Techniques & Culture
Revue semestrielle d'anthropologie des techniques
Suppléments au n°73

The lamp, the fly, and the fungus

Observing and experimenting with living organisms in a biomimetic artifact

La lampe, la mouche et le champignon

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Electronic version
URL: http://journals.openedition.org/tc/13771
ISSN: 1952-420X

Publisher
Éditions de l'EHESS

Electronic reference
Lauren Kamili, « The lamp, the fly, and the fungus », *Techniques & Culture* [Online], Suppléments au n°73, Online since 03 July 2020, connection on 03 July 2020. URL : http://journals.openedition.org/tc/13771

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This project has obtained financial support from the CNRS through the Mission's programs for Transversal and Interdisciplinary Initiatives (MITI).

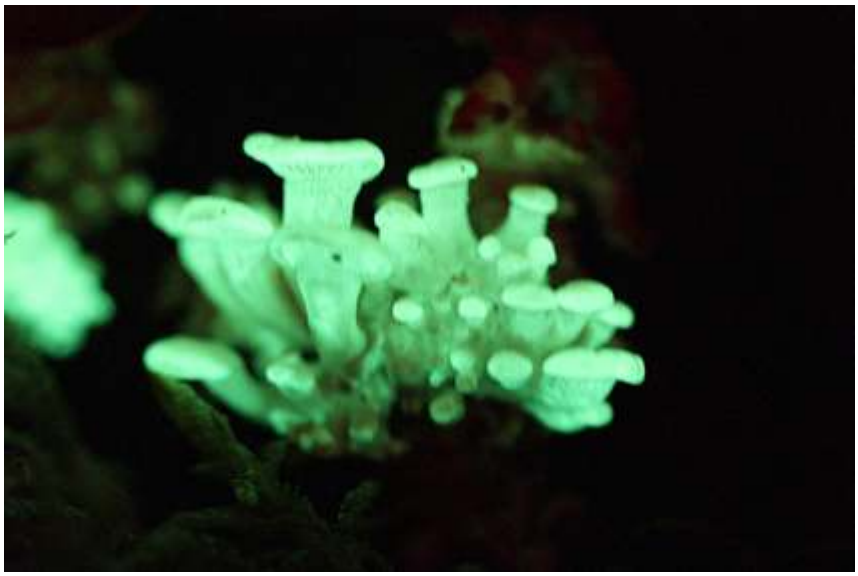
Figure 1. (opening image)

Panellus stipticus, a bioluminescent fungus, photographed in the dark
Helena Amalric / Romaric Nivelet

At nightfall, after all the visitors have left and well after dinner has ended, with peach moonshine flowing freely, about fifteen people gather in a warehouse. It is still possible to make out who is who in the dark. Too much light. A young woman goes out to move her truck in front of the windows, in order to block the light coming in from outside,

though the night is moonless. Inside, a white fabric projection screen is moved to block another window. Disembodied voices, slightly tipsy and impatient, can be heard in the obscurity. Now it's dark enough. The young woman asks the spectators to wait until their eyes have adjusted to the faint glow of *Panellus stipticus*. They move together as a group to crowd around the nightlight, further deepening the darkness they're seeking. One after another, each one leans over a lamp that has been placed in a black, opaque cloth bag, with their hands cupping their eyes and their eyes fixated on the fungi inside. At first, there is nothing to see. Then, as the eye focuses, a faint green light can finally be made out: elegant, subtle, and entirely astonishing (**figs. 1 and 2**).

Figure 2.



Bioluminescent fungi emit a subtle green light. The photographic techniques used here amplify their luminosity.

Helena Amalric/Romaric Nivelet

1 I participated in this gathering as part of my fieldwork on biomimicry in France. It occurred during the Mycelium Forum, held on October 13 and 14 in Saint-André-en-Vivarais (07) and organized by the Mycorium Sauvage group, which was founded by several fungus enthusiasts who met on Facebook. Every year since 2016, this event, dedicated to mycology in all its forms, offers "nature" excursions, conferences, workshops, a raffle, and a mycology exhibit. As part of the conference, Helena Amalric, one of the association's founding members, leads a workshop on cultivating fungi at home. At her stand, she presents the nightlight she created using bioluminescent fungi, samples of which she has brought with her. These are of great interest to the participants of the Mycelium Forum. Everyone speaks of them as marvelous curiosities; everyone is dying to see them glow, and, at the end of the Forum's first day, they implore Helena to let them see them.

2 During the day, we had all passed before these mushrooms, little carpophores that appeared almost shriveled up in the light of day. Now, in the dark, one of the speakers at the Forum, a professor from the National Museum of Natural History, is extremely curious about them; a well-known mycologist cannot get over the fact that he did not know about them, and a Franciscan monk who specializes in permaculture is overcome by the beauty of life. "How beautiful they are!" someone says, their voice full of

emotion. Everyone murmurs their agreement, the alcohol having helped loosen their tongues. The next day, when it is time to leave, Helena gives samples of her fungi to the professor and the agronomist monk as a souvenir.

