial consumption in pre-Columbian Mesoamerica. https://doi.org/10.2307/278737

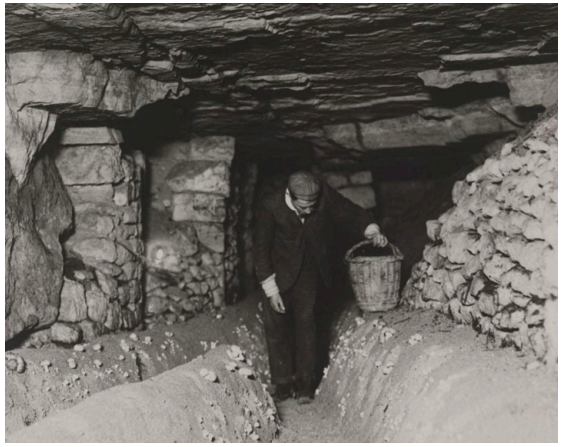

Fig.8: Champignonnière in Paris between 1916-1922 Photo: Charles Joseph Antoine Lansiaux, Musée Carnavalet, Paris

Myco-human relationships

"Fungi are everywhere. They are inside you and around you. They sustain you and all that you depend on. As you read these words, fungi are changing the way that life happens, as they have done for more than a billion years." - Merlin Sheldrake

Often invisible to the naked eye, yet omnipresent and essential for life on earth, fungi were, for a long time, under-attended in science. Historically treated as part of botany, only a few decades ago they were officially recognized as making up a kingdom of their own, and are, it turns out, strangely closer to animals than plants. Mycology is now an acknowledged branch of biology, studying fungi, including yeasts, molds and mushrooms. More than 90% of the estimated 3.8 million fungi remain currently undocumented.(Sheldrake 2020) We still know very little about this - until recently - overlooked set of organisms.

Records indicate that fungi likely first appeared on earth about a billion years ago (Fig.6). Our own species origins being much younger, with the first human imprints from Homo erectus dating back to just about 2 million years.(Van Arsdale 2013)
Microfungi make up part of our own body mass. We can host not only fungi that potentially make us sick, microfungi are along with bacteria and viruses an important part of the microbiome. This fact challenges the notion of human individualism questioning where one individual ends and another begins.
We can't say precisely when we started to develop an intentional relationship with fungi. Evidence shows that already our ancestors foraged and used mushrooms for medicinal and culinary purposes. Magic mushrooms containing psilocybin are believed to have been used in rituals thousands of years ago (Fig.7) and to have contributed to the development of the human brain. Furthermore, archeological records from the stone age suggest the cultivation of yeasts to ferment beer, wine and cereals to bake bread even before the beginnings of agriculture.
We started domesticating animals and plants around 12'000 years ago, but the most ancient known evidence of humans intentionally cultivating mushrooms only dates from less than 2'000 years ago in China. Later, in the nineteenth century, Parisian mushroom farmers were producing 'champignons de Paris' in massive quantities underground the city (Fig.8).

Mushrooms can generate intense and contrasting feelings in us, ranging from extreme aversion to appreciation. The origins for mycophobia or mycophilia are often social and cultural. Mycophobia is usually irrational and based on the idea that all mushrooms are toxic or gross and more generally founded in a fear of the unknown. Some fungi are indeed toxic, and can pose a threat to our health and biodiversity. While over an estimated 8,000 - mostly microfungi - are known to cause plant diseases, only 300 fungi are known to be pathogenic to humans (Nature Microbiology Journal 2017).
For my research I focus on macrofungi, the ones that produce mushrooms.

Fig.9: Homegrown oyster mushrooms
Photo: Miriam Josi, 2021

Fig.10:
Fermented yeast for bread making
Photo: Miriam Josi, 2021

I have enjoyed eating mushrooms since I can remember, wild-foraged or commercially-grown ones. Yet I have long been oblivious to the fact that they are just the fruiting body of the fungus and to the whole invisible world that generates them.
Mushrooms are the only visible part of the fungus. They produce spores and release them into the environment for propagation. Below the ground we find mycelium (Fig.11), a mass of branched interwoven filaments, known as hyphae, forming the vegetative body of the fungus. It has no determative form and grows exponentially in three dimensions in search of food interacting with bacterias, roots, rocks and soil. Mycelium has an indispensable role in the natural ecosystem. By decomposing organic matter it prevents it from accumulating, and regenerates soils making space for new life. Mycelium connects trees and plants, facilitating the transfer of nutrients and information between them through mycorrhizal networks (Simard 1997) and has the remarkable capacity to thrive even in human disturbed environments. (Tsing 2015)

Fig.11: Photo:
Mylo Unleather 2021

My first conscious encounter with mycelium was in 2019. I had just started to teach a course at Parsons School of Design in Paris called *Sustainable Systems*, which is required for undergraduate first-year students across all disciplines. Following the recommendation of our colleagues from Parsons New York, we implemented a science lab as part of the course's curriculum to grow new materials from mycelium and waste. The hands-on experience of discovering and experimenting with this organism turned out to be every bit as valuable and insightful for the students as for myself.
Quickly fungi took over my own creative practice and everyday life. Aside from growing materials and objects (Fig.12,13), I started cultivating oyster mushrooms at home (Fig.9), became obsessed with composting and making sourdough bread (Fig.10), and walks in the forest became a whole new multisensory, immersive experience.
The encounter with mycelium gave birth to my fascination for growth and decay and changed my approach to materiality and design for good.

Citizen scientists and radical mycologists are inspiring a new generation of processes and applications. Often based on ancient techniques and knowledge, new areas of research of applied mycology have emerged that go beyond fermentation, brewing and cultivation of mushrooms. Mycoforestry, for example, a branch of permaculture, looks at introducing local fungi species to enhance forest's ecosystems. Mycoremediation is another fascinating and promising example as it looks at using mycelium to decontaminate degraded environments. Depending on the strain, heavy metals, dyes, chemicals, petroleum, pesticides, herbicides or pharmaceuticals can be removed from water and soil. Popularized by Paul Stamets, mycoremediation and mycoforestry, along with mycofiltration and mycopesticides are all approaches of mycorestoration.

The work I have been doing with my students can be referred to as myco-fabrication and explores developing methods for growing new bio-circular materials with the goal to replace harmful existing ones. Cultivating mycelium on organic waste, the mycelium's hyphae act like a natural binder as it feeds on waste substrates, such as wood chips, coffee grounds, paper or cardboard. Depending on the used substrate and growth conditions, the materials can acquire several useful properties, while remaining compostable once no longer in use. Experimenting with different substrates and mold making, such as using the substrate itself as the mold or structure, help to uncover new features and potential uses.

The accessible and low-tech process allows anyone who is motivated and equipped with some patience to myco-fabricate at a small scale. This is inspiring designers, architects and researchers to explore the numerous opportunities that arise from working with mycelium. Using waste as a resource and growth as a process, allows for self-assembled, regenerative, local manufacturing.
First industrial applications have already emerged of these new composite materials, that unlike conventional ones, don't require toxic resins or glues and have the potential to replace materials such as styrofoam, plastic, plywood, leather, cement and steel. American companies are dominating the commercialization of mycelium materials. Ecovative produces and sells mycelium packaging and DIY growing kits. Meanwhile in Italy, Mogu produces mycelium acoustic panels and will soon launch floor tiles made with a mycelium based technology.
Biotech companies Mycoworks and Bolt Threads have developed processes, manipulating the mycelium's DNA to grow leather materials. The engineering of living organisms to optimize its abilities, is also called Synthetic biology and is seeing a recent boom. On one hand its emergence has delivered numerous technological innovations and more sustainable alternatives to conventional materials and processes. On the other hand the idea of redesigning DNA has also given rise to ethical debates, about the risk of being used for the wrong reasons and how far we can go in interfering with nature.

Fig.12,13: Interactive 'Play vases': glass & mycelium grown on hemp and cotton scraps, juxtaposing the contrasting materials' characteristics and temporalities. Miriam Josi, 2019

Humans are not the only, and definitely not the first animal species that has been domesticating fungi. In fact our history with them is very recent when compared to other organisms who have formed symbiotic relationships with fungi over hundreds of millions of years. African Macrotermes termites, for example, have developed sophisticated ways to cultivate white rot fungus Termitomyces inside their colonies, to digest their foraged wood. Their very survival depends on their collaboration with the fungus. (Sheldrake 2020)

What might this teach us about our own fungal interactions? Learning about interspecies relationships does emphasize our dependence on other living organisms, and may serve as an inspiration to rethink the ways we collaborate with them to ensure our own survival.

Fig.14,15: Experimental mold making: broken wine bottle, mycelium grown on reclaimed paper. From the introductory project 'Augmented object' in the First Year class 'Space Materiality' at Parsons Paris I teach along with Francesca Bonesio. Photo: Marci Signori, 2021

Fungi have turned out to be helpful companions and teachers in my journey reconciling my role as a designer. In the next chapter I will discuss the pedagogical value of the experience of myco-collaboration in design education and its potential to assist in shaping the designers of tomorrow.

Fig.16

"The mushrooms remind us of our dependence on more-than-human natural processes: we can't fix anything, even what we have broken, by ourselves"
– Anna Lowenhaupt Tsing

Fig.17: Ideation drawings to repair and augment existing objects with mycelium.
Fig.18: Experiment of mycelium grown on wood chips and rose leaves interacting with a 3d printed structure. From a workshop at Ecole Condé Paris. Diego Lourenco Ramos, 2020

4

Mycelium as a pedagogical tool

As designers, materials are the fundamental medium at our disposal. But how well do we really understand where they come from, how they are processed and how they will age over time?
In this section I will reflect on the pedagogical value of working with mycelium and explore its potential for design students to challenge the prevailing industrial carbon intensive material sourcing and processing.
I will discuss how this multisensory hands-on experience can enable students with a deeper understanding of concepts - such as life cycles, material processes and temporalities - as well as challenge their perceptions around waste and resources, cultivate practices of care and set the ground for conversations around aesthetics and ethics related to designing with living systems.

During the past three years I have animated a number of workshops at different design and art schools through a variety of formats, using mycelium as a point of departure. (Appendix A) Whether the workshops are just two or several days long, on-site or online (due to covid 19), with first year undergraduate or product design graduate students, the basic structure remains similar. It typically begins with a phase of immersive exploration and observation, followed by a second one of testing and documentation of the experimentations (Fig.18) leading into a phase of ideation (Fig.17) and development of a meaningful application proposal. The final outcome is intentionally open-ended, taking the form of a new material, object or process, and can be small or large scale, concrete or speculative.

