



*Mycology and the Rhizome Archetype  
in New Media Arts*

**Miguel Canal Marulanda**  
**Master in Media Spaces**  
**University of Applied Sciences Europe**  
**Supervised by:**  
**Sebastian Neitsch & Claudia Rohrmoser**  
**Berlin, Germany**

**2017**

Mycology  
and the  
Rhizome  
Archetype  
in New  
Media  
Arts



# abstract

This project is developed using the mushroom mycelium as a living example of the rhizome figure created by Gilles Deleuze and Felix Guattari. By comparing those 2 systems, and exploring their inherent characteristics and architecture, is then possible to find their structure occurring in other dimensions of the existent, like the brain, the internet, the black matter in the outer space, the protozoa kingdom and artificial neuronal networks. By doing that, it is possible to define the mycelium and the rhizome as an archetypal shape of system, and therefore, understand it as a naturally created structure that permits flows of energy in special ways, at the same time that occurs in nature and technology blurring the line marked between them. Finally, and with the boundaries between us and our technology dissolved, this project explores new media arts as an extension of our bodies, that when used wisely, have the potential to merge elements from all kingdoms and spheres towards the understanding of them as whole and complete super system of relations.



# content

Introduction	/11
1: The fungi kingdom	/15
1.1: Mycelium	/17
2: The mycological rhizome	/21
3: The mycelial mind	/27
3.1: Slime Mold	/30
4: The artificial mind	/35
4.1: Artificial neuronal networks	/38
5: Essentially cyborgs	/47
6: Natural flows in new media arts	/53
6.1; Relational art and the fluxus laboratory	/55
6.2: Saša Spačal	/60
6.3: Synthetic poetry	/64
6.4: Plantas nómadas	/67
Conclusion	/73
Endnotes	/77
Figures	/81
Bibliography	/85



# introduction

This thesis starts by examining some inherent processes, behaviors and elements of the fungi kingdom, focusing specially on the mushroom mycelium: an underground, rhizome-like structure that allow fungi to grow, eat, create symbiosis relationships and transfer nutrients and information with plants and molecules. Then, it explores the architecture of the mycelial system, seeing it as an archetypal structure of nature which have been used widely in many scales of the natural and also within the human technological sphere. Finally, it examines how this super efficient natural system, was, and is being used for the creation of new media art projects.

Paul Stamets, one of the most important researchers, pioneers, and biologist working in the mycological field, speaks about fungi as the most essential element to heal our planet. Not only because their potential for Mychoremediation and other processes that fungus can perform, but specially because of the inherent quality that fungus owns to create interconnections within nature. Those connecting processes from the fungi kingdom are essential for organisms like plants to survive, and for ecosystems to thrive. They are also the main inspiration and base for the development of this work.

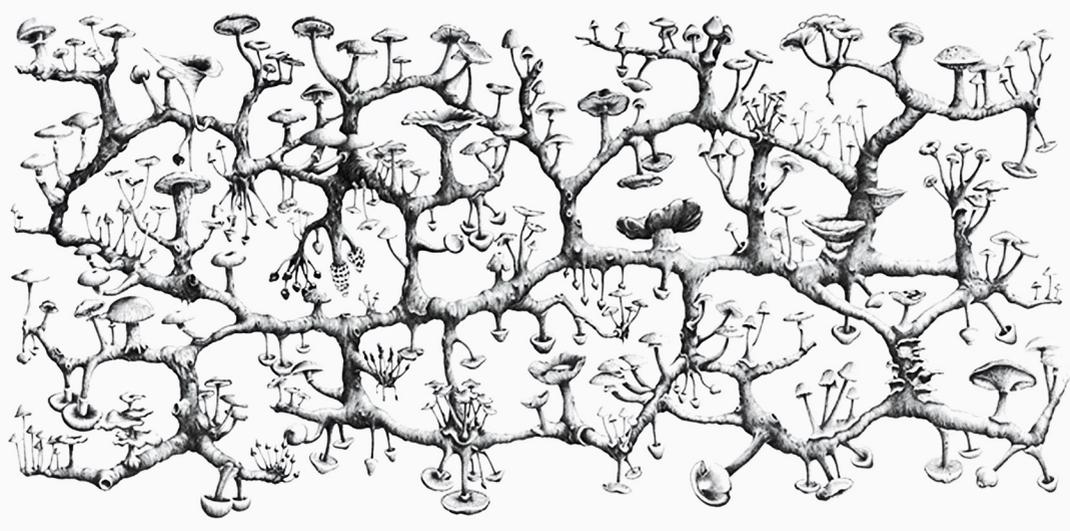
The main focus of this text will be on the figure of the rhizome: a system theory developed by the french philosophers Gilles Deleuze and Felix Guattari. By understanding the functioning of such structure, and by finding it operating in many levels of the natural and the technological, it is possible to use it for blurring the limits between what we consider natural versus artificial in order to understand art practices and technology as an organic and biological part of existence.

Therefore, because its potential for bringing disciplines and multiplicities together, art is here treated as an excellent field for experimentation and innovation towards an understanding of nature and the ability to see it as a whole. A whole where the human experience, with its technology and creations, is included and developed in order to construct an ecosystem of heterogeneity.

Furthermore, the mycelial or rhizome architecture, is here constantly connected with the idea of consciousness; a consciousness which in essence is based on the concept of interconnection, and that therefore, if we understand and use it properly, can help us create inter kingdom, technological and spiritual communication channels with basically everything in the universe.

1//

# the fungi kingdom



“Fungi are the interface organism between life and death.”<sup>1</sup>

The fungi kingdom is in the list of the less studied life forms on the planet. There is thousands and thousands of species growing all along the land, performing processes that will astonish everyone who is interested enough to take look at them.

Probably the most important process they do is the decomposition or recycling of organic matter, breaking it down into smaller molecules that then are going to feed other parts of the ecosystem. As they do that, soils are created allowing many different organisms to thrive.

Among all the characteristics of the fungal species, their ability to create symbiotic relationships with plants is on the first places of the list.

Ninety percent of plants can not live without this relationship where nutrients are transferred in both directions for the mutual benefit. They are connectors within ecosystems, behaving like interfaces between the essential elements of them and making all the nutrients cycle through the food chain.

Fungi are considered to be important healers of ecosystems, by performing actions like the ones mentioned above, they can heal environments with poor nutrition and even clean places infected by toxic waste.

The more we study those organisms, the more qualities they seem to have. There are actually capable of filtering polluted water, producing molecules that are used for the development of drugs against cancer and many other diseases, being used as the more natural and less ecologically harming weapon against pests, being a nutritive source of food for many species including ours etc...

However, to really understand the functioning of the fungi kingdom is essential to understand the mushroom mycelium: and underground network of cells, that against the popular thinking, is the most important part of the organism. What is called mushroom is only the “flower” of the mycelium: A reproductive body that can shoot billions of spores a day.

## 1.1: Mycelium

“Mycelium are the root-like fibers of fungi which grow beneath the surface of the ground, appearing as a frost-like growth beneath leaves and bark and growing into a dense network for sprouting mushrooms. Mycelium holds together large amounts of the planet’s topsoil and has already been used to create powerful antibiotics. As humans, we actually share more than half of our DNA with fungi, making them a much closer relative than most would think.”<sup>2</sup>



fig. 2.

This is an introduction to the biological concept of mycelium. Here the intention is to give a basic insight of what the mycelium is. As this texts develops we are going to come back many times to the idea of mycelium to study and compare many of the processes that this organisms can perform.

Mycelium is also defined as “the mass of interwoven filamentous hyphae”<sup>3</sup> that is often living inside another body: as of soil, organic matter or the tissues of a host.

Mycelium is the fungal “root”. It can be considered the vegetative part of the entire fungal organism, and it can create net like structures, spread across the fields, propagate, and share nutrients over great distances, eventually sprouting fruiting bodies: mushrooms.

Paul Stamets, one of the most important experts in mycology of the United States, recipient of the Collective Heritage Institute’s Bioneers Award, writer of many books on fungi and their technological importance, owner of nine patents on the antiviral, pesticidal, and remedial properties of mushroom mycelia, in his book *Mycelium Running* speaks about mycelium as:

- The main part of the fungus for nutrients absorption.
- A vital element in terrestrial and aquatic ecosystems because of their role in decomposition of plant material.
- Soil generator.
- A key for the aerate of the earth.
- Increaser of efficiency of water and nutrient absorption of most plants.
- Creator of enzymes to destroy pathogens that affect other organisms.
- Food source for many soil invertebrates.
- The neurological network of nature.



fig. 3.

Mycelium then, can be understood as an underground, sentient, perfectly articulated network that grows in every direction conquering virtually all land masses in the search for food. It breaks out molecules as it finds them, for example in plants, rocks and other living beings, to unlock their nutrients and to create soils, that after all, are going to be the main ground for other life to thrive.

It is a web like connector that can transmit information through an entire ecosystem creating symbiotic relationships with plants, for example, which are actually interdependent of mycelial networks to survive. It is an excellent decomposer of matter and toxins, and because of that, it is able to heal entire habitats by transforming toxic waste into nutrients.

Furthermore, Stamets explains in his book *Mycelium Running* that the largest organism in the world is a huge mycelial network; a 2,200 years old and 970 hectare of underground mycelium in eastern Oregon. It grows under a forest that was killed by it many times. That process has produced deeper layers of soil allowing bigger trees to grow every time there is a new cycle. This huge “Honey Mushroom” mycelial network is the living proof of the efficiency of the system developed by the fungi kingdom.

fig. 4.



fig. 5.

“Mycelium is not something to take lightly[...]There is something beautiful and horrifying, ancient and keenly *technological* about these organisms, a complexity it may take a psychedelically-informed, non-institutional mind to fully appreciate.”<sup>4</sup>

2//

# the mycological rhizome



With a basic knowledge about the mycelium, let's focus on its structure: seeing it as form, as the archetype of the net, as a shape where every single part is connected through different lines; Seeing it as the Deleuzian and Guattarian rhizome.

In the book *A thousand plateaus*, the French philosopher Gilles Deleuze together with the French psychiatrist and political activist Felix Guattari, introduced the term rhizome for the first time. It was placed in a dialectic discussion with the figure of the tree model; an arborescent structure that originates from one point (the seed) and spreads through many ramifications. See Figure 7. They argue that the last model is oversimplified and is based on linearity, predictability and a binary logic. On the other hand, they propose the term rhizome as a more complex, multi dimensional, non linear, heterogeneous structure.



fig. 7.

The rhizome, as the authors suggest, can be sketched through a set of characteristics inherent to its functionality. What I'll do next, is examine the key elements of those characteristics to find what is essential on the rhizome structure. After that, a parallel between the rhizome and the fungal mycelium will be outlined, to understand mycelium as a brother structure of the rhizome archetype.

Once this system is defined and connected with the fungi kingdom, I'll focus on finding those archetypal structures of nature, affecting and functioning in the new media arts world, or more specifically, being an essential part of the relational art, Fluxus, information ecology systems, Bioart and artificial neuronal networks.

The rhizome is a system of relationships between multiplicities; A shape varying and constantly growing structure that condenses energy in spots where elements coming from all places confront themselves only to explode in all other directions. By doing so, they create infinite possibilities for the elements to connect and mix, in a constant flowing system that can be seen as the figure of the movement, as the spiral, as a rootless structure that will never become static.

