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Biodesign as a strategy of autonomy in the emergency scenario

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Summary: The Covid19 pandemic and the Russian-Ukraine war have had a dramatic impact on global economy and markets. The uncontrollable fluctuations in energy supply and material resources, the disruption of certain trade routes and the disproportionate increase in energy and consequently transport prices, have led to a reassessment of concepts of localism and short supply chains. In light of this radical transformation in the design sector, emerging phenomena such as biodesign, i.e. the functional use of living organisms in the production process of artifacts, take over with a fundamental role and represent hope for a more sustainable future, based on the values of renewability, self-production and proximity.

Keywords: Biodesign - Self-production - Sustainability - Hybridization - Proximity - Growing Design

[Resúmenes en inglés y en portugués en las páginas 46-47]

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1. Design, fragility and geopolitics

The Covid19 crisis and the Russia-Ukraine conflict affects world economy dramatically. The Covid19 epidemic has had numerous negative effects on human life around the world. The ruthlessness of the pandemic has, for a long time, shifted everyone's attention to concepts of safety and preservation of human life. The perception of insecurity has led

to a reexamination of priorities and an emphasis on environmental sustainability and enhancement of local, material energy and creative resources.
Particularly in Italy starting from the first ministerial ordinances in March 2019 which reduced movement on national territory due to the pandemic and the quarantine period, the fragmented entrepreneurial system was forced to face the impossibility of accessing suppliers outside the nation and to work with a reduced number of employees (Comite, 2020).
The state of emergency induced several companies to choose between suspending their production or converting their industrial plants to meet social-health needs, such as the production of fundamental products like hand sanitizing gel or face masks.
The choice to convert the production in such short time was sometimes favored by the elastic nature of the Italian entrepreneurial system based on small and medium-sized companies who managed to adapt quickly to new needs, confirming the distinctive features of Made in Italy (Rapaccini, Saccani, Kowalkowski, Paiola & Adrodegari, 2020). A relevant role in this state of emergency was played by the cooperation between industry and makers and between hospitals and makers (McCausland, 2020).
In this suspended atmosphere triggered by the pandemic, the challenge was to speed up the production of unavailable products. With the shortage of personal protective equipment and its high demand that companies were unable to meet in the first months of the pandemic, the world of design proved to be particularly active through its DIY faction: many designers and makers, connected on-line from their own places, were able to come up with templates and patterns to self-produce protective equipment and biomedical accessories with 3D printers. The pandemic revealed a scenario in which designers tried to experiment new ways to find biomedical product solutions characterized by adaptabilities, aesthetic acceptability, ergonomics, and cleanability, albeit characterized by higher costs compared to mass production (Vellone *et al*., 2020).
The result of this phenomenon has been a great rise in the reputation of the makers and DIY (Do It Yourself) approach, which, from a niche phenomenon considered by many to be naïve, superfluous, and of low economic value, has become a valuable potential of innovation for companies, markets, and society. This subversion has also overhauled the role of design, which for many years has been experimenting with approaches related to self-production. All the experiences conducted in recent years in the fields of digital manufacturing, upcycling DIY materials, and biodesign now seem more possible, useful, and feasible.
The geopolitical crisis caused by the war between Russia and Ukraine has further exacerbated this process. The reduction of some trade channels and supply of resources across borders has been compounded by the very serious escalation of energy prices, as Russia is one of the world's largest gas producers and energy exporters. Both Covid19 and the geopolitical crisis have increased the prices of food and all consumer goods. As a result, 71 million people faced poverty (Armitage, 2022).
As the context of digital manufacturing was being discovered by the general public, politicians, and corporations, the universe of biodesign and synthetic biology also encountered this good fortune due to the need for easily accessible, renewable, and low-cost energy and material resources. From niche phenomena relegated to biotechnology laboratories or to the scientifically naïve experiments of designers, research defined as living materials,

growing design, and biodesign has become of global interest. The results of this research emerged from laboratories, intriguing manufacturing companies that were interested in finding more cost-effective processes and materials. The DIY and biodesign trends have thus met in a dimension of acute crisis offering new hope for a more sustainable future.
This paper offers, through a critical overview of scientific and design literature, a contribution to design cultures by identifying the tendency emerging from the recent experimentations in the fields of biodesign and self-production. The dynamics observed are explained and related to the global emergency status due to the spread of the Sars-Covid-2 virus and the geopolitical effects of war. The observed route shows a strong influence on artifacts generating and producing processes, but also on their symbolic, expressive, evocative, and aesthetic aspects.
The paper explores different experimental paths related to emerging design-based practices such as bio-design, growing design, living and DIY design.
This scenario is explored also through the description of projects developed in teaching and research activities carried out by the author in the Hybrid Design Lab characterized by a new vision of bio-autarchy supported by a multidisciplinary research and project approach as well as from a long experience in the fields of design for environmental sustainability, upcycling and science driven design.