3 Helena Amalric is a bio-designer who specializes in biomimetic design and is known for her bioluminescent nightlights. Since 2016, her project "Biotope" has been housed in and partially funded by the SCOP[1] Terre Vivante, which is located in the region of the Trièves, 60 kilometers from Grenoble, in the Isère department. The project involves three activities focused on gaining knowledge about living beings and biomimicry: creating a forest garden to serve as a site for bio-inspired agricultural experiments; establishing a hiking trail on the Terre Vivante property for doing "biomimetic readings" that focus on direct observation of living beings in their ecological context and spreading knowledge about them; and opening a low-tech experimental laboratory in a mobile home in the forest, dedicated to research on living beings and open to experts and amateurs alike (Kamili 2019b). This final element of the project, the "lab-biotope," is for conducting experiments that extend *in situ* observation of living beings, and its goal is the fabrication of biomimetic artifacts such as the bioluminescent nightlight. The methods, techniques, and forms of reasoning behind the nightlight are now at work in the lab-biotope. So then how was this bioluminescent nightlight created? How does observing living beings aid in conceptualizing the construction of a technical object? How does a technical project orient exploration of a biological system? What are the effects of the artifact that is ultimately built?

4 This paper is based on a multi-sited ethnographic study of biomimetic practices in France that included the Biotope project in the Trièves. An initial exploratory one-week study was carried out in October 2017 and was followed by a four-week fieldwork study in October 2018, both of which involved participant observation. I observed Helena Amalric's work on a daily basis and participated in many of her activities, including the Mycelium Forum, in addition to documenting them through photographs and video recordings.

5 The observation of living beings is fundamental to biomimicry as defined by Janine Benyus in her essential work *Biomimicry* (1997). Benyus presents observation as the first stage of the biomimetic process; it should allow one to understand the functioning of a living being in order to better replicate it. The connection between observation and experimentation was studied by Claude Bernard in his *Introduction à l'étude de la médecine expérimentale* (*An Introduction to the Study of Experimental Medicine*), first published in 1865. While Bernard does make a distinction between the observer, who is "passive" in "producing phenomena" (Bernard 1957 [1865]: 6), merely observing the facts of nature, and the experimenter, who, to the contrary, "tak[es] a direct and active part in producing them" (*ibid.*), he does so in order to highlight their imbrication in experimental practice. Jessica Riskin, in her work on Jacques Vaucanson's automatons (2003) also discusses a process that involves observation, experimentation, and comprehension of biological phenomena. Automatons are "simulations"; that is, experimental models on the basis of which it is possible to discover the principles of operation at work in the entities they imitate. The construction and fabrication of artifacts thus serves as a source of intelligibility of biological processes, which are made objective in different ways depending on the types of techniques used, which range from engineering to bricolage by way of art and craftsmanship (Pitrou 2017).

6 In this article, I focus on the concrete practice of making a biomimetic artifact. My description and analysis of the experimental process that led to the creation of a bioluminescent lamp will investigate the connection between observation, imitation, and the construction of knowledge about living beings. The technical project behind this creation initially looked at bioluminescent fungi from a functionalist point of view, but the mimetic artifact revealed biological processes that caused an ecological point of view—one attentive to the milieu—to emerge. Finally, the example of the biomimetic lamp shows how observing and understanding a vital process makes it possible to reproduce its functioning. It becomes clear that imitation, in turn, produces knowledge about that which it imitates, and has effects on the relationships between humans and non-human living beings.

From fungus to light bulb: making a biomimetic lamp

In order to understand the process by which such an artifact is made, let us begin by looking at Helena's personal trajectory and the environmental relations and scientific collaborations that have nurtured it. Originally from the Trièves, Helena Amalric studied design in Lyon. She received her degree in the late 2000s and was immediately recruited by a design agency in Nice that specializes in ecological furniture. Helena worked there as the assistant to the director for a year and a half before breaking her contract and returning to the Trièves in 2009, feeling like she had "been going in circles" making "cloud curtains, cushions in the shape of stones...." So she created her own company offering furniture design and graphic arts services, and began focusing on how woodworkers' scraps could be converted into furniture. "I took the time to try out lots of things, to fiddle around, to work with farmers on turning vegetables into something other than [food to be eaten], like vegetable paper." In trying to get the furniture she designed made, she began to realize that there were many small artisanal shops in the Trièves, but, without storefronts or websites, they lacked visibility. She created the organization La Fabrique du Trièves in order to establish a network for these artisans. For several years, in parallel with her own work, she developed this network and eventually opened a boutique with a salesperson whose salary is subsidized.

7 At the same time, as an extension of her experiments with vegetable paper, she began working on a project for a lamp using bioluminescent fungi. She had already made prototypes for a nightlight when, in 2013, she discovered biomimicry thanks to Janine Benyus's book: "There was a word that corresponded to what I wanted to do and what I was beginning, little by little, to do." The nightlight, which she named "*Substrat*" ["Substratum"] operates as a "mini-ecosystem" encapsulated in a closed apparatus, and is intended to be observed in the dark, by children. This unique lamp—which took an entire year to refine and complete—quickly became quite successful, making Helena rather famous within the nascent French biomimetic movement; her lamp is a rare example of a successfully completed biomimetic design project in France.

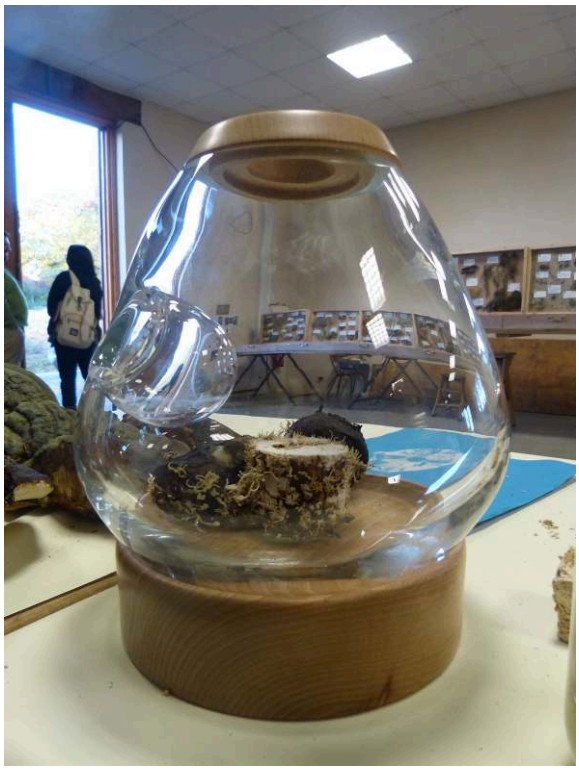
8 The nightlight Helena presented at the Mycelium Forum has a large glass bubble that is about twenty centimeters in diameter and is narrower at the top; it rests on a light-colored wooden base and is sealed with a cover made of the same wood. On one side, a depression in the glass forms an opening, which is also sealed by a wooden cork. Inside, at the bottom, there are small circular pieces of wood and bits of branches covered with