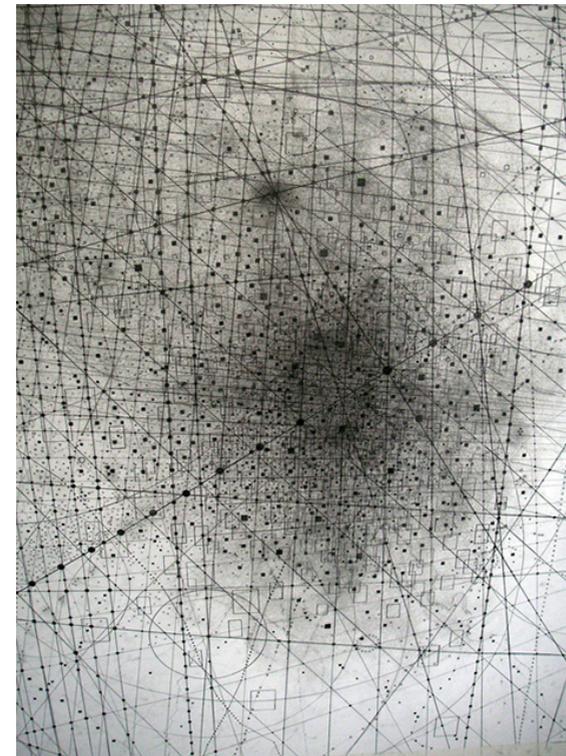


fig. 8.

“A rhizome ceaselessly establishes connections between semiotic chains, organizations of power, and circumstances relative to the arts, sciences, and social struggles.”<sup>5</sup>

The first three characteristics that Deleuze and Guattari showed us, are the principles of *connection*, *heterogeneity* and *multiplicity*.

This sense of connectivity implies constant relations between elements of different dimensions.

The mycelium can be used as a perfect example to understand the rhizome, not only because of its form or shape, but also because it functions and flows following the principles mentioned above: *connection*, *heterogeneity* and *multiplicity*.

As Paul Stamets says in his book *Mycelium running*, these fungal underground networks are again, a constantly growing structure seeking to create mutualistic relationships with other beings. Plants are the biggest beneficiaries of this network as 90% of them have mutualistic, symbiosis-like relationships with fungi, and would not be able to survive without them. As the mycelium grows and expands in a rhizome-like interconnecting way, it is able to build a relationship of interconnectivity with the entire ecosystem, communicating information through the network and making possible for it to know where the resources are.

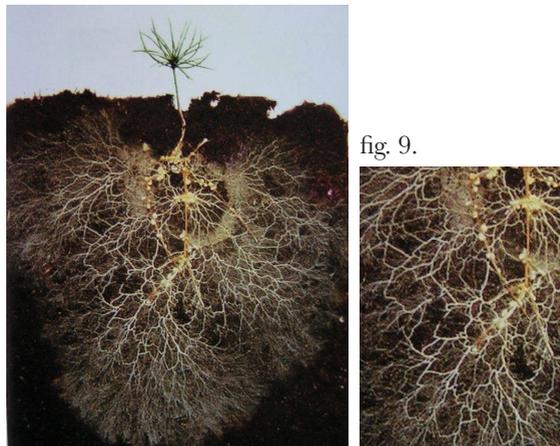


fig. 9.

By doing this, the mushroom mycelium creates connections between different kinds of organisms, blurring the boundaries in our categorization of species, creating not only a system of communication and relationships, but an heterogeneity state of diversity, interconnected by rhizomatic iphae, and functioning as a multiplicity.

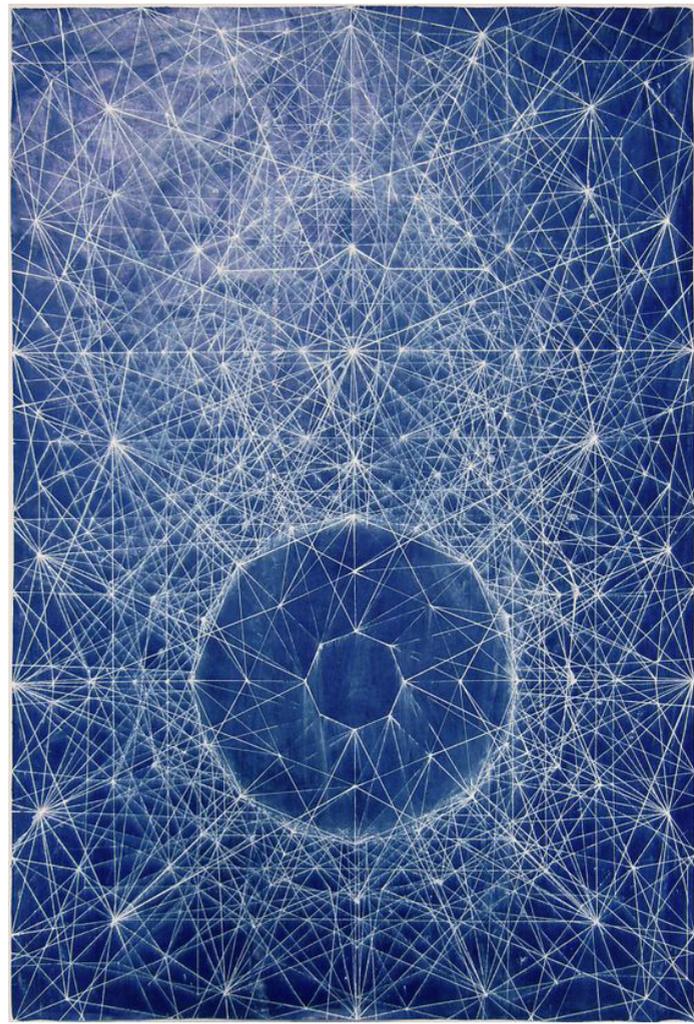
“A multiplicity has neither subject nor object, only determinations, magnitudes, and dimensions that cannot increase in number without the multiplicity changing in nature (the laws of combination therefore increase in number as the multiplicity grows).”<sup>6</sup>

In short, because of the processes occurring within the fungal system, and following the Deleuzian-Guattarian rhizome principles, it is possible to say that the mycelium is a rhizome like system because it functions under the same principles:

- Under the principle of *connection*, by the mycelium information transfer process, where the creation of multi connected channels of information are built to allow the system to transfer information between its different parts.
- Under the principle of *multiplicity*, by seeing the different species as separated wholes connected by the fungal network into a bigger ecosystem.
- Under the principle of *heterogeneity*: by the mycelium mutualistic and symbiotic relationships with ecosystems, where the interspecies connection is able to blend them all into a multi dimensional system of divergency.

3//

the  
mycelial  
mind



The rhizome system, figure, form, structure or archetype, is not only found in philosophy or fungi, but is actually a recurrent form in nature, happening for example in the human brain and its interconnectedness via neuronal synapses.

Paul Stamets is one of the most reckless defender and sharer of that idea. He says that mycelium is the neurological network of nature: an intelligent system that not only is aware, but is also capable of responding to changes in the environment. He also argues that mycelium is *Earth's natural internet*; "I believe that the structure of the internet is simply an archetypal form, the inevitable consequence of a previously proven evolutionary model, which is also seen in the human brain".<sup>7</sup>

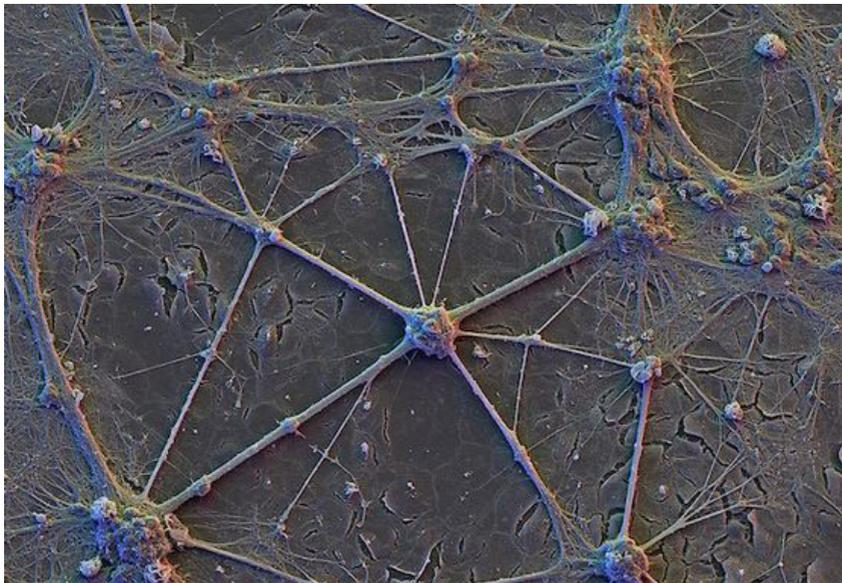


fig. 11.

He argues that nature tend to work with what have functioned in a good way before, and that the similarities between the structure of mycelium and other forms in nature can't be a mere coincidence.

"Biological systems are influenced by the laws of physics[...] [...]The architecture of mycelium resembles patterns predicted in string theory,

and astrophysicist theorize that the most energy conserving forms in the universe will be organized as threads of matter-energy. The arrangement of these strings resembles the architecture of mycelium."<sup>8</sup>

The mycelial archetype is a natural architecture system, forged under the influences of the physic laws, that occurs throughout diverse landscapes of nature. Its functioning have became through evolution, a way for creating better channels of information sharing and more successful and complex organisms. It is the archetype of consciousness.

For accepting that, I believe necessary to let go the idea that consciousness is an explicit process of the human form, and embrace the term as a process inherent to nature itself, occurring in a fractal way, from the most microscopic organisms to the biggest elements we have found in the universe, but not forgetting that all of them, or all of us if you will, are deeply related and interconnected.

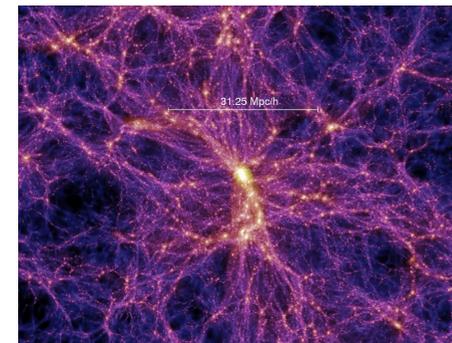


fig. 12.