2. Material proximity

In the history of material culture, every emergency determines a trend of production based on the use of local resources for their accessibility (Skibo & Schiffer, 2008). From crisis and its resulting frustrations, innovation emerges together with the incremental evaluation of what can be produced through thrifty processes (Verganti, 2017).
Anthropological studies show how times of uncertainty have driven to seek reassuring solutions through history and nature. The primordial memory of the human being is nature, and it is from nature that design draws raw materials, inspiration and references to fight socio-economic crises.
The use of local resources, natural materials and self-production forced by the Sars-Cov-2 pandemic and Russian-Ukraine war evocates other historical periods that have been relevant for the Made in Italy productive culture, such as the autarky imposed to the country since the ‘20s and for the following decades (Giardina, Sabbatucci, & Vidotto, 1988, p. 504). It is in Italy in the ‘30s that the policies booted an industrial renovation based on the use of national resources to reach an economic and political independence in the production processes, reducing as a consequence the productive costs. A set of synergic actions were therefore based on investing on local renewable raw materials, on reduction of fossil fuels, electrification of transportation, substitution of imported materials with local equivalents for all the different productions (Saraiva & Wise, 2010). It is a striking case of how a politically sad and painful affair turned out to be an opportunity for the production system known as made in Italy, now appreciated and recognized all over the world (Finessi, 2014).

The Italian autarky has been defined as an "unintentional laboratory for ideas", anticipatory of the green economy (Ruzzenenti, 2012) and of the DIY (Do It Yourself) phenomenon together with the Markers culture in recent years.
In the autarky scenario of the '30s, the choice to refuse the use of imported materials was supported by the boost of local production of raw materials and by enhancing the production of surrogates of foreign materials through the vanguard chemical industry (Dal Falco, 2014). Incentives were given in the Italian territory and in the colonies to cultivate and process local plants such as hemp, cotton, flax, jute, broom and the more unusual horticultural plants producing mulberry for its derived *Gelsolino* and ramiè. Chemical research developed materials such as *Raion*, a derivative of the transformation of cellulose, similar to silk, and *Lanital*, a yarn obtained from milk casein, proposed as a substitute for wool (Doctor, 1941, pp.19-21).
The experimentation on materials occurred outside of chemical laboratories too, with research on fibers conducted by designers and artists while reinterpreting ancient techniques of wicker weave, knitting and crochet for home decor and fashion (Cuffaro & Vasselli, 2014, pp. 82-85). These experiments constitute a precious wealth of process approach and aesthetic references, instrumental for the current context of circular economy (Pecorario Martucci, 2017) and DIY materials.
The DIY approach has been strongly pushed, for several years, both from below through the maker movement, and from above through the action of universities, schools and design academies which have focused their attention on the processes, machinery modification, waste upcycling, and transformation of easily accessible materials, also including edible ingredients (Koskinen, Zimmerman, Binder, Redstrom & Wensveen, 2011).
The scenario of self-production, both analog and digital, is particularly inclined to involve local and sustainable material solutions developed to satisfy specific production needs (Salvia, 2016). For example, the sector of new materials for additive 3D printing is strongly interested in the use of new recycled, reactive, biodegradable material solutions, as hemp, fruit and vegetable waste, keratin, mycelium, or materials of marine origin like mussels, and chitin (Rossi, Di Nicolantonio, Barcarolo & Lagatta, 2019). This interest is a further reason to encourage designers oriented to face the economical crisis by focusing on new production visions based on local and customization values (Dassisti, & De Nicolò, 2011).
Furthermore, the choice to manipulate matter autonomously becomes an opportunity for designers to investigate the relationship between nature and artifice and the issues of sustainability, through the use of materiality rather than dematerialisation (Langella, 2021).
Designers have been interested in renewable, recyclable, and sustainable materials earlier than manufacturing companies and long before the current geopolitical crisis (Ljungberg, 2007). For example, new forms of upcycling of waste products or the reproposing of plant-based resins and fibers were experimented (Ramamoorthy, Skrifvars & Persson, 2015). To the rediscovery of the materials from the past, designers also associate the reinterpretation of techniques, procedures and tools traced in ancient ethnographic memories implemented through innovative tools too such as digital ones (Yuan & Chai, 2019).
In the empirical approach to the material, the work of design is based on aspects related to intuition, to synesthetic perception (Schifferstein & Wastiels, 2014), and to the instinctive

and emotional prefiguration of the fruitful experience that constitute the genetic heritage of design discipline.