a cream-colored substance out of which rise, reaching toward the sky, dozens of miniscule, twisting arms—like a bed of algae swayed by a wave, yet perfectly still (**figs. 3 and 4b**). Upon closer inspection, once one lifts the cover and peers into the glass, one notices other shapes whose identity leaves no doubt: they are indeed mushrooms, the very same ones whose pretty green glow was so pleasing to participants of the Mycelium Forum.

Figure 3.

Interior of the *Substrat* lamp. Saint-André-en-Vivarais, October 2018
Lauren Kamili

Figure 4.



The *Substrat* nightlight at the Mycelium Forum. Saint-André-en-Vivarais, October 2018
Lauren Kamili

9 It all began when a friend offered to show Helena some mushrooms he was growing in his basement. "There was no light, the light bulb had [burned out], and he said... 'if only the mushrooms made light' and I thought...'I'm sure that exists!' I did some research and found out that it does." A year later, Helena sold her first "*Substrat*" nightlights, whose light comes from the fungi that grow within them. What happened between that day in the basement and the moment when she began to sell the lamps? What process guided their creation?

10 In keeping with her experiments with vegetable paper and her work in biodesign, Helena's project was from the outset oriented by the goal of identifying a utilitarian function within a living being in order to solve a human technical problem: here, the failure of an electric light bulb and thus a lack of light. From the beginning, "luminous" fungi were seen as potential technical objects and understood on the basis of the lamp model. A correspondence was established between the most obvious visual characteristics of these living beings and a technical artifact that behaves similarly: both emit light. But Helena's nightlight was not simply the result of juxtaposing these two systems, one living and one technical. Her observation went beyond a fortuitous initial discovery, and included a process of comprehending a living being on the basis of a specific project.

11 First, Helena researched what species of bioluminescent fungi she might be able to find in France and identified two: *Panellus stipticus* or astringent panus, a member of the Mycenaceae family, and *Omphalotus olearius*, commonly known in English as the jack-o'-lantern mushroom and in French as the "*pleurote de l'olivier*" ("olive tree oyster mushroom"). Since "there are no olive trees here," she focused on *P. stipticus* and began

seeking out wild strains, doing what she laughingly calls "forest tracking" [*affûts en forêt*]. *L'affût* is a very specific type of observation technique, requiring camouflage clothing and a concealed shelter, which are used in order to listen to and observe wild animals, particularly at nightfall, when humans vacate the hiking trails and forests and animals go about their business. In the Trièves, *affût* excursions are organized in particular to see and hear wolves, who both fascinate locals and stir up political passions. Humans who participate in such excursions must be as immobile, silent, and odorless as possible, in order to either go entirely unnoticed or at least not be perceived as a threat, so as to observe the moving and usually invisible animals of the forest. *L'affût* is above all a hunting technique used by humans and some animal predators, in which prey unknowingly pass near by the hunter and are captured. It is surprising and striking that Helena would use this expression to talk about going out looking for bioluminescent fungi. She thus compares these fungi to beings that must be tracked, who are hidden: just like a hunter tracks animals in the forest, Helena tracks fungi. For her, gathering mushrooms is "hunting but without killing." Finally, *l'affût* requires using a set of "techniques of the body" (Mauss 1973)—seeing, feeling, hearing, walking in the forest, using one's eyes to identify living beings—which are necessary in order to successfully carry out the lamp project. In order to "hunt" bioluminescent mushrooms, Helena began by identifying several sites in the Trièves and in the Belledonne mountain range in the north of the Isère department where she knew there would likely be fungi that resemble *P. stipticus*. Next, she regularly returned to those sites at night to observe them, since the bioluminescence of fungi is invisible to the human eye during daylight, until she found the bioluminescent strain—which is usually found in North America, not in the Vercors region.

12 She says it was then that she began to work on the nightlight, but the idea for it had already been there, orienting her gaze. Helena began collaborating with a microbiologist from the University of Lyon 1, Didier Blaha,[2] whom she had met in 2012 at the Fungi Festival of Lus-la-Croix-Haute, 25 kilometers from Mens, where he organizes a booth for identifying fungi for his pharmacology students every year. Dr. Blaha, who also had the bioluminescent American strains in his laboratory, was impressed by Helena's *in situ* discovery and agreed to work with her. He put the fungi in a culture in his laboratory while Helena grew them at her home, and thus their joint research advanced in tandem. They were quickly led to investigate *P. stipticus*'s mode of living: what does it eat? What does it like? What does it grow best on, and at what speed? Under what conditions, how, and why does it emit light? How long does the light last? Are there variations in intensity? **(fig. 5)**?

Figure 5a.

Panellus stipticus photographed in daylight
Helena Amalric / Romaric Nivelet

Figure 5b.