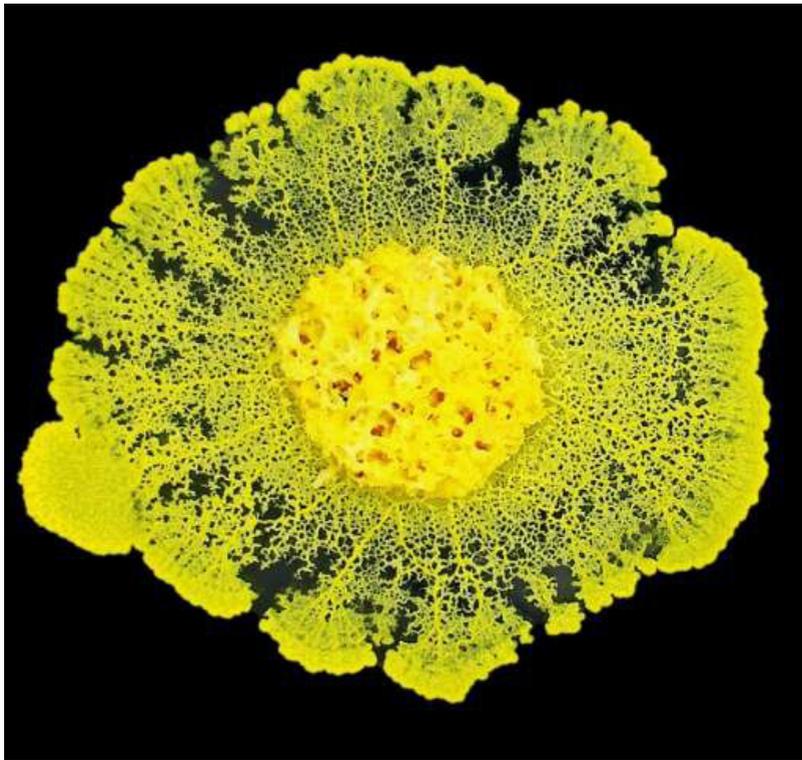
In Figure 12 its possible to appreciate a gamma ray image from Nasa's Fermi Gamma-Ray Space Telescope that shows energy flows between galaxies. This kind of image is being used to study and understand what black matter is. However we still don't really understand it, we know that it represents the 80% of the total matter in our universe.

The visual relation between that image, the rhizome, and the mycelium is obvious, and as Stamets says, it makes us wonder if what we are looking here is a cosmic consciousness.

### 3.1: Slime Mold.

“Slime mold is an informal name given to several kinds of unrelated eukaryotic organisms that can live freely as single cells, but can aggregate together to form multicellular reproductive structures. Slime molds were formerly classified as fungi but are no longer considered part of that kingdom. Although not related to one another, they are still sometimes grouped for convenience within the paraphyletic group referred to as kingdom Protista.”<sup>9</sup>

fig. 13.



Protista is “a taxonomic group reserved for everything we don’t really understand” says Chris Reid of the University of Sydney.

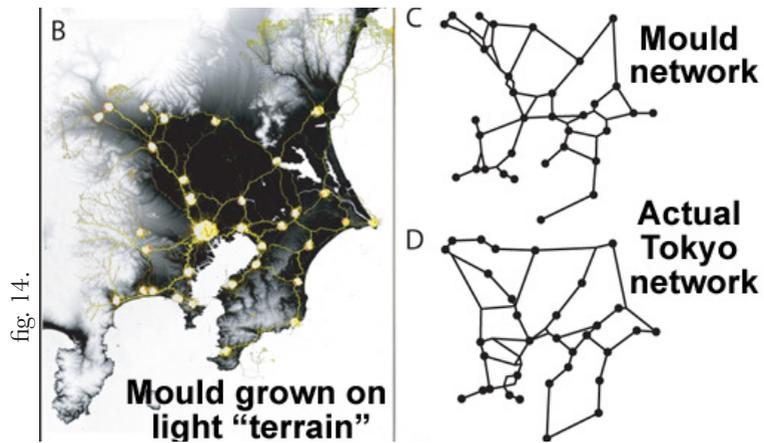
Slime molds have surprised the scientific world because its intelligence and its way to perform very interesting processes without having a brain. What it has instead, is the possibility to grow, move and interact by using this a rhizome-like system that we have said it’s archetypal of the universal consciousness.

Even though, slime molds are not considered part of the fungal kingdom anymore, their live cycle functions exactly in the same way as the mushrooms does. The division comes from the cellular composition.

“Slime molds are redefining what you need to have to qualify as intelligent,” Reid says. They can navigate within mazes, solve problems related with effectiveness in interconnected systems and choose the healthiest food from a diverse menu—and all this without a brain or nervous system.

In an article called *How slime molds are redefining intelligence* by the Scientific American, the author explains how those organisms can navigate a maze “retracting its branches from dead-end corridors, growing exclusively along the shortest path possible between two pieces of food.”<sup>10</sup> at the same time as it leaves traces of a translucent slime that helps other parts or other slime molds, to avoid the already “walked” paths. “This extracellular slime, Reid reasoned, is a kind of externalized spatial memory that reminds polycephalum to explore somewhere new.”

Furthermore, and still following the mentioned article, there are some experiments where the organisms have been placed in recreated environments where food was placed in a map, exactly in the positions where the rail stations of Tokyo are, and the slime mold grew in a way that connects those points in a very similar way than the humans did for the creation of those rail systems. That means that the single-celled brainless being didn’t grow randomly but instead it behaved like a team, building the connections in the most efficient and conservative way to save the energy. See *Figure 14*.



“Compared with most organisms, slime molds have been on the planet for a very long time—they first evolved at least 600 million years ago and perhaps as long as one billion years ago. At the time, no organisms had yet evolved brains or even simple nervous systems. Yet slime molds do not blindly ooze from one place to another—they carefully explore their environments, seeking the most efficient routes between resources. They do not accept whatever circumstances they find themselves in, but rather choose conditions most amenable to their survival. They remember, anticipate and decide. By doing so much with so little, slime molds represent a successful and admirable alternative to convoluted brain-based intelligence. You might say that they break the mold.”<sup>11</sup>

When looking at this incredible creatures, and seeing how they are redefining our understanding of intelligence by behaving in a mycelial-rhizome-like network to perform all their actions, it's important to remark that is possible to understand things as conscious or intelligent even though they lack a brain or a nervous system.

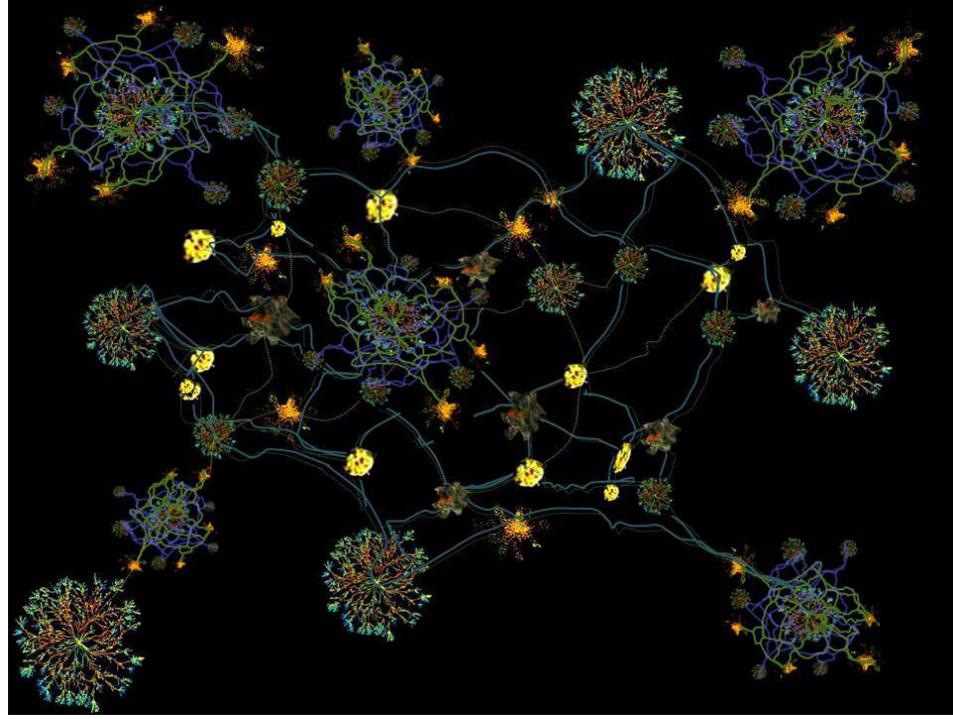
We have seen how mycelial forms contain some of the essential processes that Deleuze and Guattari have sketched in their basic characteristics of the rhizome logic. The principles of *connection*, *heterogeneity* and *multiplicity*. We have also seen that the rhizome-mycelial archetype is a structure that appears in many different places in nature, including

the mushroom mycelium, our brain, the energy flows in the space and the Protista or “alien like” kingdoms; all of them possible to use for the understanding of consciousness as a rhizome-like system architecture, or as a multi connected network where information and energy flows in every direction.

Once we have seen those ideas happening in nature, we can now enter into the machine world to see those natural systems or structures happening inside a “human created” environment, where the existence of those systems and their repercussion in our lives can sometimes blur the line between what's human and what's natural.

4//

# the artificial mind



I'll focus now on a more contemporary view of the mycelial system, approaching it from the informational side in digital media.

Felix Stalder, in his text *Information Economy* (2005), introduces the term information ecology as a process that is used for understanding the characteristics of digital information networks.

Four dimensions are necessary to understand the flow of information, and the nodes formed in the recurrent intersections: Interdependency, change, time-boundless and differentiation.

“The very nature of ecological environments is its connectedness. The uniqueness of each node, the fact that every node embeds a singular combination of connections to other nodes, ties them into one large shared environment in which all elements are interdependent.”<sup>12</sup>

Stadler continues by arguing that change is the inevitable reaction of an information system when two or more sides are connected. By creating relationships between the nodes they become interdependent and the smallest change in the system can have consequences in the total. Just like if you remove one fungal species from its habitat, the consequence will be a new environment with different information flows seeking to adapt and create new interconnections.

“The newest version of a piece of software is not better because it has less bugs but because it incorporates new capabilities, adapting to the fast-paced changes of the internet.”<sup>13</sup>

Paul Stamets refers to our relationship with fungi as something that is really short. That is because their cycles are very fast and therefore the “learning window is so attenuated”. They are ephemeral beings by essence, because their informational networks works really fast. Stadler says that “In an environment where information flows very quickly [...] [...] and the relations are born as fast as old connections die, time is a supreme factor. Apart from the fact that there is continuous change, nothing is fixed.”

That means, that within rhizome like systems, the information is flowing very fast and therefore new connections are being created all the time as well as old connections may disappear out of a sudden. However, the strongest connections, for example in our brains, on slime molds or even on the internet, are the ones that remain longer and that become essential for improving the performance of the entire system.

The internet, of course, is the most representative and important mycelial like system that we have in our digital dimension, and its branches are so deeply connected with our lives, that it can not be considered anymore an artificial system to share information, but an extension of our own bodies and minds to connect, share and create a super organism that not only includes millions of people around the planet but also all the rest of nature and of course machines.