Based on this deep-rooted experience, design thus found itself ahead of other fields coming up with bio-based and self-produced solutions in response to Covid19 and warfare induced resource constraints (Rognoli, Poblete, Bolzan, & Parisi, 2022). Design did not struggle to get used to the new post aesthetic crisis characterized by frugality, imperfections, and hybridization of biology and technology.

3. Biodesign and co-production between humans and nature

Contemporary design progressively integrates project and biology, giving nature an active role in design and production processes. In the meantime, design enters into natural processes such as growing of plants or the functionalization of microorganisms.

This mutual influence is represented in the term biodesign, used by Alexandra Daisy Ginsberg and Natsai Chieza to define the width of the relations between design and the bio universe. In their editorial *Other Biological Futures*, they state:

> If design is humanity's process for changing present conditions to other, preferred ones (to paraphrase political scientist Herbert Simon), then biodesign –which we broadly define here as the design of, with, or from biology– offers novel perspectives on what change could look like, for ourselves and other living things (Ginsberg & Chieza, 2018).

The paths of contemporary design and their hybridization with biosciences present an interesting scenario with multiple facets and potential. Nevertheless, the required interdisciplinary approach implies difficulties to translate the innovation into tangible results, mainly due to the lack of adequate methodological references.

The most recognized meaning of the term biodesign currently refers to the embedding of life (bio) into the product development process. This can occur early in the life cycle through the choice of bio-based raw materials of plant, animal, or microbial origin. In this case the raw material is not produced but grown or cultivated. This is the simplest solution of employing the concept of biodesign, the one most widely used, as in the case of replacing fossil-based polymers with bioplastics or mycelium.

However, the most interesting meaning of biodesign refers to the cases in which living organisms actively participate in the definition of the product remaining active within it. The living component could directly act during the artifact production process and not only as a material. This is the case, for example, of the *Fullgrown* project by designers Alice and Gavin Munro, which translate typical agricultural concepts and activities such as cultivation, grafting, and nurturing to make chairs, tables, and other hybrid furniture, unique and unrepeatable pieces grown as plants rather than produced as objects. This is such an iconic and emblematic experimentation that two of the chairs in the series were chosen by Louis Vuitton for their window display. From a speculative design experiment