Panellus stipticus photographed at night
Helena Amalric / Romaric Nivelet

13 Claude Lévi-Strauss distinguished between two technical *ethos* connected to two sets of practices: that of the engineer and that of the bricoleur (Lévi-Strauss 1966). The practice of the former is guided by a goal established ahead of time, while the latter is characterized by use of the means available at a given moment. The bricoleur "makes do" with a finite, limited set of materials which he or she readily repurposes, reuses, and reinvents, whereas the engineer deploys the exact means necessary in order to carry out his or her project. In the context of relations with living beings, these two kinds of relationships to functionality and purposiveness bring out two kinds of views

of living beings. The engineer tends to look for what in nature may correspond to a precise function, while the bricoleur will look instead to make new potentials emerge by adopting an eco-systemic perspective. Thus, the process of creating the lamp corresponded to the engineer's practice: the living being was understood in terms of the project in question, which advanced on the basis of an analogy between the fungus and an electric light bulb on the one hand and between bioluminescence and home lighting on the other.

14 Over time, Dr. Blaha and Helena accumulated observations, became better and better at cultivating and understanding *P. stipticus*, and noticed that it grew on many types of wood but only made light if it grew on oak. In an attempt to understand this phenomenon, they ran experiments where they deprived the fungus of oxygen and then added it back, since the enzyme in the fungus that produces light, luciferase, reacts with oxygen, but "that didn't change anything." The questions posed by Helena and her colleague, although both biological and ecological, remained centered around the organism in itself and focused on maximizing the biological process of bioluminescence in order to integrate it into a technical device for lighting. Although they took into account numerous parameters and various factors influencing the fungus's production of light, their perspective was still that of the engineer: focused on creating an efficient artifact. Until the fruit flies.

From organism to system: decoding vital processes

Having retraced how Helena's perspective and mode of experimenting were constructed, in this section I show how the lamp in turn became a tool for exploring a living being. By combining interviews with Helena Amalric with the description of a technical object and analysis of its materiality, I then turn to the question of how biological processes are perceived and objectivized.

15 After a time, Didier Blaha began to notice small flies around the fungi cultures that were growing on oak, and he concluded that these were contaminated and had to be cleaned. Helena noticed the same thing, including with the nightlights she had already begun to sell at local fairs and exhibitions; her customers told her about seeing these flies inside the lamps themselves. Helena rejected the contamination hypothesis, "made the connection," and reckoned that if all these flies were present around fungi that made light—and not other fungi—"it must be for good reason." Didier Blaha took on the task of understanding exactly what this reason was, and, drawing on the scientific literature on *P. stipticus*, supposed that the fungus "called" the fruit flies to it by emitting a light intended specifically for them, and, ultimately, he discovered the ecological relations between the fungus, the fly, and the oak wood. The flies, attracted by the light, lay their eggs on the wood; the larvae eat the wood, and thus cause it to decompose, making the nutrients it contains much more accessible to the fungi. The fungi and the fruit flies thus work together, symbiotically, to decompose the wood.

16 It is not enough to establish an equivalence between technical and biological functionalities. These living beings, which are more than a set of functions, displayed a behavior that was initially incomprehensible, and resisted the engineer's project. Their aleatory aspect ultimately pushed Helena and Dr. Blaha to envision biological phenomena differently and to take eco-systemic operations into account. From the

beginning, unbeknownst to them, the nightlight had been harboring a miniature ecosystem, of which bioluminescence was but one component.

17 The *Substrat* lamp serves the utilitarian purpose of providing light, but it is also a technical device that prolongs observation of a living being *in situ* and *in lab*; it is an artifact that showcases the fungi and makes their biological processes visible. Today, two versions of the nightlight are sold. The first is a tube nine centimeters in diameter, in which a small log weighing between 200 and 400 grams has been placed, and it sells for 80 euros. The second is the glass bubble 40 centimeters high and 20 centimeters in diameter, sold for 350 euros (**figs. 4 and 6**).[3] The latter is a sizable work of craftsmanship, both heavy and precious, and Helena must take many precautions when transporting it from one exhibition to another. The glass was blown by an artisanal glassblower in the Dordogne, and the wooden base and cover were made by a regional woodworker who is a member of the Fabrique du Trièves organization. The very shape of the nightlights invites contemplation, as well as a more active relationship to what they house: a miniature ecosystem.

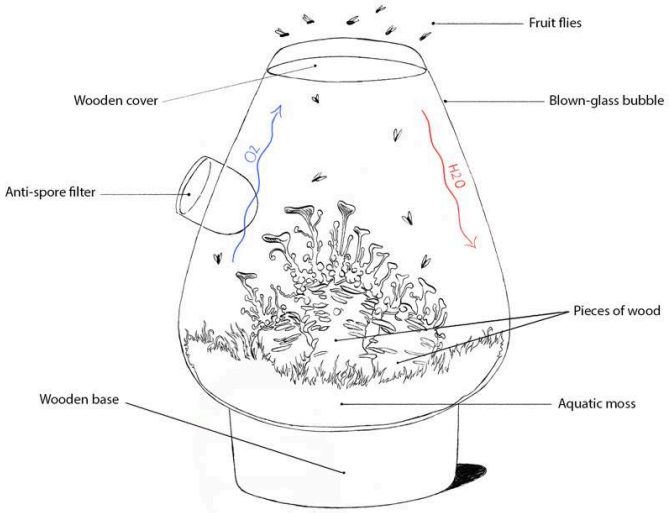
Figure 6.