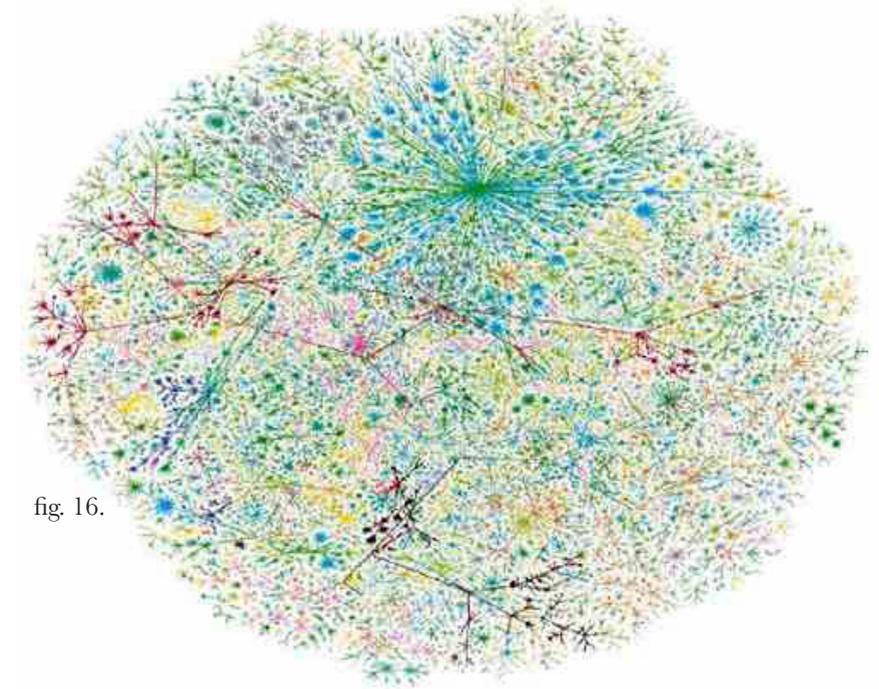


fig. 16.

It is well known how the internet works, at least in a basic way of talking, so its functioning is not to be told here. However, and once again, when we look at the image above the similarities with the mycelium, rhizome, neurons and space are undeniable. But the point here is not only to say how natural and archetypal this image is, but that this system is constantly growing and creating million of new connections between millions of things and therefore is allowing us to learn more and more things; a process that is always related with the level of consciousness.

So the more we understand about biological or natural rhizomes, the better artificial systems we can create and hopefully the better tools we can design to go back and connect with the natural ones.

#### 4.1 Artificial neuronal networks

We already saw that the fungal mycelium can be understood as the “*earth’s natural internet*”, also as the “*World Wood Web*” as some scientists call it, or simply as an underground network that connects many different multiplicities within an ecosystem.

I believe that the most important process that such systems are able to perform, is the information transfer or communication process. That means that if we think about the mycelium structure, the rhizome archetype, the internet, or the brain neuronal structure, we can easily see that the essential process that is occurring within those systems is the flowing or transferring of energy or information. That of course, have consequences in all the multiplicities connected to the system, and also in the structure of the system itself (its organization).

More interesting is how we are able to study natural systems and their processes to create our own versions of them, in our artificial dimensions. That not only let us understand them in better ways, but it also gives us tools to create in many senses.

Artificial neuronal networks are a relatively new way of coding that may be seen as another example of a mycelial-rhizome-like structure, that based and inspired in the biological-neuronal processes of the brain, is able to recreate its functioning. It reconfigures the way of coding through a programming method that functions and process information in a very similar way than the neuronal synapses. This method, brings with it the possibility for a machine to learn (machine learning) and therefore many possible applications in the contemporary world. In this text, however, the focus will be in the structure of the system itself compared to biology (fungi, and the brain) and in examples of artists using it to create very interesting pieces.

“Artificial neuronal networks (ANN’s) are relatively new computational tools that have found extensive utilization in solving many complex real-world problems. [...] [...] ANN’s may be defined as structures comprised of densely interconnected, adaptive, simple processing elements (called artificial neurons or nodes) that are capable of performing massively parallel computations for data processing and knowledge representation[...] [...] The main objective of ANN-based computing (neuro-computing) is to develop mathematical algorithms that will enable Ann’s to learn by mimicking information processing and knowledge acquisition in the human brain.”<sup>14</sup>

In other words, Ann’s are coding systems that work by interconnecting many different nodes (neurons) creating a possibility for the information to flow in many different “directions” at the same time. Just like the neurons in the brain, the mycelium or the rhizome. This form of organization, or structure, brings the possibility for ANN systems to process information in a non-linear way, (parallel), but more important, brings the possibility to the system to learn.

The ways Ann's work or function, are many. There are even many ways of building different types of Ann's depending on the different and specific tasks or problems one may want to solve. Also their structure layers, way of learning, inputs and outputs can vary depending on the type of ANN you may refer to. However, those things are not essential for the development of this text. More important here, is the fact that when you compare natural neural systems with artificial neuronal systems (ANN's) it is possible to find a lot of similarities in their functionality, structure and behavior, even though they don't work exactly in the same way.

Artificial neuronal networks are complex computational tools. For the purpose of this text, is not important to understand all their complexities and possibilities.

However, guided by the text *Artificial Neural Networks: A Tutorial*. Written by Anil K. Jain from the Michigan State University, I'll mention their basic characteristics and their connection with the brain structure, to finally see some examples of their usage in creative processes.

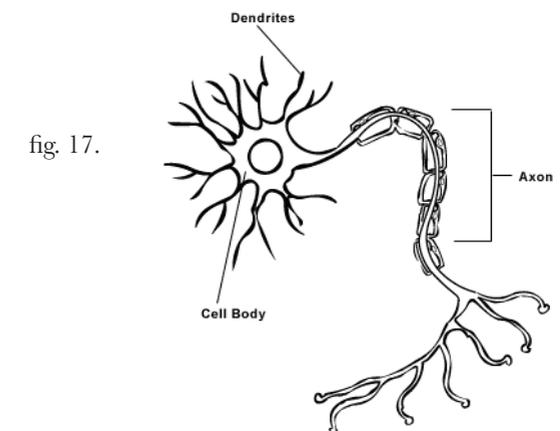
Ann's are special because their characteristics to process information. Here are the most important ones.

- Massive parallelism
- Distributed representation and computation
- Learning ability
- Generalization ability
- Adaptivity
- Inherent contextual information processing
- Fault tolerance
- Low energy consumption

Ann's are based on biological neuronal networks, and consist of a very big number of processors with many interconnections. "ANN models attempt to use some organizational principles believed to be used in the human brain."<sup>15</sup>

Continuing following K. Jain's text, we can see that the human nervous system is composed by many different types of neurons. They are the main element in the system and therefore, understanding their main characteristics is essential to understand the information processing in biological neural systems and also in artificial neuronal systems.

Let's simplify a neuron and see it as the conjunction of three essential parts: Dendrites, cell body, and axon See *Figure 17*. I like to understand them as input, processor and output.



An electric signal, coming from another neuron or an external stimuli, arrives at the dendrites (input) and goes directly to the cell body (processor). There, depending on the strength of such signal, a "door" may or may not open, for triggering a chemical reaction (neurotransmitter) that is released in a quantity proportional to the strength of the incoming signal, towards the axon (output) and the synaptic gap. There the information (signal) flows towards the dendrites (inputs) of other neurons, where the same process will be repeated.

The “door” is actually called the threshold, and is responsible for letting the information (signal) pass or not depending on the intensity of the signal itself. That intensity, depends on the synaptic strength, and the threshold of the previous cell body. “Because a neuron has a large number of dendrites/ synapses, it can receive and transfer many signals simultaneously. These signals may either assist (excite) or inhibit the firing of the neuron.”<sup>16</sup>

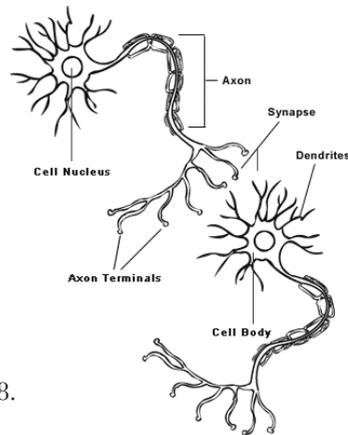


fig. 18.

Although the intention of this work is to clarify this process, its complex dimensions will not be considered here for the sake of the main idea of the thesis. However, this basic sketch may be enough to get a basic knowledge to understand the similarities between biological and artificial neurons.

An artificial neuron basically works in the same way as the organic one. It all starts with an input, that may be an external stimuli or the incoming signal from another artificial neuron. This signal is a number, that vary in its strength (+ or -) depending on the threshold of the last neuron, and the synaptic strength (weight) or connection with the next. Then is processed (let pass or not) by the threshold (cell body) of the artificial neuron triggering a new signal towards the output. In *Figure 19* we can see an example;

The one on the right side is the artificial neuron and the one in the left represents the biological neuron with its connection to another one.

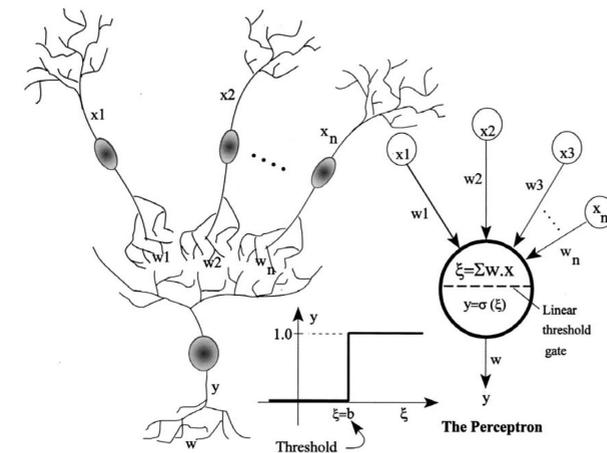


fig. 19.

Now following I.A. Basheera and M. Hajmeer text, it is possible to say that when we speak about an artificial neuron, we can understand the connections between different neurons as the axons and dendrites. The connection weights would be then the synapses, and the threshold would be the activity in the body cell.

Both, Artificial and organic neurons, learn by incrementally adjusting the weights or synapses forces. They also work all the time in a cycle were they receive “inputs as stimuli from the environment, combines them in a special way to form a ‘net input’, passes that over through a linear threshold gate, and transmits the output signal forward to another neuron or the environment”<sup>17</sup>

Ann’s are the prove that is possible to translate biological processes into the development of technology which work in a similar way, allowing us to create very interesting machines, that not only are useful for commercial or artistic goals, but also that may help us understand and connect with nature itself.

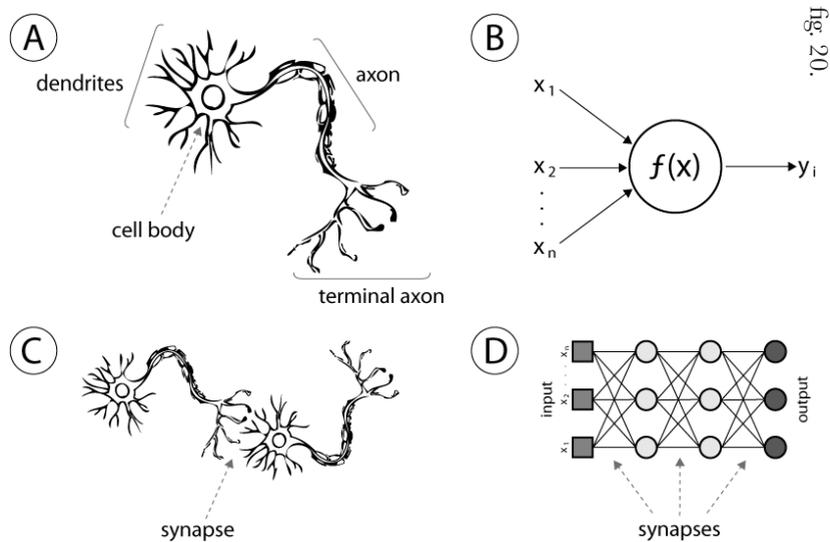


fig. 20.