I will draw from my experience to illustrate how mycelium labs can enable experiential learning with nature in an urban setting. By introducing students to a local small-scale production system that embraces nature-culture interdependency, the aim is to confront them to the reality of what it means to be a designer on a finite planet in the age of climate change, mass extinction and environmental destruction.
Along with sharing some personal reflections sparked by my interactions with mycelium, I will try to keep coming back to my initial question about the opportunity presented by collaborating with a living organism to redefine the designer's role and relationship to materials.

Fig.19: 'Food for mycelium', Miriam Josi 2021

Perceptions of waste and resources

A few days ahead of a mycelium workshop I always ask students to collect organic waste and bring them to class on the first day.
There we find ourselves in front of an array of substrates, destined to become food for our organism (Fig.19). The engagement with used coffee grounds, egg cartons, discarded magazines, nutshells, sawdust and banana peels, forces us to review our individual and communal waste streams and ultimately regard our societies' systemic consumption and waste problem. It prepares a fertile ground for discussions about biodegradability, composting, waste management systems, issues with recycling, overconsumption, and our own perceptions of waste.

Mycelium has a unique advantage allowing us to create new materials from local organic residues, while inorganic waste can become molds (Fig.15&16). Looking at waste as a resource, provokes to reconsider the very concept of resources, waste and value.
Our material culture is grounded in the mentality that natural resources are here for our exploitation. How can we challenge this common notion of resources as assets at our free disposal to meet our needs and wants? How do other life forms manage the use of their resources?
Mycelium is a useful teacher to help us challenge our approach to resources and potentially eliminate the concept of waste.
Our organic waste is only waste to us but to the mycelium it is a valuable resource. If our needs are entwined with that of the organism we begin to look at our waste from a new perspective. Mycelium thrives on something we don't need anymore, doesn't this sound like a good beginning for a symbiotic relationship?

Working with mycelium presents an opportunity for an embodied experience to understand some of nature's patterns and life's principles as suggested by Janine Benyus. "Nature recycles everything"(Benyus, 1997:7) or in other words, as developed in the book Cradle to Cradle, "waste equals food."(McDonough & Braungart, 2002:92)

It seems that when the designer sources their raw materials with their own hands, a new, potentially deeper connection to their medium starts to emerge.

Getting to know

As designers we come to work with mycelium with little to no understanding of the complexity of this organism's kingdom.
Our ignorance sows the seeds for interdisciplinary collaboration forcing us to become involved in the unknown territories of science and biology. (Fig.21)
But what is the required level of knowledge for a designer of the fungi's life cycle (Fig.20), the mycelium's role in the ecosystem, its capacities to store carbon, to remediate and regenerate soils?
What is the kind of relationship creatives need to establish with a living organism to collaborate with it? How do we find the right balance that allows for a respectful (inter)action and open-ended exploration?
For making the mycelium grow, we need to inoculate our substrate and create the ideal environment for it to grow. For this, a basic understanding of its needs and following a strict protocol might be enough. However, I will try to argue that a deeper commitment to the organism should be attempted, perhaps more tacit ways of knowing, in order to engage with reciprocity and develop a meaningful practice.

Typically product designers begin with a specific problem to solve. The choice of materials is based on the function needed for the solution they developed and usually happens in a prototyping phase later in the design process.
What happens if we reverse this process and start with the material, which is in our case organic waste and mycelium?
The material-driven design approach, as well as the immersion in getting to know a living organism, can pose a challenge to product design students that are used to specific briefs and more traditional industrial design methods.
In my experience first year undergraduate students, who don't have yet a formal design education, seem to be able to immerse themselves more freely and discover the organism not simply for what it is, but for what it does, how it behaves, what it seems to want, what it reveals and inspires.

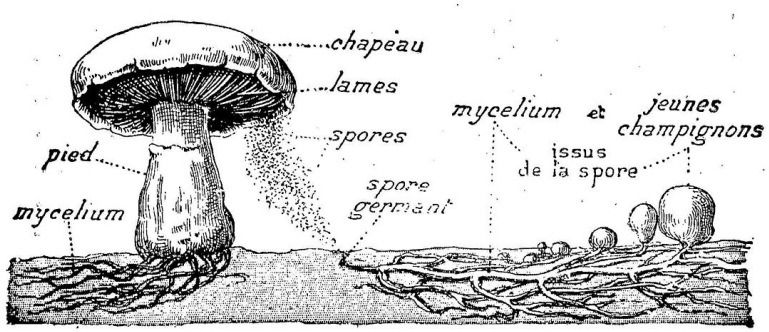

Fig. 42. — Schéma du développement du Champignon de couche.

Fig.20: Mushroom life cycle drawing from the book 'Le Monde végétal' by Gaston Bonnier, Ernest Flammarion éditeur 1907

Fig.21: Inoculation process in the lab, Workshop with Tony Jouanneau & Gisel De Billerbeck at Ensci les Ateliers, Photo: Stella Lee Prowse, 2021

Being in touch

The students' immediate reactions differ when they physically encounter mycelium for the first time. It can range from curiosity, to fascination to disgust, but they are never indifferent. Usually it is the smell that they first notice. Not an easy smell, but occasionally there is someone who loves it and compares it to the scent of a forest floor.
For their first haptic encounter, some have to overcome the aversion to the smell or a general mycophobia and prefer wearing a mask and gloves. They are often amused to find out that the hygiene protocol is instead to protect the mycelium from contamination that is potentially coming from us.
Many eventually prefer to work without protective gear, disinfect their hands and intervene in a more direct and multisensory way.

Juhani Pallasmaa reminds us in his book 'The Eyes of the skin' that "the dominance of the eye and suppression of the other senses push us into detachment, isolation and exteriority." (Pallasmaa 1996) He is talking about how architecture is experienced, yet he invites all creatives to recognise and include all senses in their work.
I argue that this goes beyond the final outcome of a building, artwork or design and starts with the very process of making. The process of working with mycelium allows for multisensory stimulation and a valuable way of getting us away from screens. The hands-on experience enables learning by doing as it triggers and emphasizes the interdependent relationship between us and the material, between making and thinking.

The haptic dimension (Fig.22) of our interaction with mycelium is a way to replace ocularcentrism with an embodied engagement with matter. It also embraces a vulnerability and has the potential for an authentic connection and resonance by cultivating a practice of care.
But what does it mean to care for more than human beings?
María Puig de la Bellacasa reflects on different notions of care and how it requires "making time to get involved with a diversity of timelines that make the web of more than human agencies." (Bellacasa, 2017:171)
Being in touch with mycelium obliges us to consider not only its temporality but also as previously mentioned, its needs. This poses further questioning about reciprocity of touch and ethics of care.

"Touching is called upon as the experience par excellence where boundaries between self and other are blurred." - María Puig de la Bellacasa

Fig.22: Material sample of mycelium grown on crushed eggshells from an experimental material workshop at Ecole Condé Paris. Photo: Tyrone Fazeuilh, 2020

Fig.23,24,25,26: Mycelium step by step instructions (Appendix B)
Photos: Miriam Josi & Stella Lee Prowse, 2020

Growth as process

Myco-fabrication employs growth as the process for fabricating new composite materials. The mycelium's hyphae grow exponentially into three dimensions, feeding on our waste substrates they bind it and solidify after the process of growth is interrupted. We will later discuss the ethical questions that come out of the fact that the organism needs to die in order to become functional as a material.
For now let's just accept that growth always implies decay and death. Perhaps that's precisely what makes the process of bio-fabrication so fascinating - it invites us to investigate our own relationships to these notions.

Working with growth is a low-tech procedure as it requires little to no energy or machinery, except occasionally for the preparation of substrates or molds. There is also the possibility to use ready made objects as molds, manipulate growth and form through experimental mold making and grow without molds at all. The substrate has to get prepared, inoculated with the mycelium spawn (Fig.31) and be put in the right conditions to start growing. And what is more the mycelium's growth uses life-friendly chemistry which makes it healthy to touch and breathe in and thus an ideal medium to work with in the classroom. Simple step by step instructions allow the students to work autonomously from home in case of lock-down. (Fig.23,24,25,26)

How does working with growth further affect the design process?
Assisting something to grow reveals that it requires our attention and care. It may also slow down the creative process as we need to take time and plan according to the mycelium's growth rate. In the same sense, working with growth also can enhance observation. This demands patience and careful documentation to make visible the invisible. For example growing experiments below a glass dome allows us to 1. grow shapes outside a finite mold and 2. observe the growth of the mycelium that usually happens below the ground. (Fig.27,28,29,30)
Here too, in order to cultivate observation that goes beyond vision, it is helpful to incorporate our other senses. For instance smell can effectively assist us in detecting the distinctive penetrative odors that tell us when our culture is contaminated.

Fig.27,28,29,30: Making visible the invisible: Pleurotus mycelium on shredded paper below glass dome taking over a magnolia cone. Four days between each photo.
Photos: Miriam Josi 2020

Slowing down to assist the mycelium's growth may also provoke us to think about time and value. Isn't taking time for making with our hands and to see something grow the biggest luxury?
As time passes, the barriers between luxuries and necessities begin to blur. We may start to reconsider the act of making, and as Tim Ingold suggests, understand it as a process of growth (Ingold, 2013:21). This may also lay the foundation to review current meanings and definitions of growth. Instead of the widespread metaphorical understanding of growth as economic growth we may think of it as physical and mental growth.

When designers directly intervene with the growth of living organisms their role evolves, "from shaping existing materials, to creating and growing new ones".
They become "cultivators, and manufacturing becomes 'horticulturing'". (Collet, 2017:27)
Growth as a process also implies for the designers to withdraw themselves and become passive at times.
This brings up a tricky question: When do we have to stop designing?
Letting go of planned expected outcomes can also be a liberating and creatively stimulating experience for students as it puts emphasis on the process and furthermore highlights the unpredictable and impermanent nature of the medium.