A humbler version of the nightlight, created by the same artisans. (See figure 4 above).
Helena Amalric / Romaric Nivelet

18 The light emitted by *P. stipticus* allows the lamp to function properly, while "in return" the lamp provides the fungi with a satisfying living environment. Helena chose the bubble shape to allow for condensation within the nightlight; droplets form and fall along the sides, bringing the water the fungus needs. Thus, the glass bubble provides a warm, humid atmosphere, favorable to the fungus's growth. Since forest moss will not grow inside, Helena replaced it with aquatic moss, which releases oxygen and cleans the stagnant water at the bottom of the nightlight. A wooden cork with an anti-spore

filter to prevent competing fungi from entering completes the device, which was initially conceived to "operate" as a closed—or nearly closed—system (**fig. 7**).

Figure 7.



The *Substrat* night light. The glass bubble allows for condensation of the oxygen released by the aquatic moss. The anti-spore filter and the cover keep the system watertight—until a user opens them, allowing small symbiotic flies to enter.

19 Originally, Helena sought to understand how luminescent fungi operate in order to replicate the process artificially, much as laboratories such as Labex Arcane[4] or ChimEco[5] try to replicate photosynthesis. But she did not have the material or scientific expertise necessary to carry out such research at the molecular level. What she did have, however, were particular skills (Ingold 2000), very similar to Anna Tsing's "art of noticing" (2015), which led her to notice the specificities of one living being's interactions with its environment: the fact that *P. stipticus* glows when it grows on oak, and that it is surrounded by fruit flies in certain circumstances and not in others. What is imitated is thus not the phenomenon of bioluminescence in itself—quite simply because Helena did not have the technical and material capacities to replicate it. Even "cutting-edge" scientific laboratories do not have such capacities. But Helena did not stop at gathering luminescent mushrooms, growing them, and enclosing them in a container. Along with Didier Blaha, she sought to understand the conditions necessary for their growth. The creation of the nightlight started off from this living being and was based on its biological needs. The nightlight is thus a hybrid object that cannot be reduced to a mere assemblage of human techniques and biological processes. Its hybridity is the result of investigating the organism and its environment and asking how its living conditions can be translated into an artifact. Imitation does not concern bioluminescence in isolation, but rather involves a form of reasoning that pays

attention to the ecological dimensions of the phenomenon. In this way, the process of creating the lamp meant that the living conditions of symbiotic flies were also taken into account.

20 The Darwinian theory of evolution envisions life as a permanent state of competition between species and between individuals of the same species, where success is measured by the number of descendants an individual produces—that is, the rate at which its genetic material is spread to the next generation. In order to nuance this theory of life as a "murderous game," Lynn Margulis and Dorion Sagan highlight the concept of symbiosis: "life…is also a symbiotic, cooperative venture in which partners triumph" (1997: 16). Symbiosis brings together living beings of different species who may live together in association or may merge to form "new collectives" (ibid: 32)—which does not necessarily imply the establishment of mutually beneficial relations between organisms. The authors emphasize how common the phenomenon of symbiosis is in the living world, and symbiosis is now considered a fundamental factor in the evolution of species. In the case of the nightlight, *P. stipticus* is perfectly capable of growing and surviving without fruit flies, but their symbiotic alliance allows each species to improve its living conditions, and increases the fungi's longevity:[6]

> H.: "If you cultivate it and it has never had access to the outside, the fungus will continue to make light to attract [fruit flies], but the flies will never make it there because they can't get in. And it's just that after a while, it will struggle, struggle, exhaust itself making light and trying to eat the piece of wood, so it won't grow as well. And if people—this is what they do, they open [the nightlight], they look in, then—whoosht, as soon as there happens to be [a fruit fly] passing by, it will go in.
> L.: "And that causes the nightlight to last a longer or shorter time?"
> H.: "Longer, because then the fungus can eat more easily…it has to make less of an effort to make light because it already has [the help of the fruit flies]."

21 Thus, the lamp is an artifact that allows exploration and invites the establishment of an experimental relationship with living beings. When users open its lid and observe and handle what is inside, or wonder about the presence of flies, they renew and prolong the process of its creators, in which observation and experimentation were not two separate things (Bernard 1957 [1865]). Moreover, human intervention is necessary for symbiosis to occur, since the nightlights do not initially contain fruit flies. It is only when curious people who want to observe these marvelous mushrooms from closer up open the lamp that the little flies, *P. stipticus*'s partners, can enter into the device. It is the actions and interactions of humans with the lamp that allow the ecosystem to become richer, and thereby, increase its technical efficacy—if the longevity of the fungi rather than the intensity of their light is the goal. The nightlight is also a hybrid in the sense that it fully integrates human intervention into the functioning of its ecosystem —something neither Helena nor Dr. Blaha expected.

22 This ecosystem "in a bottle" is a reduction, a "miniature" or "small-scale model" of a larger living system. Claude Lévi-Strauss developed the idea that humans generally seek to understand the totality of an object on the basis of its parts (1966). Dividing the object makes it easier to overcome the difficulty of immediately grasping it in its totality. The role of the small-scale model is to reverse this, since "being smaller, the object as a whole seems less formidable. By being quantitatively diminished, it seems to us qualitatively simplified" (*ibid*: 23). Reducing the scale makes it possible to make intelligible what previously was not, and even to grasp "at a glance" (*ibid*.) an otherwise inaccessible totality. Lévi-Strauss further specifies that "in the case of miniatures…

knowledge of the whole precedes knowledge of the parts" (*ibid*: 23-4). While he describes this mode of knowledge as "illusion," the nightlight did in fact play a role in building significant knowledge: the symbiotic relations between the fly and the fungus were discovered only *after* the lamp had been completely built.