In summary, the fact that is possible to design, inspired in the biological and neuronal system in the human brain, a computational tool that is able to learn by itself, and to be compared or called an artificial intelligence, is just another prove that the mycelial-fungal archetype of nature is deeply connected with processes of consciousness such as learning or information transfer.

Furthermore, by creating ANN's we are actually getting closer to understand the functioning of biological neural networks; The more we understand about biological neural systems, the best artificial neural networks we design. And the more we understand ANN's the best possibilities we have to understand biological neural systems.

The last is not only something happening in computational system theories, but also in many fields of the human knowledge. The more we connect with nature and the more we understand it, the better technology and artistic projects we are able to create. This is because, as we do the learning process, we understand better the interconnection between all the things living in the biological and the "artificial" environment.

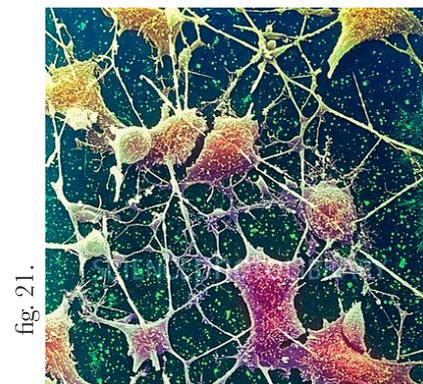


fig. 21.

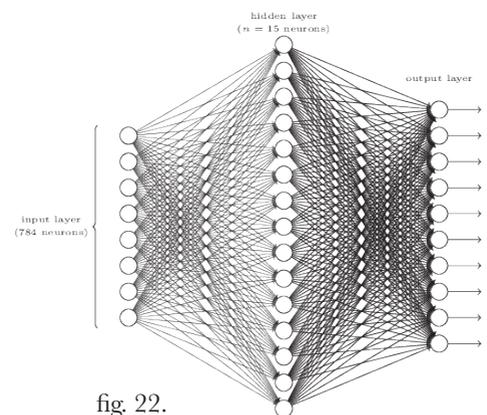


fig. 22.

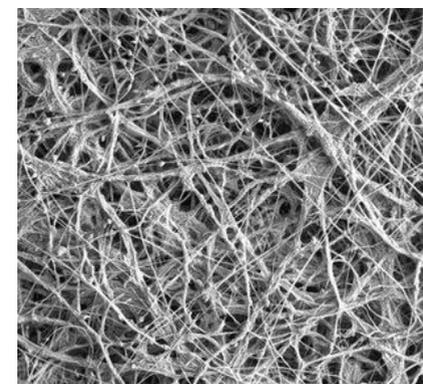
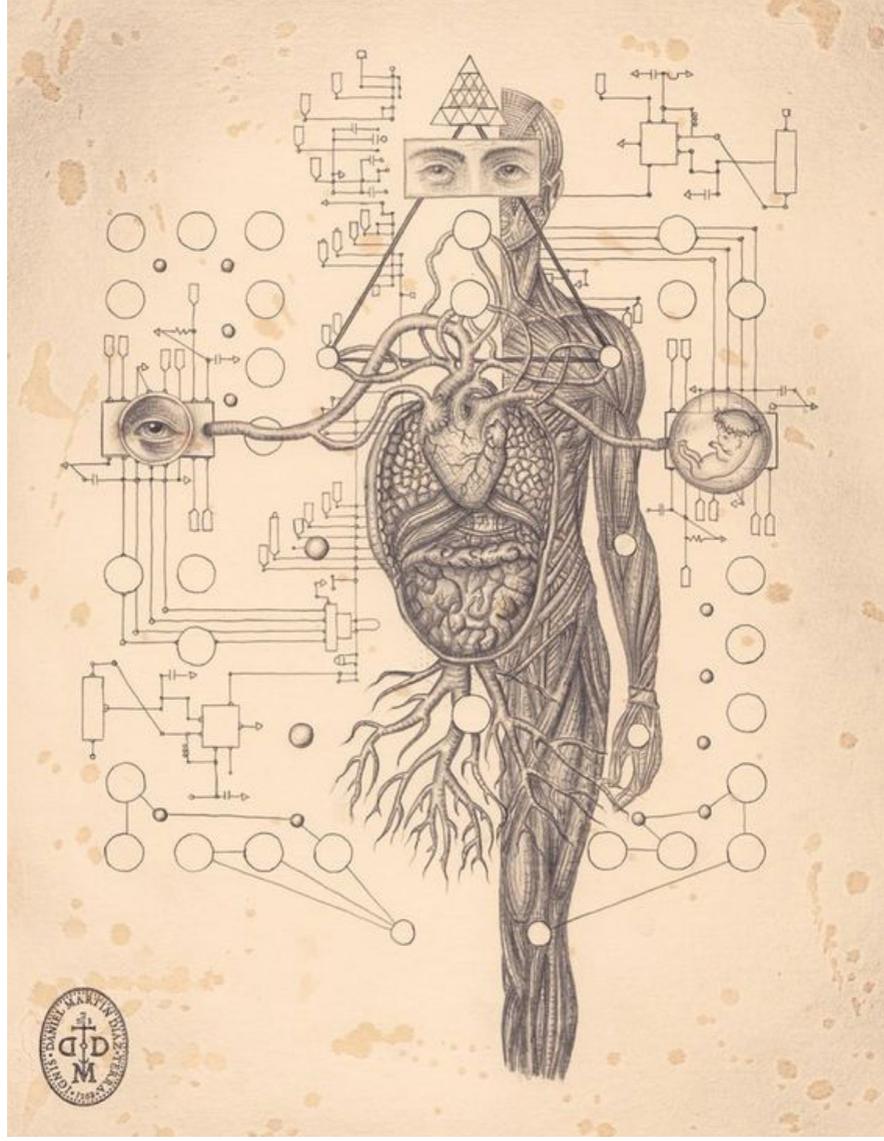


fig. 23.

5//

# essentially cyborgs



We have seen how the study of nature can guide and inspire us to create new technologies such as ANN's. Also how certain system archetypes are findable in many important processes of nature and technology. Those processes, are actually possible to find in many different aspects of the existence, including one of the most important ones; Arts.

Blaise Aguera y Arcas, leader of the Google's Machine Intelligence Group in Seattle, in his text *Art in the Age of Machine Intelligence* says: "Art has always existed in a complex, symbiotic and continually evolving relationship with the technological capabilities of a culture"<sup>18</sup>

That is nothing more than a natural cycle of information flow; an inter-connection between different dimensions that affect themselves deeply while they grow, change and create new possibilities for the information to flow and mutate.

Next, I'll show some examples of how strong this relationship between technology, arts and nature can be, focusing in the creation of projects that includes ANN's in their functioning. However, before that, I think is important to understand our connection with technology.

Let's think about nature as the endless resource of information, as the ground for learning everything we know about this universe, as the main inspiration for science to develop all kind of theories in its search for putting together all the pieces of the cosmos puzzle. Let's think about it also as the essence and the inspiration for developing all kind of technologies that transform the way we interact and see the world.

In the text *Art in the Age of Machine Intelligence* the author give us a quote from the book *The Cyborg Experiments: The Extensions of the Body in the Media Age* by Joanna Zylincka that follows: "We've always been augmented by our instruments, our technologies. Technology is what constructs our humanity; the trajectory of technology is what has propelled human developments. I've never seen the body as purely biological[...]"<sup>19</sup>

Aguera y Arcas continues saying that we are "hybrid beings" that doesn't necessarily use technology as some external tool, but instead technology is an inherent part of many processes we perform in our lives, including art in a top position on the list. He quotes the philosopher Vilém Flusser who thought about technology as "extensions of the human organs". "Preindustrial tools, like paintbrushes or pickaxes, extend the biomechanics of the human body, while more sophisticated machines extend prosthetically into the realms of information and thought. Hence, "All apparatuses (not just computers) are [...] 'artificial intelligences', the camera included [...]"<sup>20</sup>

Those technologies then, are not only tools for us to achieve certain tasks in the everyday live, they are a natural extensions of the body, they are an inherent part of our nature, and they are constantly changing the way we perceive the world by being extensions of the senses; improving seeing, hearing and feeling, and being therefore excellent tools for improving our performance in the world.

But more important is the fact that they are capable of changing the way we think because of their symbiotic and political relationship with art. That relationship allows and expands the landscapes for artistic exploration, creating an excellent platform to combine many different fields and practices.

Therefore, when technologies are embedded in our everyday life, and used for artistic purposes, they bring potential processes of healing, criticizing, breaking, innovating and creating all kind of transgression-like practices, that at the end, allow culture to be aware of itself and its failures.

In other words, we first look at nature to unravel its inherent codes, then we translate those codes into the development of our technologies, and because of the symbiotic relationship of art with them, artists are then able to use those technologies as hacked mirrors to show humanity how it behaves in relation with the environment.

But on the bottom of that, the most important thing is that there is a special relationship between us: nature, art and technology; a relationship that functions exactly as the mushroom mycelium does, connecting many different multiplicities and permitting the flow of information in every direction of the system, creating mutualistic relationships between different elements or dimensions within the system for the sake of them all.

“Seeing ourselves as always already connected, as being part of the system[...]rather than as masters of the universe to which all beings are inferior[...]is an important step to developing a more critical and a more responsible relationship to the world, to what we call “man,” “nature,” and “technology.”<sup>21</sup>

Thinking like that is thinking in a way where technology, art and nature can work together in a collaborative way, where all the parts are able to give and receive something from the others, connected by a natural, mutualistic and rhizome-mycelial web that permits the flow of information between different systems.

So, if the “Technological capabilities of a culture” are always in symbiosis with art practices, and if those technologies are inspired and connected with the natural world but are also extensions of our own bodies, that means we are cyborgs who are able to live in between what we see as different realms ( machine - nature ) creating a constant flow of information between us and them. Just like mushrooms, who are not animals and not plants, but something in between, with breathing capabilities, animal like skin structure, awareness of other animals and plants in the space, and more important, with the power to create mutualistic relationships between the two of them. Just like the slime mold, that uncategorizable alien which is always in the middle of the most well known kingdoms.

Ann’s then, are a natural based technology, a transcoding of the natural code into the artificial machine, an approximation from technology not analogous only to the eye, or other senses, but to the brain and its functionality. They are little consciousness in a very archaic state, living

in between different realms, and creating connections between them. That’s why they are an important tool for us to learn more about our own brains, artificial systems, nature, technology and at the end, for giving us new ways of creating the questions we need to ask ourselves constantly to see our mirrored image in relationship with our environment.

6//

# natural flows in new media arts



In this last chapter the idea is to examine different artists and projects that use the mycelial system within its concept, design or functioning for the creation of new media art pieces.

As we have seen, this mycelial, or rhizome like systems, are happening in many dimensions or levels of the existence: the fungi kingdom, our brain, the internet, ANN's etc... The point here then, will be to show how can artists use different possibilities of rhizome-like systems in the creation of projects that can help us understand the importance of the concept of connection, and therefore expanding the boundaries between our categorizations of things.