Fig.31: Shredded kraft paper (left) to be mixed and inoculated by pleurotus mycelium spawn (right). Photo: Miriam Josi, 2021

Unpredictability

"Mycelium is a living, growing, opportunistic investigation-speculation in volume form. This tendency is known as developmental 'indeterminism': not two mycelial networks are the same. " - Merlin Sheldrake

When the students talk about their experiences, the mycelium's unpredictable nature keeps coming up. When designing with living organisms the control we have over it is limited and unfamiliar compared with the materials students are used to working with. The unpredictability is often perceived as a constraint.
What can the constraints of collaborating with a living organism teach us and how can we turn limitations into opportunities?

My goal is to convey to my students an understanding of constraints as tools to incite creativity, by pushing them to think outside of the mold, applying a trial and error approach that embraces failures in the process. Leaving space for the potential for surprises can lead to unexpected discoveries, insights and results. (Fig.32)

When we examine the material properties and qualities of the developed techniques, samples or objects, conversations repeatedly turn towards aesthetics. Often students are unsatisfied with the quality of the finishes, finding them not visually sophisticated enough.
It is interesting to think that when we design with living materials we tend to try to impose a form and finish on them that would resemble industrially manufactured materials. Basically, attempt to make it look like something it is not. A fake, a bad copy of the real thing.
Couldn't we instead use this experience and challenge stereotyped contemporary design aesthetics and paradigms by embracing the unpredictability of the process and irregularities of the outcomes?

Fig.32: Beautiful "failure" of an experiment from a workshop at Ecole Condé Paris. Watercolor, flour, mycelium & mold in petri dish
Photo: Emilie Peralez & Laura Walker, 2021

Fig.33,34: Pleurotus mycelium on sawdust growing below glass dome two weeks apart, Photos: Miriam Josi 2020

Impermanence

"Whatever the objective forms in which they are currently cast, materials are always and already on their way to becoming something else."
– Tim Ingold

When students work with mycelium they inevitably also engage in their timeline and firsthand experience temporalities very different from those they are used to. The experience allows to witness the whole life cycle of the mycelium material: from the sourcing of the organic substrate, to manipulating, molding and inoculating it, observing its growth, to unmolding, "harvesting" and drying it, up to its use and disposal, where it can happily be composted. (The composite material's biodegradability is one of its greatest attributes, always preconditioned that we either have a garden with a compost heap or live in a city that provides a system that collects and revalorises compost, which is not everybody's case.)

The short temporality is also notable when considering the finished material evolves over time, changing its appearance depending on the environment it is exposed to. The material's ephemeral character suggests logically temporary short lasting uses and applications, emphasizing the importance to cultivate the art of documentation. What remains at the end? An image, a video, an experience, a memory?

How does working with an ephemeral material affect our perception of material temporalities and value? In a material world that celebrates the idea of durability as the ultimate goal in the name of sustainability, we may ask ourselves: What do we want to sustain? Could the emphasis on durability be a distraction of our discomfort with impermanence? Shouldn't we instead embrace aging and decay?
In the sense of the ancient Japanese philosophy Wabi Sabi, assisting the circles of growth and decay of mycelium kindly remind us about the impermanence of all things, including ourselves.

Interspecies ethics

Working with mycelium is an effective tool to make students think critically and reflect on their relationship with nature and responsibilities as designers. The experience expands agency from us to other than human and leads us to ask ethical questions that go beyond normative ethics, of what could simply be considered as morally right or wrong.
In this section I aim to discuss and explore some of the ethical dilemmas surrounding biodesign. The opening question addresses designers, students and teachers alike: What are the ethical and moral considerations when domesticating a living organism? I don't expect to get clear answers nor make judgments in this examination. I rather attempt to accept and confront instead of ignoring some of the concerns and paradoxes that keep coming up while working with mycelium.

One one hand, the idea of working with nature to support nature is convincing, promising and indeed urgent in regards to our environmental crisis. Yet, it could be argued that biofabrication emerges from the same human-centered mindset that created the crisis in the first place, a mindset that sees nature as "other" and humans as above all the rest of living beings.
We say we collaborate with living organisms but in fact we try to control them to fulfill our own material needs or desires. We feed the mycelium with substrate and put it in molds in order to achieve an imposed form and finish. And even when growing it outside the mold and letting it help decide the final shape, we are keeping it trapped and isolated from its natural environment. (Fig.33,34,38)
What does the mycelium want? Aren't we stripping the mycelium of most of its superpowers when we grow it in a lab, away from its usual habitat and ecosystem? And yes in the end, in order to be able to use it, we kill it.
Looking at the living world, noticing how growth, decay and rebirth are deeply connected may help to accept death as an integral part of life and make us question our own relationship to death. Why should we accept killing mycelium but be disturbed by killing animals? Where do we draw the line? Of course it depends for what reason a living being dies, but it also seems to make a difference who has to die. A mosquito that wants to bite us? A chicken to be eaten? A carrot? Where does this sudden unease about killing the mycelium come from?
When we grow something we develop a relationship with it. But what kind of relationship is this? Is it reciprocal? What does it really mean to collaborate?
In the world of fungi "collaboration is always a blend of competition and cooperation". (Sheldrake, 2020:162) The same seems to be true for the rest of the natural world, including us human beings. To collaborate, to work together, is also to converse, to exchange, to teach, to learn, to compete, to cooperate, to co-evolve.

Symbiotic interactions between species (Fig.35,36,37) are not always mutually beneficial, they can also be commensalistic benefiting only one, or even parasitic, harming the other. Brief interactions such as predation however are not considered a symbiotic relationship. Evolutionist Lynn Margulis Margulis showed symbiosis as the central force behind evolution, contesting the dominant theory of neo-Darwinism of evolution by natural selection. (Margulis 2011)

"Lichens are remarkable examples of innovation emerging from partnership. The association is far more than the sum of its parts." - Lynn Margulis

Fig.35,36,37:Lichen on granite rocks in Ronco s. Ascona, Switzerland. Photos: Miriam Josi 2021. Lichens are formed of a symbiotic relationship between a fungus and an alga. The dominant partner is the fungus, which gives the lichen the majority of its characteristics, from its thallus shape to its fruiting bodies. Together they exist and grow in places where neither of them could by themselves.

Margulis has also co-developed the Gaia hypothesis along with James Lovelock, proposing the earth as one single complex self-regulating system, which again influenced the Deep ecology movement founded in 1973 by Arne Naess. Deep ecology pleads not just to protect the planet for the sake of humanity, but for the planet itself and promotes the inherent worth of all living beings without hierarchy.

Maybe we also have to ask how far we can go in considering non-hierarchical interspecies ethics. Is 'de-anthropocizing' biofabrication contradictory, utopian and is there a risk to distract us from our interhuman ethical obligations?
To attempt a response to this question, I would argue that when we realize that everything is connected, from our minds to our bodies, the fungi and other living organisms in them, to our environment and the world, then we can consider that caring for the more than human, affects and includes us humans too.
This thought takes me to the ecofeminist view of the natural world as a community of beings and to respect the individuality of the "other".
I resonate with Freya Mathews' proposal to consider a 'bio-inclusive' ethics (Mathews 2011) and aim to seek a balance "between the cherishing of life and honoring of death." (Mathews, 1994:166)

Fig.38: Experiments of pleurotus mycelium on different substrates growing out of their petri dishes, Photo: Miriam Josi 2021

Concluding thoughts *on mycelium as a pedagogical tool*

Myco-fabrication is not a miracle solution to our material problems. But it offers a promising alternative to predominantly unsustainable ways of making, thanks to its low embodied energy, ability to recycle waste and the capacity to be returned safely to the earth.
What is certain is that collaborating with mycelium is an effective tool to change perspective and inspire questions that ultimately might allow for a shift towards an approach to design that accepts the limits of human control and recognizes our interdependence with the rest of the living world.
The unique embodied learning experience is permitted by the mycelium's timeline that allows assisting the full life cycle of a material. Using waste as a resource, as well as the interaction with the living organism, obliges students to get outside of their comfort levels and reconsider presumptions.
The workshops allow students to translate scientific knowledge into their creative practice, evaluate their work in relation to larger ecological systems and reflect on ethical implications of biofabrication. The emphasis on process and experimentation, without the pressure for a finished outcome (Fig.39,40) brings students closer together. As they work in groups, they constantly share their ideas, successes and frustrations, fostering a supportive communal environment.

Fig.39,40: Material samples from a workshop during the first year course Sustainable Systems at Parsons Paris, the students experimented growing mycelium on a variety of discarded organic substrates, such as coffee grounds, shredded paper, cardboard and natural fabric scraps. Photos: Rizq Naherta, 2020

The connection and understanding that students often gain through working with mycelium could help shape a different attitude towards other materials too. Maybe we can start to reconsider all materials as not being passive, but as having agency.
Ultimately, the short timescale of the mycelium's life cycle reintroduces us to an intimacy with materials reminiscent of our ancestors' anonymous designers and makers.
This thought leads me back to the very origins of design, long before it was called design. The next chapter will introduce us to ancient ways of making and the principles of vernacular design. We will draw parallels to myco-fabrication and examine the potential of fabricating with mycelia in contributing to a new form of vernacular.

5

The new vernacular

In this section I aim to demonstrate how the accessible and low-tech nature of myco-fabrication combined with the use of ultra-local waste as a resource holds promise to contribute to a new notion of vernacular design.
We will examine the potential of growing mycelium on local organic waste to inspire designers to imagine regenerative, locally attuned material processes and ultimately more resilient communities.

Vernacular

The word vernacular is etymologically derived from Latin *vernaculus* "native, domestic, indigenous" that originates from the word *verna* "home-born slave" of Etruscan origin. (Online Etymology Dictionary, 2021) Vernacular refers to the use of a dialect, native to a place or characteristic to a group, rather than a formal literary language.

Having grown up in Switzerland I am familiar with the awareness of speaking a dialect compared to the standard *lingua franca*. We have hundreds of Swiss dialects and sub dialects that can vary from one village to the next and all significantly differ from our four official languages French, German, Italian and Romansh. Growing up we speak our local dialect and only at school we are introduced to learn the formal "high" versions of our languages. For a long time I considered not having a formal native tongue to be a disadvantage. Only later when living abroad did I start to appreciate and see the value of a native dialect, one that sounds funny, doesn't get me far and only few understand. But one that is distinct and unique, that is part of my identity and gives me a sense of connection to my family and where I come from.

Beside its use in relation to language, the term vernacular today is also commonly utilized in architecture. Vernacular architecture refers to a building style particular to a period or place, and is understood as a result of local means, traditionally happening outside academic structures.
Because vernacular architecture is based on distinctly local circumstances and traditions, it can't be characterized into a specific stylistic description and is therefore often overlooked in traditional design history.