23 On the one hand, it is when the mushroom organism is placed inside a glass bubble that it becomes an element of a hybrid lighting system. On the other hand, this glass bubble is what makes it possible to grasp the organism at the eco-systemic level, thus revealing the symbiotic relations between the flies and the fungus. For Lévi-Strauss, the miniature is characteristic of the practice of the bricoleur; thus, shifting from understanding a living being at the level of the organism to understanding it at the ecological level, which looks at the system it is part of, goes along with a shift from engineering to bricolage. From then on, one must "make do" with the presence of fruit flies.

24 For Lévi-Strauss, "the artist is both something of a scientist and of a bricoleur. By his craftsmanship he constructs a material object which is also an object of knowledge" (Lévi-Strauss 1966: 22). But he specifies that miniatures "have a further feature. They are 'man made' and, what is more, made by hand" (*ibid*: 24). Thus, they combine the intellectual pleasure of grasping something in its totality with the pleasure that comes from making an artifact "by hand." Helena's lamp, which is a miniature, indeed corresponds to this double dimension, at once aesthetic and practical, and Helena herself, as a designer, used both engineering and bricolage to make it. The nightlight's glass bubble invites both observation and handling of its miniature ecosystem, and, like an aquarium, it also lends itself to showing, to a display—as the Mycelium Forum participants' eagerness to view this miniature ecosystem demonstrates.

From *curiositas* to care: making images, creating relations

As an object, the nightlight took different forms over time, but from the very first prototypes to the two versions of the lamp that were eventually completed and sold, both had a spherical or cylindrical shape that allows for extended observation of what they contain, and highlights the most obvious characteristic of the fungi, as originally identified by Helena: their bioluminescence. In this section, I examine how the lamp is used and how a relationship to a technical object is constructed.

25 The shape of the glass keeps humidity in, but it also plays an aesthetic role, and gently diffuses the light. The lamp is a design object that fulfills a utilitarian function, but it is also, and above all, ornamental (**fig. 8**). The lamp makes a domesticated and artificialized piece of nature available for viewing; it is a visualization device that, by putting a living being behind glass, would seem to keep it at a distance. Being transparent, it makes a living system visible within a very precisely circumscribed space: living beings are literally placed "under the eyes" of humans. But, by bringing fungi and flies—living beings usually considered undesirable in a home—into the house, the nightlight also contributes to bringing them nearer to humans, thus inviting the establishment of a more familiar relationship. Given as a gift to children to protect them from their fear of the dark, it is intended to be placed in one of the most intimate spaces within a home: on a bedside table, in a bedroom, near the bed.

Figure 8.

The *Substrat* lamp displayed by Helena on her stand at the Mycelium Forum in Saint-André-en-Vivarais. The photograph of *P. stipticus* goes with her on her stand everywhere.

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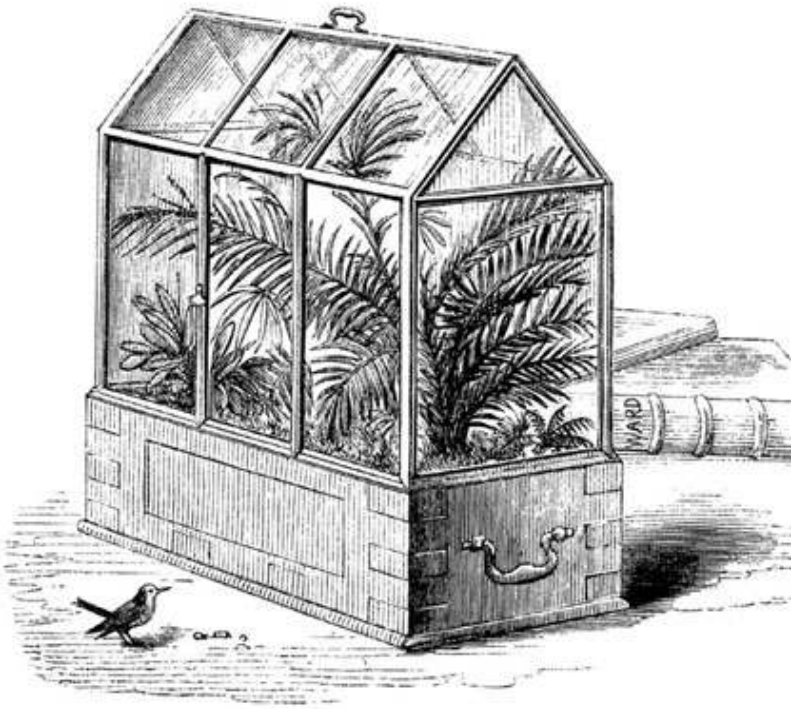
26 The practice of putting living beings under or behind glass became especially popular during the 19th century, with the invention, in 1829, of the precursors to terrariums by Dr. Nathaniel Bagshaw Ward[7]—known as "Wardian cases"—which made it possible to cultivate and transport exotic living plants (Hershey 1996), and of "Power cages" by Jeanne Villepreux-Power during the same period, which prefigured the advent of aquariums (Lorenzi 2009). The latter made it possible to keep aquatic animals alive over the long term and thus to study not only their physiology but also their "customs" in their natural environment (*ibid.*: 268). The creation of these objects was the result of intentions similar to those behind the *Substrat* nightlight: to make a device available to a wide audience that would allow people to observe and admire the living world. This initial project of popularization rapidly transformed into intense passion on the part of French and British elites, who displayed these beautiful objects of curiosity in their living rooms (*ibid.*). The "aquarium mania" of the 1850s followed the "fern craze" launched by the widespread sale of Wardian cases (**fig. 9**).