Those projects, and the experience of connection itself, are nothing more than natural flows of energy following what nature has proven to be an efficient system: One that unites elements all across the universe to permit better channels of information and therefore to create an endlessly growing super network that constructs something we may call a super consciousness.

“The new media are not bridges between man and nature, they are nature.”<sup>22</sup>

## 6.1: Relational art and the Fluxus laboratory

The structure and processes of the mycelial system have been consciously or unconsciously, imitated or translated into art practices and media information theories. Relational art will serve here as a first example of it. Maybe is not to be considered part of the new media arts, but I think is important to start with them since their connection with the processes I'm discussing here is very big and the repercussions for the art world where extremely important.



fig. 26.

Relational art is a term that was widely developed by the author Nicolas Bourriaud in the book *Relational Aesthetics*. He has defined it as “a set of artistic practices which take as their theoretical and practical point of departure the whole of human relations and their social context, rather than an independent and private space.”<sup>23</sup>

Relational art was focusing in working towards a relationship of the spectator with the artwork in a two way communication or interaction. That is opposed to the one way directional relation, that was focused in the object itself in the modernist tradition. According to Bourriaud “Social “formation” has taken precedence over aesthetic ‘form’.”<sup>24</sup>

Piero Gilardi, a pioneer artist that has played important roles in many art movements, like Arte Povera, conceptual art, land art and even bio art, was “among the first to define a ‘relational’ aspect of art, namely the tendency to regard the integration of the views as the core focus of the work.”<sup>25</sup>

In an interview made by Emanuele Quinz, the interviewer asks the artist to define what relational art is. Gilardi answers “[...] is the expressive symptom of a cultural mutation of historical proportions that changed the very nature of artistic practice.”<sup>26</sup> He argues then, that the ratifications of Bourriaud in relational aesthetics, however useful, are limited because he didn’t take into account “the versatility of relational art as intrinsically transcultural.”<sup>27</sup> Than means, he continues, Bourriaud’s approach lacks the interlinkedness with other cultural practices. Finally, Gilardi argues that relational art cannot be observed and investigated from the limited point of view of aesthetics, but from a “wider field of vision of cultural anthropology”<sup>28</sup>

Following Gilardi’s thoughts, the essential ground of relational art is the relationality between the spectator and the work itself, but furthermore important is its relationship with other social or cultural practices. Because of that, what is on the table when we speak about relational art, is the dimension of interconnectivity; a dimension that as we saw before, is an essential part of the mycological rhizome structure.

As a note: If the Deleuzian *principle of connection* goes trough philosophy, astronomy, neuroscience, arts, information and I would dare to say, every field of knowledge, then why contemporary art practices are not paying more attention to the natural sciences which have been working since ever with living relationships?

This idea of interconnectivity is very common nowadays because our dependence and expertise in the functioning of the internet. However It wasn’t always that obvious. The fact that relational art created a different way of relationship between the artwork, the spectator and the world, was something considered paradigm shifting. Craig Saper in his text *Fluxus as a laboratory* published by the MIT’s press in the book *Information*, concentrates his efforts in the Fluxus research methodologies called “networked ideas”. A part of the Fluxus history that received less attention.

Saper argues that Fluxus works highlighted socio-poetic interaction and encourage epistemological experimentation among participant-users, and that Fluxus works where playing against the idea of art following modernist rules of form. In addition, one of the most interesting behaviors or processes that Saper underlines, is the way Fluxus work as a social networks organizer, creating two way communication channels from sender to receiver, and moving towards an anti aesthetic art that was valuable for the idea itself an its inclusion in society. With that inclusion comes the process of transferring ideas by interacting with the multiple possibilities of performing them.

Fluxus was also directing efforts to dislocate the idea of the author-artists as an illuminated genius by offering, instead of truths to be swallowed, works that became “models for alternative forms of social organization”.<sup>29</sup>

“Fluxus Flux Art: Non art- amusement forgoes distinction between art and non-art forgoes artists indispensability, exclusiveness, individuality, ambition, forgoes all pretension towards a significance variety, inspiration, skill, complexity, profundity, greatness, institutional and commodity value. It strives for non structural, non theatrical, non baroque, impersonal qualities of a simple, natural event, an object, a game, a puzzle, or a gag. It is a fusion of Spike Jones, gags, games, Vaudeville, Cage and Duchamp.”<sup>30</sup>

Many of the fluxus works were created by a number of participants instead of the unique and illuminated artist. Saper continues in his text about the fluxus laboratory, explaining the idea of many individual contributions as something way more interesting than any of the parts by itself. Those are multiplicities connecting themselves to create more, and more complex multiplicities, that then are going to mix with others in a process that will flow endlessly, exactly as the *multiplicity* principle of the rhizome. Furthermore, this action of blending the figure of the artist into a “virtual community networked through with hypermedia links and relays.”<sup>31</sup> is transforming the whole work into an *heterogeneity* of variety.

Like the fungus that cleans up the ecosystem around itself by making use of its potentiality for communication, Fluxus and the Fluxus laboratory, sought to clean the art world from the ego disease by creating a decentralized system that works and grows based on people that influence other people via the creation of links or hyperlinks.

I have chosen not to talk about any specific artwork, or artist from the relational art or Fluxus movements because what I want to emphasize here is the structure of how they worked, the form, the processes and concepts they were dealing with; processes or ideas that were actually the most important part of the works themselves because of the waves they were able to generate in the social context.

The idea of the author was supposed to be erased or replaced for the idea of community, of connection, of working together towards exploiting all the possibilities from any single idea, and celebrating diversity instead of increasing the artist's ego. It all was a movement of ecology, of consciousness, of understanding the importance of interconnection in nature to bring those codes into the social and artistic environment.

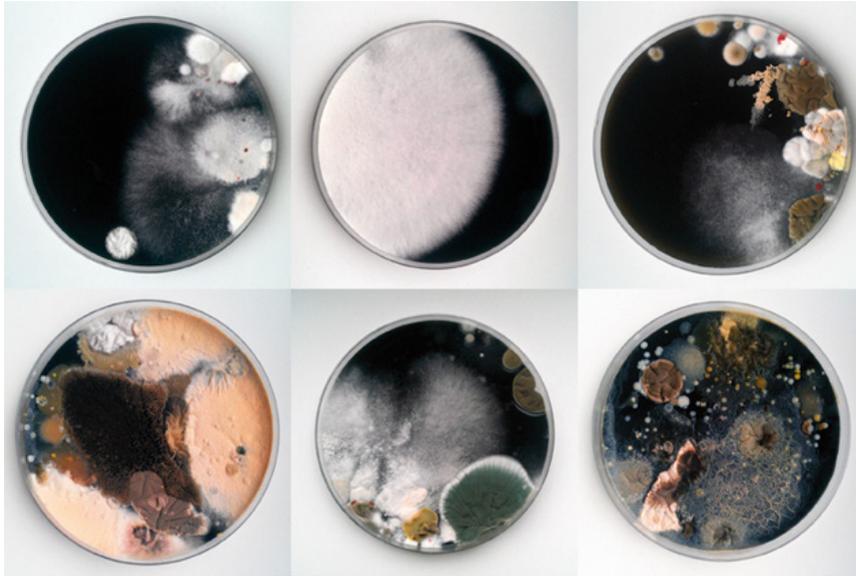
Another important point here, is the interest of some of the Fluxus artists, like John Cage or Joseph Beuys, in the world of fungi and shamanism. As we know that Cage was a good mycologist and that he developed a big part of its conceptual structures based on the experiences and knowledge that the fungi kingdom gave to him.

Fluxus were actually working as the mushroom mycelium, building channels of information in every direction, connecting all kind of nodes to create bigger and bigger clusters of heterogeneity, they were trying to cure the social ecosystem by creating new flows of the energy that resides within it, just exactly as mushrooms do.

In the text *Theatrum Fungorum: John Cage's mythology and photomechanical reproduction*, by Mara Mills, is possible to find very interesting stories and approaches of Cage's relationship and inspiration on the fungi world.

## 6.2: Saša Spačal

fig. 27.



In a more contemporary environment, we can find the Slovenian artist Saša Spačal mixing biology and technology for the creation of installations that reflect on the principles of interspecies communication and multiple biological connections of beings in order to create a whole, bigger organism.

“Saša Spačal (1978) is a media artist with background in humanities, currently working at the intersection of living systems research and media art. The focus of her work is the post-human environment where human beings exist and act as one of the elements in the ecosystem and not as sovereigns. It’s about abandoning the Cartesian system and accepting the fact that technology not only expanded from hardware to software but also to wetware and consequently hybrid phenomena of mechanical, digital and organic logic.”<sup>32</sup>

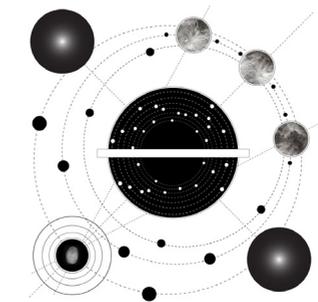
Spačal’s view of technology and biology erase the boundary created between what’s natural and what’s artificial since she “sees both as living systems which humans are party to, but no sovereign over.”<sup>33</sup>

An important point when reviewing her installations, is the viewer: many of her works are high dependent on the viewer, for example by being activated using biorhythms, touch and people’s behavior in the space. Furthermore, her usage of sound is also a key factor that works deeply connected with her collaborations with the Theremidi Orchestra: “a community that holds workshops dedicated to creating experimental interfaces to generate sound.”<sup>34</sup>

*Mycophone\_unison* (2013), is a very interesting piece that Spačal developed in collaboration with Mirjan Švigelj and Anil Podgornik, where they were reflecting on the human being as a “plurality of live”, as an organization of biomes, of multiple microorganisms that functioning together create a whole, complex being. “The works interface includes living microbes from Spačal and her two collaborators, set on Petri dishes and linked by electrodes. Signals sent to the installation translate variation between the samples into pitch alteration. Over time, the quality of sound changes as the samples develop, reflecting the cooperative but ever changing composition of all the life that makes us.”<sup>35</sup>



fig. 28.



On the other hand, *Myconnect* (2013), is a piece that works as an interspecies connector between the human being and the mushroom mycelium. It is trying to create some kind of communication between both, aiming to erase the limits science draws on our understanding of kingdoms.

fig. 29.



In the installation a person gets inside a chamber that reads its heartbeat and amplify it. That sound is constantly affected by the living mycelium that is actually living inside the mentioned chamber. “Specifically, natural chemical reactions of the fungi are read, and this data are used to modulate the human heartbeat amplification, which in turn subtly affect the human nervous system and heart rate”<sup>36</sup> The result of the piece is a feedback loop where both, human and fungal organisms are affecting each other and therefore the sound output of the installation. This is a symbiosis-like relationship that’s being created by the artist in order to build a flow of information between organisms that are considered by science as belonging to very different dimensions.

In short, what this artist is doing, is pointing the complex interdependencies that can exist between biology and technology, and by doing so, she reflects on the universal net that’s able to connect every single element of this world into a bigger and complex multiplicity of multiplicities.

As it was written before, there are many ways of seeing and understanding the natural principle of interconnection. There are also many ways of “hacking its code” to then use it in the creation of projects. What we see on Spačal’s work, is an approach to the natural archetype where the symbiosis between machine and organism creates the possibility for the development of systems where elements that apparently are not connectible are then able to come together and form a bio-machine organism. She actually believes that the six kingdoms that biology has taught us, are not enough since she sees the existence of a seventh one; a kingdom of technologies where ideas, tools and human social organizations are being a real part of nature.