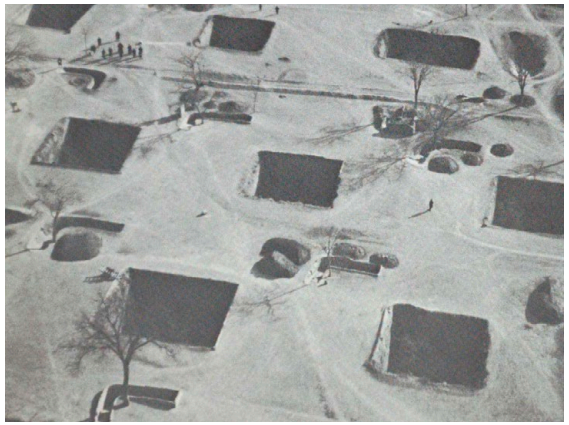

Fig. 41: A Chinese underground village near Tungkwan (Honnan) as appeared in the catalogue of the exhibition 'Architecture without architects' by Bernard Rudofsky at the MoMA New York 1964

Whether referring to language or architecture, the origin and uses of the word vernacular are mostly condescending, dismissing it as primitive, rudimentary and vulgar.
This is slowly changing favorably and vernacular architecture is increasingly receiving more consideration.
In 1964 the Museum of Modern Art, in New York hosted an exhibition called *Architecture without architects* designed by Bernard Rudofsky. Showcasing photographs of vernacular buildings from all around the world (Fig. 41), the exhibit invited people to step away from the narrow view of commercial design "by introducing the unfamiliar world of nonpedigreed architecture". (Rudofsky 1964) In contrast to formal architecture, vernacular architecture is considered nonpedigreed, ancestral, indigenous, but instead of just depicting it as anonymous, spontaneous or rural, Rudofsky presented it as a sophisticated 'how to live and let live'. (Rudofsky 1964)
Vernacular architecture is integrated in its environment rather than standing out, small rather than large scale, non-specialized rather than overspecialized, adapted rather than planned, communal rather than individual.
In the last decades more and more architects are showing their interest and find inspiration in this locally attuned, anonymous kind of architecture.
More recently, the book *LO-TEK Design by Radical Indigenism* by architect Julia Watson, presented traditional rural communities from all over the world, living in symbiosis with the natural world through highly advanced systems, based on deep ecological knowledge, practices and beliefs.
Watson challenges the Western myth of technology and idea of progress, and demonstrates that indigenous innovation is not primitive and isolated from technology but extremely sophisticated and designed to sustainably work with complex ecosystems. Introducing us to another approach to innovation and design for sustainability, *Lo-TEK* stands for *traditional ecological knowledge* (Watson, 2020). Distinctive form low-tech, but in the same sense the book opposes the mindset of *high tech* techno-salvation, supporting the idea that we shouldn't use the same attitude and tools to solve the problems that created them in the first place.

I understand these beautifully illustrated traditional technologies used in the book as pioneering examples of bio-assistance, bio-collaboration, or biofabrication. For instance the living root bridges and ladders (Fig. 42) are developed by the Khasi tribe of Northern India to cope with the intensity of the rain during the monsoon season. Carefully planned, cultivated and guided over decades, integrated in the forest landscape, the root bridges look like they have grown on their own.(Watson 2020)
Indigenous philosophy considers seven generations for the impacts of any decisions taken. The idea to think beyond the immediate needs of today is also supported by the most common definition of sustainability, as developed in the *Brundtland report* 1987 by The United Nations that defines it as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." (Brundtland 1987)
The definition is very broad and raises questions as well. Generations of who? In whom's interest? For how long?
Given the world's situation and the extent of the damage, we can't talk about sustainability without resilience. We are finally starting to rediscover that our resilience depends on nature. While nature is resilient, most recent human-made systems are not and drastically alter natural ecosystems.
On the contrary, vernacular buildings are a good case for resilient nature-culture coexistence. Using resources and processes that are adapted to the climate and environment of their particular place, indigenous and vernacular architecture seem to stand the test of time. The materials sourced from the immediate natural environment and manipulated by hand or with basic tools have drastically different timescales. Ranging from mineral and durable to organic and ephemeral, rocks, earth, wood, leaves, roots or other organic materials allow the constructions to age gracefully, be repairable or biodegrade eventually.

Fig.42: Living root bridge by the Khasi tribe of Northern India, from the book 'LO-TEK Design by Radical Indigenism' by Julia Watson, 2020

Considering that vernacular architecture and ancient nature-based technologies have only recently gained the attention they deserve, there is a lot of knowledge that has already been lost.
Assuming that there are many uncounted ancient processes that we have no records of, how can we be so sure that myco-fabrication is really an emerging technology? Isn't this assumption that biodesign a new field just an extension of our colonialist worldview?
The short life cycle of these bio-circular materials wouldn't allow it to go into archeological record. But in a world with built environments and too many products that have outlived their designers and users, it is precisely their ability to biodegrade quickly that can make them preferable choices.

Fig.43: Nest of Sociable weavers nests built over generations, Photos: Kyle Weeks for Atmos, 2021

Design without designers

Throughout history, besides buildings, humans have been making also smaller artifacts, based on the availability of local materials, local needs and desires, local knowhow and craftsmanship.
When talking about vernacular design, we typically refer to architecture. But there are also countless examples of vernacular design of products and tools, from the mysterious hand-ax, to pottery, basketry, traditional clothing and ritualistic objects. Anonymously conceived and crafted artifacts, sometimes documented, but often overlooked; yet used, repaired, passed on and evolved. These designs without formal designers have shaped everyday life and altered humans and their environment.

Yet, humans are not the only sophisticated vernacular builders. Beavers build dams, termites mounds and birds nests that are responsive to the raw materials found in their immediate environment.
The Sociable weavers birds for example gather sticks and dry grass to build their nests and repair eventual unwanted holes. Their intricate communal dwellings can last over many generations.(Atmos 2021) (Fig.43)

Fig.44,45,46: 'Wilder Mann' by Charles Fréger, 2010-2011

What is it then that makes human making different from other animals?

Neurologist Frank R. Wilson argues that the human hand in interaction with the brain has shaped language and culture and allowed *Homo sapiens* to become the predominant animal on the planet. (Wilson 1998) In other words, the intimate interdependent relationship of human making and thinking caused and still contributes to the ongoing development of human traditions and culture. (Fig.44,45,46)
What does this mean in a world where digital technology and machinery has taken over most of our making? The alienation from our hands seems to have expanded to our environment. Could an attempt to reconnect our brain with our hands help us revise our relationship with the non-human world?

For my part, what drew me to design in the first place was the simple but satisfying sensation of the process of physical making. Creating something new from what I have at hand (Fig.47), assisting the transformation of matter, is still what drives me today.
If we consider making and building as a phenomenon of human instinct, how can vernacular design give us a hand in reconciling our innate desire to make?

Fig.47: Making clothes from leaves and branches in Northern Italy. Photo: Barbara Josi, 1993

Consolidated, I would define vernacular design as *making under constraints of locality and context; based on availability of materials and collaboration between people and their close environment.*

Vernacular design principles

\+ Based on constraints:
Local resources, needs, climate

\+ Resourceful:
Use of locally abundant materials
Making the most with the least
Create no waste

\+ Low embodied energy:
Made locally by hand or simple tools
Nature-based technologies

\+ Based on collaboration:
Works with local expertise & community

\+ Local Identity:
Creates traditions & culture
Strengthens relationships
between people and their place

\+ Adaptability:
Responsive and resilient
Repairable and evolving

\+ Integrated:
Supportive Nature-culture coexistence
Ages gracefully

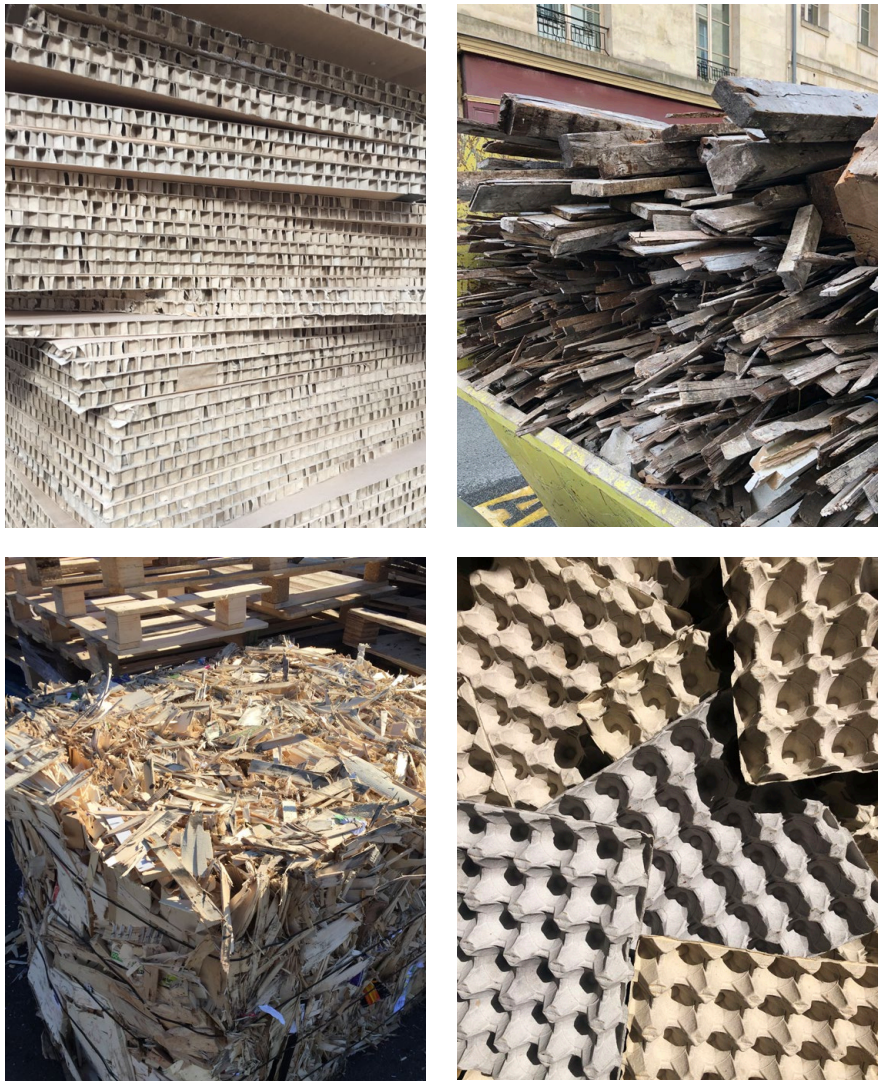

Fig.48,49,50,51: Different abundant resources around Paris. Photos: Miriam Josi 2021