Figure 9.



A Wardian case. The similarity between this device and the *Substrat* nightlight is striking, with the exception of the handles, since the lamp is not meant to be transported.
(Image taken from Ward 1852 [1842]: 71)

27 The spectacular dimension of these artifacts, which are displayed in domestic and public spaces, is not insignificant. For the historian Camille Lorenzi, "by offering the possibility of viewing a real, living spectacle through a screen, the aquarium opened a new field for creating images" (Lorenzi 2009: 263).[8] Similarly, the biomimetic lamp involves both a specific form of lighting and a frame that magnifies what it contains. It is both an observation station for a strange form of life and a device for making images. Like an aquarium or terrarium, its development implies collecting and isolating a fragment of the real in order to make it visible, in order to reveal it to the observer's gaze, but as part of a new composition—behind glass—which convokes a specific imaginary.

28 The light produced by the fungi is described as "*Avatar*-esque" on Helena's online shop, in reference to James Cameron's film of that name (2009), which is set in a bioluminescent forest. Helena also notes that upon seeing the lamp and its green light for the first time, some customers exclaim "Woah! It's like *The Matrix*!" Thus, the images produced by her lamp evoke the world of science fiction; a different world, with different forms of life, just as an aquarium, which "reveals all hidden and unknown life" (*ibid.*: 264) does. Here, the life in question is that of the bioluminescent fungi Helena tracked through the forest (**figs. 10 and 11**).

Figure 10.

Photomontage on the website of the online store. The bioluminescent lamps are shown in a dark, foggy forest, which recalls their nocturnal and mysterious origins. The photomontage also suggests the integration of the artifact into a larger ecosystem.

Helena Amalric / Romaric Nivelet

Figure 11.

The nightlight makes a form of the strange accessible.

Helena Amalric/Romaric Nivelet

29 The wonder that this object excites is at the heart of Helena's biomimetic project, just as it structures the most common contemporary biomimetic discourses and

representations. Situated at the crossroads between a scientific project and an aesthetic agenda,[9] the nightlight belongs to a tradition that goes back to the cabinets of curiosity that became popular beginning in the 16th century. In particular, the model of the *Wunderkammer* or "room of wonders"—distinct from the *Kunstkammer*, intended for collections of works of art—consisted in bringing together extraordinary, unusual, or rare objects that would spark astonishment and admiration in visitors (Rivallain 2001). The *curiositas* that guided collectors fed an enthusiasm for the "wonders of nature" similar to that which permeates the biomimicry of today.

30 But for the lamp to continue working—that is, for the fungus and its fruit fly allies to be able to continue their existence—a minimum of care is required. Although the bioluminescent nightlight ensures the autonomy of the living beings it houses, it is not an entirely closed system, and the fungus must be fed and kept in a humid atmosphere. It must be fed two or three times a year, by giving it a small piece of oak wood cut within the past year, or sawdust; this requires opening the lid, putting one's hand in, and even touching the mushrooms, then closing the glass—which implies more than a relationship of objectivization and aestheticization to the living being. *P. stipticus* eats the wood, leaving the pieces hollow and empty of all nutritional substance. Since sawdust is easier for the fungus to eat, it will emit less light, because it has less need of the fruit flies' help in decomposing the oak lignin. Taking care of the nightlight, making the mushrooms grow, and obtaining light—in other words, capturing the biological process of bioluminescence—requires constantly adjusting elements of the fungus's living conditions: oxygen, water, the presence or absence of insects, the type of wood, and the openness of the container to the outside.

31 "Growing" the fungus does not require simply placing the organism on a substratum and waiting, but rather practicing constant and attentive care, spending three months acting to ensure its reproduction. Making the lamps thus means adjusting to the fungus's temporality: if Helena doesn't have the time to take care of them and they don't grow, there will be no lamp to sell, and she will not make any money. Sometimes, care takes rather aleatory forms: Helena admits that one time, the day before an exhibition, the mushrooms still hadn't sprouted, so she sang to them. The next day, they had emerged.

32 This relationship of care and maintenance is characteristic of a number of biodesign and bio-art projects that use living beings. In 1996, Ionat Zurr and Oron Catts started the Tissue Culture & Art Project (TC&A), a major bio-art project in which they examine uses of artificial living tissues in artistic creation. As part of this project, they created "semi-living" sculptures made of animal cells that were cultivated on artificial substrata. Their installations invite the viewer to go beyond a merely contemplative relation to these semi-living entities (Zurr & Catts 2004). The establishment of a daily "feeding ritual" performed during exhibitions emphasizes the "responsibilities, as well as the intellectual and emotional impact, which results from manipulating and creating living systems as part of an artistic process" (*ibid.*: 177). Similarly, the *Substrat* nightlights are never static, they are constantly evolving at the rhythm of the fungi and flies that live in them. The lamp is far from being an automatic system like an aquarium, or a nightlight with an electric bulb: it is a home for living beings, which one must get to know in order to establish, maintain, and optimize their living conditions.

33 Although an aquarium might seem to represent human and scientific domination over nature (Lorenzi 2009), it is also a technical system that requires the active participation

of aquariophiles in maintaining the living conditions of the beings that inhabit it, and it is the basis for unique relationships with non-human beings (Gérard 2019). Similarly, Helena's nightlight creates images that have structuring effects on the owner's relationship to living beings. Its display implies a spectator who participates, who is not merely a passive observer but also an experimenter. Maintaining the lamp generates an active relationship of care, which engages the human who owns it and was inherent in the process of its creation: the mimetic project sought not only to replicate the fungus and its bioluminescence, but also the milieu that makes the latter possible.