### 6.3: Synthetic poetry

We have seen that artificial neuronal networks are based on the functioning of the human brain neurons to create a coding system that is able to learn and perform complex computing processes. But can they actually be creative?

Jack Hopkins from the University of Cambridge together with the Facebook AI researcher Douwe Kiela, created a project called *Automatically Generating Rhythmic Verse with Neural Networks*. They looked at the already made research about the automatic generation of rhythmic poetry, and come up with two new methodologies for creating poetry in a variety of forms:

“The first approach uses a neural language model trained on a phonetic encoding to learn an implicit representation of both the *form and content* of English poetry. This model can effectively learn common poetic devices such as rhyme, rhythm and alliteration. The second one considers poetry generation as a constraint satisfaction problem where a generative neural language model is tasked with learning a representation of content, and a discriminative weighted finite state machine constrains it on the basis of form. By manipulating the constraints of the latter model, we can generate coherent poetry with arbitrary forms and themes.”<sup>37</sup>

The neuronal network was trained with thousands of Online poems, than together with the second approach mentioned before, gave the possibility for the system to be tunable, or in other words, to be programmable to write in a specific rhythm or even write poems on selected topics.

This one for example was written under the theme of desolation:

*The frozen waters that are dead are now  
black as the rain to freeze a boundless sky,  
and frozen ode of our terrors with  
the grisly lady shall be free to cry*

“The AI can be endlessly tweaked to produce different flavours of poetry. It could write about Brexit in the style of a Greek epic, or rewrite snippets of Romeo and Juliet while mimicking Eminem, Hopkins says.”<sup>38</sup>

The neural network is able to write about any topic using only words that are related with the chosen theme or concept working for an outcome that can be written in specific poetry styles and rhythms. Despite its amazing abilities, it has been criticized under the idea that the restraints used for creating the rules, that actually help it to perform the mentioned processes, make the network a slave of them and therefore a truly creative outcome can never be reached.

But despite the criticism around its potential for creativity, when the generated poetry was evaluated in a big scale by human participants, the result was that they considered the machine generated poems to be human 54% of the times. Also they considered the “artificial” poems to be the most human-like, the most emotive and the most aesthetic among all of the evaluated.

Here are some examples (coming from the original paper of the authors) of the computer generated poems together with human written ones:

(a)

*The crow crooked on more beautiful and free,  
He journeyed off into the quarter sea.  
his radiant ribs girdled empty and very least  
beautiful as dignified to see.*

(b)

*Is that people like things (are the way we to figure it out)  
and I thought of you reading and then is your show or you  
know we will finish along will you play.*

(c)

*Man with the broken blood blue glass and gold.  
Cheap chatter chants to be a lover do.*

(d)

*How dreary to be somebody,  
How public like a frog  
To tell one's name the livelong day To an  
admiring bog.*

(e)

*The son still streams and strength and spirit.  
The ridden souls of which the fills of.*

Can you tell which of them have been created by a computer and which by a human ?

Only (d) was actually written by a human being. However, it fooled halve of the questioned participants.

This project is an excellent example of what an artificial neuronal network can do when its programed with a creative intention. Its also good for seeing how an electronic system, build, coded and inspired on the natural functioning on the brain, is able to create an artistic output that maybe one day can teach us something back.

## 6.4: Plantas Nómadas

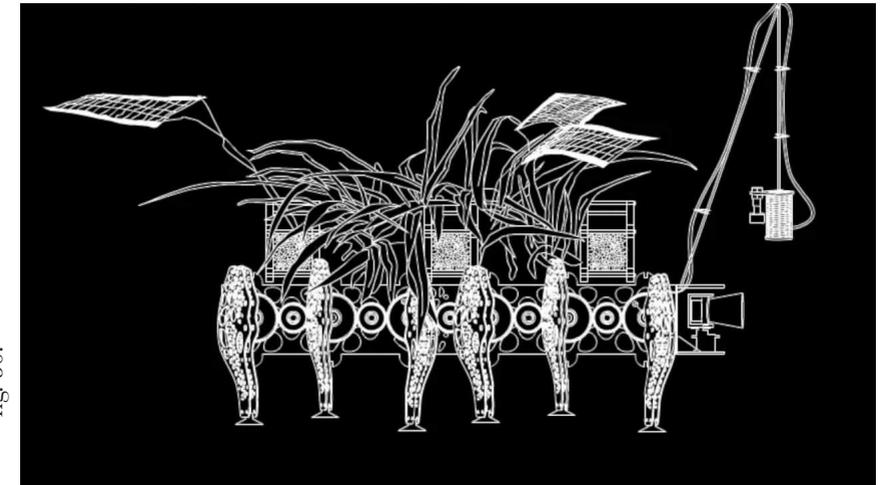


fig. 30.

We have seen the archetype of systems operating on many different layers. Also working on some art works or movements as a modulator of the processes made by the artists or even as a philosophical concept that can influence our levels of consciousness.

In *Plantas Nómadas*, from the Mexican artist Gilberto Esparza, is possible to see the mycelial archetype operating in a non literal way, but in a way that's based on creating real connections between technology and the natural world for the creation of new hybrid organisms.

Gilberto Esparza, visual artist from the Visual Arts School of the University of Guanajuato and Fine Arts School of the Polytechnic University in Valencia, has dedicated his live to working with electronic media, seeing it as a powerful source for creating disruptions when introduced in the every day life of the urban ecosystem, recycling the leftovers from a technological consumption society, and more important, developing possibilities for the conception and creation of hybrid organisms, that not only live in a beautiful symbiosis between different natural kingdoms

and machines, but also organisms that help healing the environment at the same time that are prototypes for new ecological technologies to emerge.

His work *Plantas Nómadas* is an excellent example of an heterogeneity of multiplicities, or in other words, a big organism or whole, composed by many organisms from different kingdoms, forming an entity that's seeking to connect with its natural environment in a symbiosis-like process where every part can give and get the best out of the others.



fig. 31.

*Plantas Nómadas* is a project that aims to reflect on the environmental impacts of the human activity. Its is trying to engage with the fight against the contamination of the water, against the resistance to an energetic transition, against the overconsumption of natural resources, and in short, is trying to point at the lack of consciousness that rules human behaviors and thoughts, when it comes to find a way of life that connects with empathy to nature. It is also seeking to use technology for the development of projects which can help to the transformations that our planet requires.

As Reynaldo Thompson and Juan A. Mejia, PH. D's from the university of Guanajuato say in their essay *Toward a new symbiosis. Planta nomada / simbiosis energética*: "*Plantas Nómadas* is a hybrid species, made up of diverse organisms that coexist in symbiosis to survive in contaminated environments.[...][...] The Nomad Plant is a living organism, consisting of a robotic system, an organic plant species and a set of microbial and photovoltaic fuel cells.[...][...] It has the potential to restore on a small scale the damage of the environment. To survive, this organism takes contaminated water and processes it in its fuel cells through a colony of bacteria native to these waters, which feed by transforming the nutrients into electricity which is then stored by their energy harvesting system. In this process of biodegradation it improves water quality and gives it to the plant species that also produces electricity with its metabolism..."<sup>39</sup>

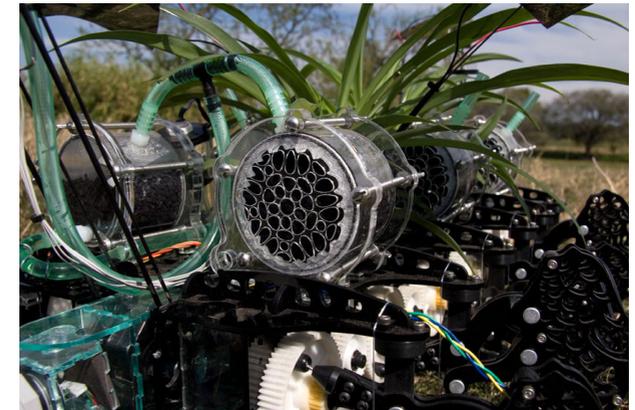


fig. 32.

In other words, *Plantas Nomadas*, is a robot that can navigate trough and infected ecosystem, drink polluted water and create the energy it needs to move out of a metabolic process perform by its bacteria to then, with the clean water, feed its plants who can also produce energy for the entire system. It can also make some cricket-like sounds with the remanent energy.

What is possible to see in this project is a rhizome network connecting elements from different essences in order to create a new ecosystem where the symbiosis between technology, nature, science, art and culture is created by making them work together for their mutual benefit.

Following again Thompson and Mejia's text, and referring to a quotation they bring from Nietzsche in the *Apollonian and Dionysian Concepts in the Birth of Tragedy*, "Man is no longer an artist, he has become a work of art; man himself now moves with the same ecstasy and sublimity with which, in dream, he once saw the gods talk" and in this case we may say that it is not man who became a work of art but a fusion of nature and machine creating new organisms."<sup>40</sup>

*Plantas Nomadas* is then an organism living in between worlds, or connecting those worlds if you will, reminding us that the intersections between disciplines, kingdoms and technologies are a good way to look in order to create extensions from the separated elements of the systems, which by themselves, are not as strong as they are when working together.



# CONCLUSION

This investigation is just another example of how connected are things in the universe. By focusing and studying just a small part of nature, the fungi kingdom, it was possible to find a structure that was chosen by nature to permit massive energy flows within hyper connected networks. A structure that not only operates in the mushroom mycelium, but one that because its special qualities and properties, is possible to find in all the spectrum of existence.

This structure has been related in this text with the idea of the rhizome: A system of relationships between multiplicities that was introduced by Gilles Deleuze and Felix Guattari in the book *A thousand Plateaus*.

By comparing the Deleuzian philosophic idea of the rhizome with the natural network of the mycelium, it was possible to sketch a set of characteristics to understand structures of the same kind and find them operating in many different levels of life. The main shared qualities from those architectures where the principles of connection, heterogeneity and multiplicity. Principles which were very helpful to identify other rhizome-like systems occurring in different layers of existence. For example the brain, energy flows in the outer space, ecosystems, the internet, artificial neuronal networks and art projects, which were working in the convergence point between the natural and the technological.

The similarities between the mushroom mycelium and the Deleuzian Rhizome, plus the discovery of the same architecture flowing across the elements mentioned before, were very useful to define the idea of such a structure as the archetype of the system, or in other words, as the idealized and perfect example of a natural connection device.

By seeing this system working on very different multiplicities, and by seeing also how they were able to create symbiosis-like connections with beings from other “kingdoms”, like the mushroom mycelium with the plant roots, or the internet system with the human being, the idea of connection as a boundary dissolving concept was brought into this text and connected, on the first hand with the idea of consciousness, and on the other, with the idea of arts as a facilitator and exemplar field to experiment and connect all fields together.

Following that train of thoughts, the one of interconnection for the mutual benefit of the parts, technology was understood as a natural tool of the human being, and the new media arts as extensions of our body. An extension that's possible to use towards the understanding of the whole through its intricate but simple system of interconnections.