Myco-vernacular design

The fundamentals of vernacular making are useful guidelines for contemporary designers to design more resourcefully and locally attuned.
Furthermore, the extraction of these basic principles reveals a remarkable resemblance to the process of myco-fabrication.
The main advantages of creating materials in collaboration with mycelium are the possibility to use and valorise local waste, as well as the accessible low-tech and regenerative nature of the process. These circumstances present an opportunity for the emergence of a new vernacular.
A new vernacular design could present a promising alternative to current globalized ways of production, where there is usually no physical or emotional interaction between designers, makers, and final users, between the material sources, where they are processed, and where they end up.
Linear industrial manufacturing and overconsumption have led us to deplete natural resources faster than they can regenerate, while we keep producing, using, and disposing of an obscene amount of stuff, generally without adapted systems for repurpose.
With the recent emergence of biodesign and notably the use of mycelium “waste has become a valuable resource to be upcycled into new materials thanks to the dynamic properties of biological agents.” (Collet, 2017:88)
Indeed, many of the locally abundant “resources” in the Anthropocene, in particular in urban environments, are waste.
Walking around Paris, I can’t prevent myself from noticing - and occasionally collecting - the unwanted objects and materials standing on the sidewalks. Construction waste, empty boxes or egg cartons, I see potential resources for my projects and food for mycelium. (Fig.48,49,50,51)

While tempting and promising, designing with waste raises some decisive questions too. Is the used waste materials worthwhile for the design? Depending on the context, certain organic waste is better being composted.
What are the bigger systems at play? What would be the opportunities, challenges and difficulties for larger production? How can we create meaningful relationships to where the waste is sourced? And ultimately, how can we use waste as a resource without justifying or encouraging the production of more waste?

Fig.52: Experiments of mycelium feeding and growing on piled egg cartons assembling them together. Photo: Miriam Josi, 2021

In support of the rise (or rediscovery) of biodesign, advances in technology for scientific equipment but also the internet and social media have allowed the development of a world-wide network. Information has become available and accessible on a global scale, giving rise to open-source platforms to exchange knowledge and experiences.
The analogies between vernacular design and myco-fabrication are many, seemingly reflecting each one of the principles I listed. The communal character of vernacular building also translates to the DIY culture of the applied mycology community.
The term vernacular is not only defined as a dialect that relates to a specific place but may also refer to "the mode of expression of a group". In our context vernacular could be also understood as the jargon of the applied mycology subculture. There is a need for a new shared vocabulary for the different actors engaging in myco-collaboration, beyond the boundaries of disciplines and countries.

For the purpose of my practice I have developed an evolving *myco-vernacular* glossary of basic useful terms in the process of its applications and experimentations. (chapter 8)

Localism in a connected world

"The study of neighbourliness turns difference into a resource for collaboration." - Anne L Tsing

The culture of a place is never static and continuously being influenced. The effects of globalism on localities are numerous, affecting often negatively the local economies. The current unprecedented "acceleration and intensification in global flows of capital, labour, and information" (UNESCO) on one hand provides new opportunities, but may also cause loss of singularity of local cultures and identity.
In agreement with Kate Fletcher, I recognise localism as essential to sustainability in order to respond to societal and environmental issues. Localism attributes economic decisions to communities and nature, favoring using "nearby resources, place-specific knowledge and community self-reliance". (Fletcher, Tham 2019:48) Operating independently from global brands, localism empowers the local community, recognising its wellbeing's dependence on its ecosystems.
I suggest that collaboration with mycelium holds promise in assisting this process. But what does locality mean in a globalised world? Can the accessibility of myco-fabrication help embrace the potential of local resources, knowledge, and skills and foster creativity and community building?

Fig.53,54: Parsons Paris first year students install their mycelium planters made with agricultural waste and molds from readymade objects and reclaimed materials from la Réserve des arts at roof garden 'Facteur Graine' in Paris. Photos: Miriam Josi, 2019

My experience of *myco-vernacular* making has allowed me to expand my network in Paris beyond my immediate routine. While deepening my existing personal and professional relations it has taken me to unexpected places and encounters along the way.
The city has proven to be the perfect playground in this endeavor offering unlimited opportunities to source my raw materials. In 2017 alone the Paris region produced approximately 5,62 millions tons of waste. (Institut Région Paris 2020)
My supplies range from cotton scraps from my mother in law's sewing atelier (Fig.58), to used coffee grounds from my favorite brasserie, invasive algae from Canal St. Martin (Fig.57), to a seemingly endless supply of shredded paper from the Parsons' office (Fig.55,56) and egg cartons from my neighbourhood's most busy bakery. (Fig.51,52) The mycelium spawn I source from a small business in Versailles that produces DIY and ready-to-grow kits, that I occasionally add to my order for friends interested in cultivating edible mushrooms at home. Working with ultra-local waste also means that it can be seasonable, for example algae (Fig.57) that grows only when it is warm or waste of the local fruits and vegetables.
My mold "making" too starts with looking out for reclaimed materials and unwanted objects. My search usually ends successfully either at a flea market, my neighbours cave, my son's daycare or at La Réserve des Arts, a huge warehouse in the Parisian suburbs that recovers leftover materials and objects from local industries. If I can't find the desired shape I make a trip to the 12th arrondissement to my favorite glass maker, who is one of the last remaining glass manufacturers in Paris.
My *myco-vernacular* involvement has allowed me not only to deepen my relationship to materials but ultimately also rediscover my current locality, strengthening my connection to it and its people. It also gave me a sense of the city with all its diversity, and a desire to continue expanding my local mycelial web in a meaningful way.

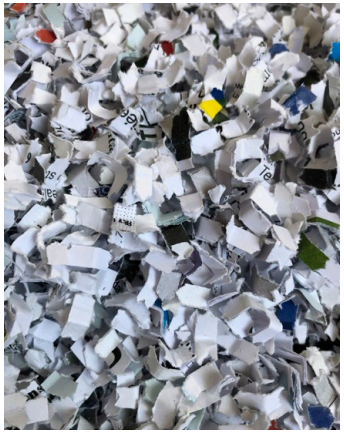

Fig.55,56: Experiments of pleurotus mycelium grown on shredded paper from the Parsons office. Photos: Miriam Josi, 2021

Fig.57: Harvest of invasive algae from Canal St. Martin to be dried and fed to mycelium. Photos: Miriam Josi, 2020

Fig.58: Example from 'Play vases'. mycelium grown at home on textile waste and hemp, glass tubes produced in Paris 12th arrondissement. Photos: Miriam Josi, 2019

Myco-fabrication - although now a globally widely accessible process - will produce different results each time depending on local contexts. Every place has its proper characteristics, influenced by its environment, climate and local culture. There is an opportunity to combine and embed the process within existing or vanishing local knowledge and crafts continuously shaping local identity and culture. At the same time there is the potential to create new traditions based on a diversity of contemporary and global influences.(Fig.53,54)
The question about the desirability of scalability is inevitable. Seemingly to have been the ultimate goal for most production methods, scaling up allows for accumulation of wealth but always involves complex logistics and extense transportation, leading to alienation and detriment for people and the environment. Perhaps we need to think about scale in relation to accessibility instead of physicality or profit.
When reconsidering scalability we have to challenge the predominant notions of progress. Where do we want to go moving forward? Do we want our human making to further distance us or to bring us together?
What is the role of technology in the scalability of this process? How can we best make use of the advances in contemporary technologies to 1. increase accessibility and exchange of knowledge and 2. move forward the research and feasibility of applications of myco-fabrication?

Fig. 59:
Myco-Vernacular Totems:
Example from a new series of totems made from waste being consumed by pleurotus mycelium. The elements being just stacked up, it is the mycelium's self-assembling quality that attaches them together.
Photo: Miriam Josi, 2021

The totems are grown below a glass dome which allows the observation of mycelium giving life to what we usually would consider waste. I contemplate and try to understand what it wants to be. Observing the hyphae spread into the void seemingly looking for food leads me to a temptative interpretation that it wants to be in its natural ecosystem where it can spread out into all directions and communicate with other living organisms.
Can we have a relationship with another species without knowing what it wants? Do we have to accept that we might never know?

Fig.60:
Mycelium inoculated reclaimed paper cube, egg carton pieces, cardboard tube, walnut shell, wooden coffee sticks, beer coaster
Photo: Miriam Josi, 2021

The role of the designer

In the process of vernacular myco-fabrication the designer evolves and expands its duties by stepping into a variety of roles: becoming an observer (Fig.59,60,61), noticing the close environment, but also participating in the role of observation by directly interacting with the organism.
The designer can become a forager and gatherer, identifying and collecting waste sources for their raw material.
Growth being the fabrication process (Fig.61) leads them to take on the role of a cultivator (Collet, 2017), creating the right conditions for the mycelium to grow.
They may also embody the role of an alchemist, conducting experiments to understand what the mycelium does when combined with other materials or grown in different environments.
Perhaps more than a problem solver the designer becomes an investigator.
Furthermore, much like the mycelium's role in his ecosystem, the designer takes the role of the facilitator and communicator.
The designer's contribution here lies in making knowledge comprehensible and spreading it along with its values.
The designer becomes a translator and ultimately a community builder, creating a more intimate link between fungi and the humans. Ultimately, this connection may hopefully enable more diverse and reciprocal ways of collaboration among humans as well as with other living beings.

	Observer
	Forager
	Gatherer
	Cultivator
The designer as a:	Investigator
	Alchemist
	Facilitator
	Communicator
	Translator
	Community builder

I argue that this shift of roles profoundly changes the designer's relationship to materials leading from detachment to intimacy. It is in fact no longer perceived or handled as a material, but it is given agency and treated like a conversation partner.