34 Tracing the process of making the *Substrat* lamp revealed two levels of imitation contained within one another. The first established an initial system of equivalence, but it was also an experimental protocol that gave access to another dimension of the living being: the ecosystem. Imitation is not only an endpoint, it is also a starting point for a new imitation that shifts from organism to system. Making the lamp also involves the coexistence of various perspectives that produce three regimes of observation correlated to three regimes of action: that of the engineer, who reconstitutes a function of the living being; that of the ecologist and bricoleur, who replicates a system; and finally, that of the admirer, who contemplates and cares for it. The mimetic project does not only consist in a term-to-term reproduction of the functions of the fungus, which ecology or biology objectivize. It also captures the production of energy through a biological process—bioluminescence—and reorients it to meet a human need: the need for lighting. This double objective corresponds to what Jessica Riskin calls the combination of "the pragmatic with the mimetic" (2003: 625).

35 Helena's lamp proposes a paradigm for lighting that uses "natural light" other than sunlight (Sicard 2000). This new lighting technique is also a device for creating rather well-known images that correspond to a science fiction world, mysterious and futurist. In creating images, it also creates future potentials—for example, large-scale urban bioluminescent lighting[10]—in which the ideal of a *reconnection* between technique and culture, so dear to biomimicry, would be realized (Fisch 2017, Kamili 2019a). But if the lamp is a living image to be contemplated, a return to the "reveries of the living lamp," as Gaston Bachelard (1961) called the candle, regretting its replacement by the electric light bulb, it is also a being that must be cared for.

36 The lamp is not only a technical device containing luminous fungi, nor an ornamental object. For it to work properly, action is required of its users: it must be properly placed, kept at the right temperature, and the mushrooms must be fed. Human intervention is integrated into the life cycle of the fungus and thus of the lamp, which ensures optimal living conditions for the living beings within it. Thus, it seems to me that this artifact does not only house a symbiosis but itself *acts as a symbiosis*, one whose mutually beneficial relations extend to humans. The *Substrat* lamp is the result of an imbrication between various processes (Pitrou, Coupaye & Provost 2016): biological processes (bioluminescence, symbiosis, growth); technical processes (lighting, efficacy), and processes of human action (looking, opening, feeding). The *bios* at the heart of the mimetic project is thus not so much imitated as constructed. The nightlight is a complex artifact that corresponds to a vision of the world, to a certain idea of design, to an ethics of knowledge anchored in experimentation and curiosity, and to an empathetic representation of living beings, and it is in fact a statement of the biomimetic project "in the strong sense" (Pitrou, Dalsuet & Hurand 2015). Finally, it is an object that is good to look at, and above all to think with, for in it various

perspectives converge, and it showcases characteristics of life and living systems grasped by humans at the same time that it mobilizes the range of actions that humans use to interact with living beings and to render life intelligible.

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NOTES

1. SCOP stands for "*sociétés cooperatives et participatives*" ("co-operative and participatory companies"); these are companies whose governance is democratic and whose profits go first toward keeping the company's jobs and project going. In addition, workers themselves are shareholders and hold the majority of share capital and voting rights.
2. Doctor Didier Blaha, professor of mycology at the University Lyon 1.
3. https://www.champignonbioluminescent.com/.
4. The Grenoble Labex ("laboratory of excellence") brings together seven laboratories around "bio-motivated" chemical research with the idea that understanding the functions of living systems and the chemical principles on which they are built makes it possible to create synthetic analogies. One notable project is to develop artificial photosynthesis.
5. The laboratory for bio-inspired chemistry and ecological innovation (ChimEco) of Grabels (UMR 5021) develops protocols for the ecological restoration of former mining sites.
6. Some of Helena's clients have reported that five years after purchasing their nightlight, the fungi were doing well and still emitting light.
7. The story of the creation of Wardian cases is strikingly similar to that behind the *Substrat* nightlights. They were the result of Ward's observing interspecies relationships between an insect (a hawk moth), a fungus (mold), and a plant (a fern). Observing a fern growing in "a wide-mouthed glass bottle," Nathaniel Bagshaw Ward writes that he "seriously asked [himself] what were the conditions necessary for its *well-being*" (Hershey 1996: 276, emphasis mine). Here too an ecological line of questioning converges with a technical question: how to transport plants over an extended period of time?
8. All translations of material not published in English are our own.
9. This link between art and science in the creation of scientific images is analyzed in detail by Lorraine Daston and Peter Galison (2010).
10. See in particular the following articles in *Sciences et vie* (https://www.science-et-vie.com/archives/bioluminescence-et-l-eclairage- devint-vivant-24716) and in *Sciences et Avenir* (https://

www.sciencesetavenir.fr/nature-environnement/des-plantes-bioluminescentes-pour-eclairer-les-villes_37626).

ABSTRACTS

On the basis of a concrete study that examined the creation of a biomimetic lamp—whose light comes from bioluminescent fungi—this article shows how observing and understanding a biological process makes it possible to reproduce its functioning and, at the same time, how imitation leads to knowledge about the model on which it is based and affects relations between humans and non-human living beings. The functionalist point of view initially adopted by the lamp's creators quickly ran up against the random and symbiotic workings of living organisms, and the lamp-object began to serve as a tool for decoding the fungi's ecosystem, which was also reproduced. Ultimately, the nightlight appears as an observation device that invites users to not only contemplate living beings but also to interact with them, to engage in a more experimental relationship of care and handling with the organisms the device houses.

INDEX

Keywords: biomimicry, living beings, bioluminescence, imitation, observation, experimentation, lamp

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