# endnotes

- 1 Stamets, Paul. *Mycelium running: How mushrooms can help save the world*. New York: Ten Speed Press; First edition, 2005.
- 2 Build Abroad. Travel and architecture blog. Available from: <https://www.buildabroad.org/2016/10/12/mycelium/>
- 3 Mycelium. Merriam-Webster.com. 2017. <https://www.merriam-webster.com/dictionary/mycelium>
- 4 Claire L Evans. *Living in a mycelial world*. Science Blogs. 2011. Available at <http://scienceblogs.com/universe/2011/07/17/living-in-a-mycelial-world/>
- 5 Deleuze, Gilles. Guattari, Felix. *A thousand plateaus: Capitalism and schizophrenia*. LONDON. University of Minnesota Press. 1989.
- 6 Ibid. Deleuze
- 7 Stamets, Paul. *Mycelium running: How mushrooms can help save the world*. New York: Ten Speed Press; First edition, 2005.
- 8 Ibid. Stamets.
- 9 Slime mold. wikipedia.org. [wikipediahttps://en.wikipedia.org/wiki/Slime\\_mold](https://en.wikipedia.org/wiki/Slime_mold)
- 10 Jabr, Ferris. *How Brainless Slime Molds Redefine Intelligence*. Scientific American. International weekly journal of science (2012) Accessed August 10, 2017. Available from: <https://www.scientificamerican.com/article/brainless-slime-molds/>
- 11 Ibid. Ferris
- 12 Stalder, Felix. *Information from the series of Documents in contemporary arts*. Edited by Sarah Cook. (London): Whitechapel Gallery and The MIT Press, 2016.
- 13 Ibid. Stalder
- 14 I.A. Basheera, M. Hajmeerb. *Artificial neural networks: fundamentals*,

computing, design, and application. *Journal of Microbiological Methods*. (2000) Accessed June 20/2017. Available from: <https://pdfs.semanticscholar.org/fc40/ad1238fba787dd8a58a7aed57a8d020a6fdc.pdf>

15 Anil K. Jain. *Artificial Neural Networks: A Tutorial*. Michigan State University, 1996 Available from: [http://www.cogsci.ucsd.edu/~ajyu/Teaching/Cogs202\\_sp12/Readings/jain\\_ann96.pdf](http://www.cogsci.ucsd.edu/~ajyu/Teaching/Cogs202_sp12/Readings/jain_ann96.pdf)

16 I.A. Basheera, M. Hajmeer. *Artificial neural networks: fundamentals, computing, design, and application*. *Journal of Microbiological Methods*. (2000) Accessed June 20/2017. Available from: <https://pdfs.semanticscholar.org/fc40/ad1238fba787dd8a58a7aed57a8d020a6fdc.pdf>

17 Ibid. Basheera

18 Aguera y Arcas, Blaise. Art in the Age of Machine Intelligence. Medium. (2016) Available from: <https://medium.com/artists-and-machine-intelligence/what-is-ami-ccd936394a83>

19 Ibid. Aguera y Arcas

20 Ibid. Aguera y Arcas

21 Ibid. Aguera y Arcas

22 McLuhan, Marshal. *Information from the series of Documents in contemporary arts*. Edited by Sarah Cook. (London): Whitechapel Gallery and The MIT Press, 2016.

23 Bourriaud, Nicolas. *Relational Aesthetics*. Les Presse Du Reel, 1998

24 Ibid. Bourriaud

25 *Practicable - From participation to interaction in contemporary Art*, Edited by Samuel Bianchini and Erik Verhagen. London: MIT Press 2016

26 Ibid.

27 Ibid.

28 Ibid.

29 Saper, Craig. *Information from the series of Documents in contemporary arts*. Edited by Sarah Cook. (London): Whitechapel Gallery and The MIT Press, 2016.

30 Ibid.

31 Ibid

32 Artist Online portfolio. <http://www.agapea.si/en/>

33 Myers, William. *Bio Art - Altered Realities*. London: Thames and Hudson, 2015.

34 Ibid

35 Ibid

36 Myers, William. *Bio Art - Altered Realities*. London: Thames and Hudson, 2015.

37 Hopkins, J., & Kiela, D. (2017). *Automatically Generating Rhythmic Verse with Neural Networks*. In Proceedings of the 55th Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)

38 Reynolds, Matt. *Neural network poetry is so bad we think it's written by humans*. New Scientist, 2017. Available from. <https://www.newscientist.com/article/2140014-neural-network-poetry-is-so-bad-we-think-its-written-by-humans/>

39 Thompson, Reynaldo. Mejia, Juan. *Planta Nomada / simbiosis energética*. Artist Blog. 2010 Guanajuato <http://www.plantasnomadas.com/#>

40 Ibid. Thompson



# figures

Figure 1 illustration of mushrooms

Figure 2 Mycelium growing on a trunk

Figure 3 Detail of the mushroom mycelium

Figure 4 Sky image of the biggest organism in the world: Honey Mushroom

Figure 5 Detail of Oregon's honey mushrooms

Figure 6 Chain Mycelium of a Cordyceps mushroom

Figure 7 Image from The Book of Trees: Visualizing Branches of Knowledge

Figure 8 Cartography art/map art and representation of the rhizome

Figure 9 Mycorrhizal fungi system in polyculture

Figure 10 Representation of interconnection by sacred geometry

Figure 11 Human brain cortex neurons with network of interconnecting dendrites

Figure 12 Gamma ray image from NASA's Fermi Gamma-Ray Space Telescope

Figure 13 Slime mold

Figure 14 Visual output of the slime mold Tokyo Railway experiment

Figure 15 Representation of interconnections between slime molds

Figure 16 Representation of the internet connections

Figure 17 Basic representation of a neuron

Figure 18 Graphic representation of synapses

Figure 19 Difference between organic neuron and digital neuron

Figure 20 Representation of organic and digital synapses: a) organic neuron b) digital neuron c) organic synapses d) digital synapses

Figure 21 Nerve cells

Figure 22 Three-layer neural network

Figure 23 Mycelium Insulation

Figure 24 Illustration from Daniel Martin Diaz

Figure 25 Saša Spačal, from the work: Myconnect. Mycelium and electric cables.

Figure 26 Joseph Beuys chalk board

Figure 27 Saša Spačal, Mirjan Švagelj & Anil Podgornik, from the work Mycophone Unison. Petri dishes with microbe.

Figure 28 Saša Spačal, Mirjan Švagelj & Anil Podgornik, Mycophone Unison from the work Mycophone Unison. Details of the installation.

Figure 29 Saša Spačal, from the work: Myconnect. Image of the installation.

Figure 30 Gilberto Esparza. Sketch for the construction of Plantas Nómadas.

Figure 31 Gilberto Esparza. Plantas Nómadas drinking water in a natural environment.

Figure 32 Gilberto Esparza. Plantas Nómadas. Detail of the full cell.



# bibliography

Youngblood, Gene. *Expanded Cinema*. New York: P. Dutton & Co., Inc., 1970

Mills, Mara. *Theatrum Fungorum: John Cage's Mycology and Photomechanical Reproduction, Variantology 1*. ed. Siegfried Zielinski and Silvia Wagnermaier. Köln: Walther König, 2005.

Stamets, Paul. *Mycelium running: How mushrooms can help save the world*. New York: Ten Speed Press; First edition, 2005.

Arora, David. *Mushrooms demystified*. New York: Ten Speed Press; 2 edition, 1986.

Eliade, Mircea. *Shamanism: Archaic techniques of ecstasy*. Princeton: Princeton University Press; New Ed edition, 2004.

Harner, Michael. *The way of the shaman*. New York: Harper & Row, 1980.

Mckenna, Terence. *Food of the gods*. New York: Bantam Books, 1992.

*Moving image - from the series of documents in contemporary arts*. Edited by Omar Kholeif. London: Whitechapel Gallery and The MIT Press, 2015.

*Information from the series of Documents in contemporary arts*. Edited by Sarah Cook. (London): Whitechapel Gallery and The MIT Press, 2016.

*Practicable - From participation to interaction in contemporary Art*. Edited by Samuel Bianchini and Erik Verhagen. London: MIT Press, 2016.

*Beyond the Display - Phenomenal art and Design in the 21st century*. Edited by Mika Iwasaka. Tokyo. BNN Inc, 2015.

Build Abroad. Travel and architecture blog. Available from: <https://www.buildabroad.org/2016/10/12/mycelium/>

Claire L Evans. *Living in a mycelial world*. Science Blogs. 2011. Available at <http://scienceblogs.com/universe/2011/07/17/living-in-a-mycelial-world/>

Myers, William. *Bio Art - Altered Realities*. London: Thames and Hudson, 2015.

Deleuze, Gilles. Guattari, Felix. *A thousand plateaus: Capitalism and schizophrenia*. LONDON. University of Minnesota Press. 1789.

Slime mold. wikipedia.org. wikipedia [https://en.wikipedia.org/wiki/Slime\\_mold](https://en.wikipedia.org/wiki/Slime_mold)

I.A. Basheera, M. Hajmeerb. *Artificial neural networks: fundamentals, computing, design, and application*. Journal of Microbiological Methods. (2000) Accessed June 20/2017. Available from: <https://pdfs.semanticscholar.org/fc40/ad1238fba787dd8a58a7aed57a8d020a6fdc.pdf>

Anil K. Jain. *Artificial Neural Networks: A Tutorial*. Michigan State University, 1996 Available from: [http://www.cogsci.ucsd.edu/~ajyu/Teaching/Cogs202\\_sp12/Readings/jain\\_ann96.pdf](http://www.cogsci.ucsd.edu/~ajyu/Teaching/Cogs202_sp12/Readings/jain_ann96.pdf)

Aguera y Arcas, Blaise. *Art in the Age of Machine Intelligence*. Medium. (2016) Available from: <https://medium.com/artists-and-machine-intelligence/what-is-ami-ccd936394a83>

Bourriaud, Nicolas. *Relational Aesthetics*. Les Presse Du Reel, 1998

Artist Online portfolio. <http://www.agapea.si/en/>

Jabr, Ferris. *How Brainless Slime Molds Redefine Intelligence*. Scientific American. International weekly journal of science (2012) Accessed August 10, 2017. Available from: <https://www.scientificamerican.com/article/brainless-slime-molds/>

Hopkins, J., & Kiela, D. (2017). *Automatically Generating Rhythmic Verse with Neural Networks*. In Proceedings of the 55th Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)

Reynolds, Matt. *Neural network poetry is so bad we think it's written by humans*. New Scientist, 2017. Available from: <https://www.newscientist.com/article/2140014-neural-network-poetry-is-so-bad-we-think-its-written-by-humans/>

McLuhan, Marshal. *Information from the series of Documents in contemporary arts*. Edited by Sarah Cook. (London): Whitechapel Gallery and The MIT Press, 2016.

Special thanks to my supervisors Claudia Rohrmoser and Sebastian Neitsch for accompanying me during the theoretical and practical development of this project. Also to Mr. Stephan Schmidt, biology professor from the Carolina Science company, for all the knowledge on the fungi and protozoa kingdoms.

I'm also very grateful for all the patience, support and design advice that my cousin Daniela Barreto gave me during this process.

At last but not least, I would like to thank all the authors mentioned in this thesis for contributing to the creation of a cluster of knowledge that I consider necessary to share, in order to build a more conscious world.