Fig.61: Closeup of the mycelium's hyphae growing on and assembling cardboard pieces. Photo: Miriam Josi, 2021

Concluding thoughts *on the new vernacular*

In this chapter I contested the idea of biofabrication processes as novel technologies by arguing that it originates in ancient vernacular and indiginous ecological knowledge.
I outlined some of the parallels between myco-fabrication and vernacular design principles and their compatibility to demonstrate the potential for a new *myco-vernacular*. In the case of an ultra-urban context, waste is the locally most abundant resource, which presents an opportunity, as it happens that mycelium thrives on our organic waste.

The idea of a *myco-vernacular* design might seem like a utopian vision for a globalised world. Admittedly it is likely not going to fully replace existing industrial manufacturing but it does present a promising opportunity for local bio-circular production, hopefully inspiring a diversity of other regenerative alternatives that we need in the transition to a more supportive and resilient coexistence of humans and the biosphere.

The *myco-vernacular* context leads designers to work under the constraints of their place, fuelling their creativity to do with what they have at hand and to connect with their locality. Using waste as resource and growth as process challenges their perceptions of material values and temporalities. In conclusion leading to deeper awareness of material impacts, ultimately honouring them and cultivating a practice of care.
Vernacular myco-collaboration assists designers in expanding their roles, moving away from purely rationalist and anthropocentric design and incites to reconsider our sense of survival as a collaborative project.(Tsing 2015) Working locally with mycelium turns proximity and diversity into a precious resource for collaboration and community building.
Essentially localism, just like lichen or mycorrhizal fungi, is about relationships. And so is *myco-vernacular* design. It is about the relationship with the organism and its environment, the relationship with a place, its climate and the resources it offers, affecting our relationship with the materials we use and the objects we make. It is furthermore about the relationships with the people, including both local suppliers, artisans, clients or collaborators, as well as the emerging global mycophile community. And finally it is also about the relationship with ourselves.

6

Back to dirt

a practical exploration

with Stella Lee Prowse

Continuing my exploration with myco-fabrication and to take further my reflections on vernacular design I feel the need to deepen my investigation into symbiotic collaboration with mycelium within a larger ecology.
This practical exploration will attempt to combine myco-fabrication and permaculture principles by letting go and sharing control to investigate the practice and ethics of working with living systems.

How we got here

Stella Lee Prowse and I met in 2012 during our undergraduate studies in product design at Parsons The New School for Design in New York. A creative and collaborative friendship emerged resulting in a number of joint and evolving projects.
A few years later we both had our first profound interaction with fungi, nearly simultaneously but in very different ways. While I experimented with mycelium with my students in Paris, Stella engaged in citizen science and mushroom foraging flourished in the woods in Upstate New York.
Here we are, a few years later together in Paris, continuing our education in Nature Inspired Design at Ensci les Ateliers, collaborating on new projects and co-teaching a class on myco-fabrication.
Our individual research and once again our joint conversations and reflections inspire us for this new collaboration.

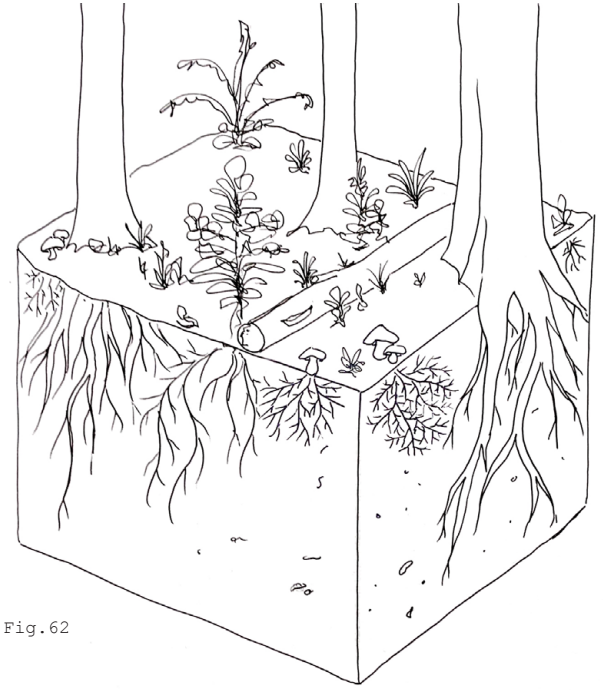

Fig.62

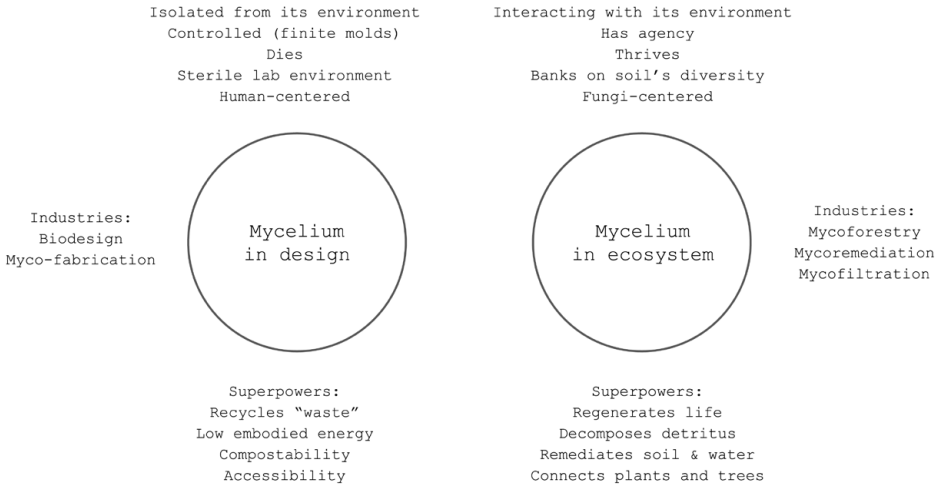

Fig.63: In the lab a sterile and isolated environment is used for the mycelium to grow, while in the ecosystem the organism thrives on the diversity of the soil and its relationships.

It is in defining a methodology grounded in interactive observation that we began to consider the disparity between mycelium in the ecosystem (Fig.62) and mycelium used in design (Fig.63). We saw an opportunity for a more integrated approach which entailed using mycelium to illustrate how fabrication processes and ecosystems could become more mutually beneficial. (Fig.64)

The following are a series of questions have led us here:

What does mycelium want?
What might the mycelium want from us?
What does the mycelium want us to want?
Why does mycelium risk contamination in the lab but not in nature?
What if we bring the lab to nature?
What if the soil became the mold?
How can the Mycelium continue to thrive, instead of having to die?
How can we collaborate with mycelium and soil in a respectful way?
Can we integrate permaculture principles into biofabrication in order to directly increase biodiversity?
How can growing mycelium in its natural habitat allow for a mutualistic rather than an exploitative relationship and benefit the surrounding ecosystem?
How can we integrate the local habitat and community?
What are the limits of control for the designer?
How can we integrate participatory citizen science in the process?

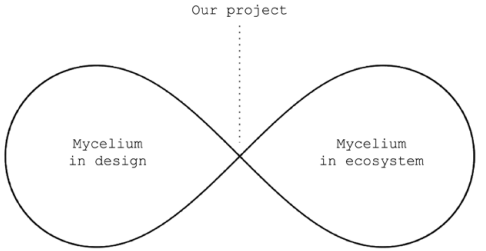

Fig.64

Intention

We intend to engage in an all immersive experience to work with mycelium in different environments exploring practices of letting go and sharing control. Instead of isolating the organism, we aim to embrace its interrelationships, in order to imagine new ways of making that benefit the more than human world.

With this inquiry we will apply our 'bio-inclusive' (Matthews 2011) design methodology grounded in holistic observation, exploring the full potential of mycelium and local resources, through reciprocal collaboration.

Design principles

We defined our design principles in an attempt to guide our practice. In doing so we drew inspiration from existing examples we align with.

Drawing on Nature's principles from Janine Benyus' book 'Biomimicry: Innovation Inspired by Nature' (Benyus, 1997:7, Appendix C) which describe nature's laws, strategies and principles, we identified that while relevant, they can be difficult to integrate into practice as they can be quite abstract. Permaculture, as a convincing example of applied Biomimicry, led us to examine its principles (Holmgren 2002, Appendix D). Another influence and perspective which guided us were the 'Hannover principles: Design for sustainability' (McDonough 1992, Appendix E) and the vernacular design principles I presented in the former chapter.

From each of these sets of principles we took elements relevant to our inquiry with mycelium, defining and reformulating them to make them more understandable for ourselves and hopefully for other designers.

Our evolving design principles are defined as followed:

+ Observe, immerse & interact
+ Trust intuition and consider all senses
+ Experiment and embrace process
+ Obtain a return
+ Adapt and respond to regular and imperfect feedback
+ Shift perspectives (time, place, participant)
+ Admit failure and seek opportunity
+ Use locally abundant resources & eliminate the concept of waste
+ Integrate (vs stand out/isolate)
+ Collaborate in diversity and recognize interdependence
+ Embrace the inbetween (science/design, nature/culture)
+ Use local expertise
+ Share control and consider reciprocity
+ Ask and raise questions
+ Communicate clearly and in metaphors

Language

"We don't need a worldview of Earth beings as objects anymore. That thinking has led us to the precipice of climate chaos and mass extinction. We need a new language that reflects the life-affirming world we want. A new language, with its roots in an ancient way of thinking."
- Robin Wall Kimmerer

In our individual research considering communication with the more than human, exploring the role of animacy and the embodied progress of collaborating with mycelium we encountered a need for a new pronoun when referring to our collaborator. 'It' doesn't feel right, because it is denying it of livelihood and reducing it to a thing, and 'he' or 'she' is up for interpretation. Instead we have arrived at the pronouns 'ki' and 'kin', introduced to us by author and citizen of the Potawatomi Nation, Robin Wall Kimmerer. Kimmerer takes the word Bemaadiziiaaki which in Anishinaaabe language means beings of the living Earth, which kimmerer suggests shortening to "ki". As part of our journey, we will try to adopt this pronoun from now on when we talk about mycelium - fully aware of the potential to sound clumsy.

What's next

This inquiry sits at the intersection of design, biology and agriculture. Inspired and empowered by the emerging fields of mycoforestry and permaculture, we see a potential for myco-fabrication to dig a little deeper.
We have developed a framework that will guide us in this investigation. During the next month we will continue our experiments, growing mycelium into shapes in different environments, varying the levels of control and reciprocity.
The first results of the process will be revealed at the final jury in September.

Fig.65: Soil Samples. Photo: Stella Lee Prowse, 2021

7
Conclusion

Concluding thoughts

The most apparent promise of myco-fabrication as a viable alternative to the existing linear exploitative manufacturing lies in its capacity to recycle our organic waste, its low embodied energy, accessibility of the process and the compostability of the developed materials.
In extension, it appears that myco-collaboration has more to offer and goes beyond the fabrication of materials. The main limitations of the process being a general loss of control and unpredictability, flawed aesthetic qualities and limited industrial scalability deeply challenge our human-centered view on aesthetics, ethics, creativity and sustainability. I tried to demonstrate that confronting and embracing these limitations inspires the conversations we need to move forward towards a new understanding of design - instead of a rationalist consumer driven - a 'bio-inclusive' vernacular design that embraces the unexpected and recognises the limits of human mastery.

In chapter 4 we explored mycelium as a pedagogical tool. Based on observations from my experiences as a designer and teacher, I discussed some of the relevant insights myco-collaboration has given to students and myself. Maybe the most valuable lesson we can take is in humility. The more we learn about mycelium, the more we realize how little we know about it. The multisensory interaction with this living organism requires a shift of attention and perspective that provides us with a humbling experience, leading us to accept the limitations of control and recognize our interdependence with the more than human world.
In chapter 5 I introduced the idea of a new *myco-vernacular* design as a radical local bio-circular alternative to existing industrial manufacturing and discussed how using local waste as a resource and growth as process leads designers to step into unknown territories provoking their role to evolve. I suggested that this change of the designer's role along with a deeper connection to locality results in a new designer-material relationship, that instead of domination can become one of reciprocity.
In chapter 6 I outlined my intention to carry out thoroughly the idea of reciprocal myco-collaboration in my joint exploration with Stella Lee Prowse, following and applying the principles of our personal design manifesto.
The big opportunity in this, still relatively new, field of material research, lies in my opinion in both, our ignorance (considering how little we still know) and our curiosity, and the way it is expanding beyond design merging with other disciplines and industries. One of our goals is precisely to incite other designers, mycologists, scientists, teachers and farmers to join us in this inquiry into a more bio-inclusive myco-collaboration. Accepting the limits of our own skills and our interdependence with the more than us presents a fertile ground for potential collaborations. (Fig.65,66)

I started this journey by asking how collaborating with living organisms can help redefine the designer's role and relationship to materials. It arises that working with mycelium requires us to adapt to its timeline and needs, demanding for a nonverbal conversation and the use of all senses, establishing an intimate companionship with the material.
Beyond answering my question, this journey has revealed mycelium to be much more than a material, a tool or even an organism. It is everywhere, connecting everything. Mycelium allows me to expand agency and awareness beyond myself. It forces me to both zoom in, observing the microscopic hyphae and zoom out, to consider my environment, offering me a lens to a more holistic perspective of the world, making me a more conscious part of it.
My engagement with mycelium has helped me reconcile my role as a designer in a shared world. In my quest to find balance and revise my design practice, I aim to welcome duality as being inseparable: Artificial and natural, growth and decay, making and growing, constraints and creativity, aesthetics and ethics, the planned and the unexpected, what I know and what I don't know.

Fig.66: Stella and I in Fontainebleau forest on a walk with citizen mycologist Jean-Pierre Méral learning about lichen and local fungi.
Photo: Guillaume Bloget, 2021

8

Glossary

Myco-vernacular vocabulary

Animism - the belief that all things possess a distinct spiritual essence
Anthropomorphism - the attribution of human characteristics to non-human entities
Applied mycology - study of fungi and their applications
Bio-assistance - (also referred to as bio-collaboration) domesticating an organism to accomplish a function (includes biofabrication and myco-fabrication)
Bio-circular - production and transformation of renewable biological resources and waste
Biodegradable - ability to break down organic matter by microorganisms, such as bacteria and fungi (a question of time!)
Biodesign - emerging design field at the intersections of design and biology (including biomimicry, bio-assistance, biophilic design, etc.)
Biofabrication - material production process by integrating living organisms
Bio-inclusive design - (term coined by Freya Mathews) refers to reciprocal collaboration with living organisms that considers the needs of the more than human
Bio-integrated design - explores how advances in synthetic biology, material science and digital fabrication are changing future design practices
Biophilic design - explores to connect humans inherent need to affiliate with nature in the modern built environment
Biomimicry - practice that learns from and mimics the strategies found in nature to solve human design challenges
Citizen Science - (also community science or crowd science) is scientific research conducted, in whole or in participatory, by amateurs
Commensalism - a kind of symbiosis in which one species obtains benefits from the other without harming or benefiting the latter
Composite material - material produced from two or more constituent materials
Compostable - ability to break down into non-toxic components in a compost environment (needs to be specified home or industrial compost)
Deep ecology - environmental movement found in 1973 by Arne Naess promoting the inherent worth of all living beings

DIY Mycology - culture and milieus of "amateur" self-taught mycologists practicing low-tech home cultivation of mushrooms and other applications

Ecofeminism - introduced by Françoise d'Eaubonne in 1974, philosophical and political movement and field of inquiry that examines the connections between women and nature

External digestion - Fungi absorb nutrients by secreting enzymes that break down material in their environments

Fermentation – chemical changes in organic substrates caused by enzymes of living microorganisms

Fungal strain - variety of individuals within a species sharing common genetic heritage but different features

Grow-made - (term coined by Carole Collet) materials grown from living organisms cultivated by a designer

Hypha - (pl., hyphae) filamentous thread of fungal mycelium

Ki / Kin - introduced by Robin Wall Kimmerer. Taken from the Anishinaaabe word Bemaadiziiaaki meaning beings of the living Earth

Inoculation - introducing microorganisms into a culture where they can grow and reproduce

Interspecies collaboration - collaboration between different species

Interspecies ethics - explores ethics across species

Lichen - dual organism in which a fungus maintains a green alga or a cyanobacterium captive in a symbiosis that approaches balanced parasitism

Localism - way of production using nearby resources, place-specific knowledge and community self-reliance

Macrofungi - fungi forming fruiting bodies or sporocarps

Materiality - 'material world' including physicality of the environment and how it is appropriated by humanity

Materials - Matter with intended use

Matter - physical substance in its different states. Anything that has mass, taking up space by having volume

Microfungi - (also micromycetes) fungi with microscopic spore-producing structures

Mold or mould (design)- container or form (soft or solid)used to cast shapes.

Mold or mould (fungi) - usually either zygomycetes or hyphomycetes, associated with deterioration of food or manufactured goods of organic origin

Mutualism - a kind of symbiosis in which both or all partners gain from the association (e.g. mycorrhizae)

Mycelium (pl. Mycelia) - body of a fungus, most of which is underground or hidden

Myco-collaboration - collaboration between humans and fungi

Myco-fabrication - material production process by integrating mycelium

Mycofiltration - use of mycelium as a membrane (selective barrier) to filter microorganisms, pollutants and silt

Myco-materials - materials made though myco-fabrication

Mycoremediation - bioremediation form using fungi to decontaminate the environment

Myco-vernacular - term I use to describe myco-fabrication of materials, objects and processes under local constraints

Mycoforestry - use of fungi to sustain forest communities

Mycophobia - Fear or aversion of fungi

Mycophilia - Love of fungi

Mycorestoration - use of fungi to restore degraded environments (including mycofiltration, mycoforestry, mycoremediation, and mycopesticides)

Mycorrhiza - structure by which a fungus and a plant exchange nutrients mutually

Mycotopia - (term coined by Paul Stamets) environment in which fungi are actively used to enhance or preserve ecological equilibrium

Organic waste - biodegradable material from a plant or animal origin

Parasitic fungi - fungi that take nutrients from living source gradually killing it

Permaculture - (term coined by Bill Mollison and David Holmgren)Integrated evolving system of perennial agriculture for human settlements

Pleurotus -(Pleurotus ostreatus or oyster mushroom) edible wild and cultivated fungus, commonly used in myco-fabrication and mycoremediation

Psilocybin mushrooms (also called shrooms) - fungi that contain psilocybin, naturally occurring psychedelic compound

Puhpowee - Potawatomi word to describe the force which causes mushrooms to push up from the earth overnight

Radical mycology - (term coined by Peter McCoy) grassroots movement promoting working with fungi for personal, societal, and ecological resilience

Regenerative - capacity to renew or restore

Rhizomorph - thick string like strand of mycelium

Saprobic fungi - "decomposer" fungi that derive nutrients from dead matter

Sentient - ability to perceive or feel things

Spawn - any material impregnated with living fungal culture

Spores - reproductive structures of a fungus, usually a single cell

Sporophore - fungal fruiting body

Substrate - any organic material on which mycelium can feed on

Symbiosis - interaction between two different organisms living in close association

Synthetic biology - redesign of existing natural biological systems

Toadstool - fruiting body of a fungus, typically in the form of a rounded cap on a stalk, often one that is believed to be inedible or poisonous

Vernacular - use of a dialect, native to a place or characteristic to a group, rather than a formal literary language

Vernacular architecture - characteristic building style of a period or place

Vernacular design - design under constraints of locality and context

White rot fungi - degrading lignin leaving decayed wood whitish in color and fibrous in texture

Wood Wide Web - (term coined by Suzanne Simard) metaphor of mycelium as nature's internet

Yeast - eukaryotic, single-celled microorganism classified as member of the fungus kingdom

9

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10
Appendixes

Appendix A

Mycelium workshop formats

1. First Year students at Parsons Paris in Sustainable Systems
10-15 students
Three times 2:40 h over three weeks per semester
Since Fall 2019

Course summary:
Sustainable Systems is a prerequisite course for all First Year students at Parsons The New School for Design, introducing them to ecological systems and their responsibilities as future-designers. The curriculum is structured around four complex and interrelated topics, Water, Materials, Energy, and Climate. Experiences and insights from field trips, lectures, discussion and studio-based workshops are developed into creative works that address diversity, adaptability and resilience in the face of ever changing conditions.

Mycelium project description: This creative work will span two topics, Materials and Energy, giving students time to experiment with a new material, mycelium, then design and fabricate an object. Since the Energy topic focuses on food systems and urban agriculture, we will be designing planters to be installed on a roof garden in Paris. The planters will be 'grown' with mycelium, using molds constructed from reclaimed materials. You will work in groups of 3 for the final work.
Part 1: Mycelium experiments and explorations (in groups), including sketches
Part 2: Design and 'grow' planters for the rooftop garden "Communauté Facteur Graine".

2. First Year students at Parsons Paris in the course 'Space Materiality'
10-15 students
Twice 5:20 h over two weeks
February 2021

Course Description:
Building is an act of transformation. How do we translate a thought into a thing? How do we take an idea from a flat world to a three-dimensional world? In this class you will learn the techniques that lead from conception to physical construction: sketching, drawing (2D, 3D), shaping, joining, folding, collapsing etc. Space Materiality will look at three types of space: haptic (related to touch); inhabited (lived in or occupied space); and social and environmental (related to society and the natural world). We embrace learning through failure, taking a trial and error approach to finding out about material properties. We will experiment with concepts such as malleability, weight, texture, durability, and think about ways to engage all the senses as we create three-dimensional projects. Discussion, critique, and written responses will create a class community of idea-sharing. These will help you to understand your work in historical and cultural contexts, including the social and ecological impacts of the materials you use.
Project 'Augmented Object: In the Anthropocene, most human-made products are used only for a tiny fraction of their actual life span. Objects generally live much longer as waste than in use and survive the humans that create them. For this project students will pick a discarded object and combine it with a regenerative material. Growing mycelium on waste substrate, they will use their objects as molds or merge them with the living organism. The goal is to create new narratives for their discarded objects and their "after-lifes".

3. Master 1 students in Product Design and 'Matériaux Innovants et Développement Durable'
Ecole Condé Paris
12students
17times 3hours over 17 weeks
Oct 2020 - March 2021

Course overview:
The course 'Pratiques Expérimentales' examines humans' evolving relationship with the living through the lens of materiality and bio-collaboration. Challenging the prevailing industrial approach to material sourcing and processing, students are exploring different directions to working with mycelium, with the intent to dig deep and make new discoveries in underexplored territories.
Growing mycelium using waste as a substrate encourages students to redefine the role of the designer and imagine more regenerative materials, processes and industries.
Through hands-on workshops, students navigate an iterative design process through trial and error, experimentation and observation. Students cultivate mycelium on different organic substrates, manipulate form through experimental mold making and test natural finishes to uncover new material properties and propose potential design opportunities that address our current environmental crisis.
This course is an experimental and supportive environment fostering interdisciplinary collaboration, idea sharing, learning by doing and embracing the failures in the process. An emphasis on documentation allows students to reflect and carry their observations and tools to be applied in their future practices.

3. Master 1 students in Interior Design
Ecole Condé Paris
10students
One week workshop February 2021

Project brief: Considering mycelium as a natural binder, students will explore the material as a solution to joinery. Ideating on modularity, dis/assembly, growth and decay, students will collaborate in small groups with multiple explorations to be imagined, grown and documented by the end of the week. Utilizing wooden sticks, recycled from previous workshops, as well as other ready-made or custom-built elements.

Final Outcome: a modular system utilizing recycled wooden sticks and mycelium as joinery

General assessments for all formats:
Participation in experiments, process sketches and proposals
Critical thinking, original research and strength of concept
Development and final project: creativity, craft, functionality and aesthetic

Appendix B

Mycelium Step by step instructions

STEP BY STEP: WORKING WITH MYCELIUM

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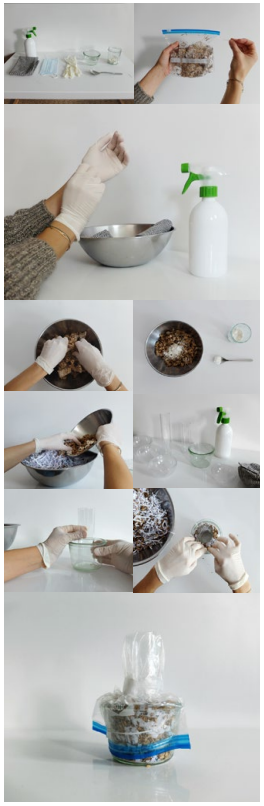
YOU WILL NEED

+ SEALED BAG OF MYCELIUM MIX (PROVIDED)
+ ADDITIONAL ORGANIC SUBSTRATE (PAPER, CARDBOARD, COTTON SCRAPS, WOOD CHIPS, SAWDUST, ETC.)
+ FLOUR
+ SPRAY BOTTLE OF ALCOHOL
+ DISPOSABLE GLOVES
+ FACE MASK
+ GLASS OF WATER
+ TABLESPOON OF FLOUR
+ MIXING BOWL OR BUCKET
+ PAPER OR FABRIC TOWEL
+ MOLD IN WHICH TO CAST YOUR MYCELIUM (UTILIZE FOUND OBJECYS AND MATERIALS FOR TESTS)
+ PLASTIC WRAP OR LARGE PLASTIC BAG
+ NEEDLE



STEP 1

PUNCH TWO HOLES IN THE TOP OF BAG WITH A NEEDLE, THE MYCELIUM REQUIRES AIR AND MOISTURE TO LIVE, STORE IN FRIDGE TO SLOW DOWN GROWTH

STEP 2

PUT ON GLOVES, STERILIZE THEM AND THE MIXING BOWL USING ALCOHOL SPRAY AND TOWEL

STEP 3

WEARING YOUR MASK, OPEN THE BAG OF MYCELIUM MIX, SOME MIGHT HAVE TURNED WHITE. CRUMBLE IT INTO THE BOWL BREAKING IT UP AS BEST YOU CAN. THE WHITE COLOR WILL BEGIN TO DISAPPEAR

STEP 4

ADD 1-4 TABLESPOONS OF FLOUR (DEPENDING ON AMOUNT OF SUBSTRATE) MIX WELL WITH GLOVED HANDS

STEP 5

STERILIZE YOUR OWN ORGANIC SUBSTRATE IF NEEDED (IF YOU BOIL IT MAKE SURE TO DRAIN THE SUBSTRATE AND LET IT COOL BEFORE ADDING IT TO THE MIX) ADD SUBSTRATE TO THE MYCELIUM, MIX WELL, MIXTURE SHOULD BE MOIST, ADD WATER IF NECESSARY

STEP 6

STERILIZE MOLDS WITH ALCOHOL AND FILL WITH MYCELIUM MIX WEARING GLOVES AND MASK (HERE IS AN OPPORTUNITY TO PUSH BOUNDARIES OF MOLD MAKING EXPERIMENT WITH FOUND OBJECTS, SOFT MOLDS, ETC...) COVER THE SUBSTRATE WITH PLASTIC WRAP OR A PLASTIC BAG TO ENSURE HUMIDITY (STERILIZE REUSED PLASTIC BAGS WITH ALCOHOL) WITH YOUR NEEDLE, POKE TWO- THREE HOLES INTO THE PLASTIC COVER SO THE MYCELIUM CAN BREATHE. STORE INDOORS SOMEWHERE CLEAN AND DRY, OUT OF THE SUN

STEP 7

IN 5-7 DAYS, DEPENDING ON THE TEMPERATURE, THE MYCELIUM MATERIAL WILL HAVE GROWN THROUGHOUT THE MOLD AND CAN BE REMOVED. IT WILL NEED TO AIR DRY FOR 1-2 DAYS OR CAN BE BAKED IN AN OVEN AT LOW HEAT (95C) THIS STOPS THE MYCELIUM FROM GROWING, COMPLETING THE PROCESS

Appendix C

Nature's Principles (Benyus, 1997:7)

Nature runs on sunlight

Nature uses only the resources it needs

Nature fits form to function

Nature recycles everything

Nature rewards cooperation

Nature banks on diversity

Nature demands local expertise

Nature curbs excesses from within

Nature taps the power of limits

Appendix D

Permaculture Design Principles (Holmgren, 2002)

Observe and interact: Take time to engage with nature to design solutions that suit a particular situation.

Catch and store energy: Develop systems that collect resources at peak abundance for use in times of need.

Obtain a yield: Emphasize projects that generate meaningful rewards.
Apply self-regulation and accept feedback: Discourage inappropriate activity to ensure that systems function well.

Use and value renewable resources and services: Make the best use of nature's abundance: reduce consumption and dependence on non-renewable resources.

Produce no waste: Value and employ all available resources: waste nothing.

Design from patterns to details: Observe patterns in nature and society and use them to inform designs, later adding details.

Integrate rather than segregate: Proper designs allow relationships to develop between design elements, allowing them to work together to support each other.

Use small and slow solutions: Small and slow systems are easier to maintain, make better use of local resources and produce more sustainable outcomes.

Use and value diversity: Diversity reduces system-level vulnerability to threats and fully exploits its environment.

Use edges and value the marginal: The border between things is where the most interesting events take place. These are often the system's most valuable, diverse and productive elements.

Creatively use and respond to change: A positive impact on inevitable change comes from careful observation, followed by well-timed intervention.

Appendix E

The Hannover Principles: Design for Sustainability (McDonough, 1992)

Insist on rights of humanity and nature to co-exist in a healthy, supportive, diverse and sustainable condition.
Recognize interdependence. The elements of human design interact with and depend upon the natural world, with broad and diverse implications at every scale. Expand design considerations to recognizing even distant effects.

Respect relationships between spirit and matter. Consider all aspects of human settlement including community, dwelling, industry and trade in terms of existing and evolving connections between spiritual and material consciousness.

Accept responsibility for the consequences of design decisions upon human well-being, the viability of natural systems and their right to co-exist.

Create safe objects of long-term value. Do not burden future generations with requirements for maintenance or vigilant administration of potential danger due to the careless creation of products, processes or standards.

Eliminate the concept of waste. Evaluate and optimize the full life-cycle of products and processes, to approach the state of natural systems, in which there is no waste.

Rely on natural energy flows. Human designs should, like the living world, derive their creative forces from perpetual solar income. Incorporate this energy efficiently and safely for responsible use.

Understand the limitations of design. No human creation lasts forever and design does not solve all problems. Those who create and plan should practice humility in the face of nature. Treat nature as a model and mentor, not as an inconvenience to be evaded or controlled.

Seek constant improvement by the sharing of knowledge. Encourage direct and open communication between colleagues, patrons, manufacturers and users to link long term sustainable considerations with ethical responsibility, and re-establish the integral relationship between natural processes and human activity.

Myco-collaboration
for a new vernacular

a mycelium informed journey

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