with a veteran aesthetic, the project has thus become an icon of luxury fashion that is increasingly sensitive to issues of environmental sustainability. Furthermore, the living component may reside in the functioning of the product as in the case of lamps based on luminescent organisms.
Therefore, biodesign is based on a cooperation between design and biology, where organisms as plants, animals, bacteria, or yeasts are manipulated to produce innovative and sustainable artifacts (Myers & Antonelli, 2012). Cooperation is compulsory in the biodesign experimentation where designers farm microorganisms to produce materials as bioleathers based on nanocellulose from bacterial production (Gallegos, 2016), mycelium derivatives (Karana, Blauwhoff, Hultink, & Camere, 2018) or bio- luminescent materials containing algae or fungi (Barati, Karana, Pont, & van Dortmont, 2021).
In recent years, bacterial cellulose has been used in a number of areas ranging from cosmetics to clothing, accessories, and lamps. The ease of self-production and the symbolic value of replacing leather have decreed the great success of the kombucha-based vegan leather. The first scientist to introduce bacterial cellulose (BC) produced from *Acetobacter xylinum* was Brown in 1886. Subsequently, several bacterial strains were identified as cellulose producers. Bacterial cellulose has a three-dimensional structure of porous fibrils with dimensions in the order of 10-100 nanometres. Numerous wild and recombinant strains have been identified as cellulose producers, using various carbon sources as substrates, including various wastes.
The most industrially used species are *A. xylinum*, *A. hansenii* and *A. pasteurianus*, *Komagataeibacter*. In addition to wild-type strains, the bacteria are modified by genetic engineering principles to develop different mutant strains in order to improve BC structural characteristics and productivity.
Unlike plant cellulose, cellulose produced by microbial strains is purer and devoid of substances that are present in plant pulp such as hemicellulose, lignin, or pectin. In addition to purity, bacterial cellulose has excellent mechanical properties, a high degree of crystallinity, and water-holding capacity. These properties make it suitable for applications such as tissue engineering, drug delivery, cosmetics, food use and the manufacture of polymer nanocomposites. The insertion of inorganic or organic fillers has further expanded BC's application in many other areas, such as food packaging, thermo-responsive materials, biomedical device manufacturing and many others.
Fungi and mushrooms are other biological elements of large consumption in the biodesign self-productive world. All over the world there are companies producing mycelium-based products such as *Ecovative* or *Mogu*. These companies also provide kit for micelium farming oriented to food consumption or to introduce consumers to self-made sustainable simple products for domestic use, as the lampshades developed by *Ecovative* design in collaboration with Danielle Trofe Design Studio.
The use of mycelium leads to experimentation with complex three-dimensional morphologies by making molds through digital manufacturing systems to grow mycelium. It is interesting to use flexible silicone molds as they generate very detailed shapes. This opportunity offers the world of design a wide range of new and original expressive possibilities that translate into new forms of ergonomics and usability. Electronic devices, for example, embedded in the soft, undefined morphologies of mycelium, acquire a more natural, or-

ganic, and unique character. Despite using molds, however, each mycelium artefact has its own unique aesthetic qualities, variations in texture color and hardness. Differences that, in addition to the shape in which it is molded and the material of the mold, derive from the moisture content, temperature of its environment, and nutrients. Thus, a new generation of unique, irregular artefacts can be generated. Growing mycelium on a wood substrate, for example, produces better properties than physically mixing pure wood particles and mycelium (Sun *et al.* 2019).

Products with more complex behavior can also be made from mycelium. By integrating mycelium and genetically modified bacteria, programmable, self-ealing and sensing materials have been made (McBee, *et al.*, 2022).

In addition to looking for living organisms that can replace fossil-derived materials, designers are particularly attracted by the idea of transplanting vital features such as luminescence into objects. Bioluminescence of organisms and vegetables is one of the most investigated paths in biodesign research. Many companies, among which Philips, have been engaged in the development of lightening solutions that incorporate microorganisms in the devices in order to produce light. Owning a "living lamp" means taking care of a small ecosystem of microorganisms or algae that exchange light for care. These dynamics cause a reversal of the traditional paradigm according to which to illuminate an environment it is sufficient to operate a switch without being aware that the light is obtained by non-renewable energy (Barati, Karana, Pont, & van Dortmont, 2021).

Dutch designer Teresa van Dongen, has been conducting cross-disciplinary experiments between design and science for several years. The *Ambio* lamp and its extension in the form of the installation *One Luminous Dot*, developed in collaboration with the biotechnologists Bart Joosse and Richard Groen, incorporate bacteria (a particular species of Photobacterium isolated from octopus). These bacteria in order to be kept alive, and thus able to emit light, require a great deal of care from the user, in terms of nutrient and environmental parameters.

The works *Spark of Life* and *Electric Life*, produced in collaboration with the Center for Microbial Ecology and Technology (CMET) at Ghent University and the Flemish Institute for Technological Research (VITO) are, however, more advanced because they are more autonomous and require less care. Whereas in the first lamps the bacteria emitted light radiation directly, in the latter they release electrons as a waste product that are channeled into electrical circuits that power an artificial LED source. The microorganisms need to be fed very small amounts of vinegar, tap water and nutrients about once a week.

These experiments perfectly represent the concept of hybridization between organic and synthetic because they elude traditional demarcations. LED technology is, in fact, artificial, but it is powered by living microorganisms, hence natural entities, through a biotechnological device. It is virtually impossible to define these products as biological or synthetic because the two components are perfectly integrated.

For the development of these lamps, the designer collaborated with other disciplines, neology, and engineering. The involved team of biologists was already engaged in research on bacteria able to emit electrons, thus already aware of the possibility of channeling them as a source of energy. But the designer's intervention offered an opportunity to make this hypothesis tangible and to verify that using a single batch of bacteria is possible to power

four LEDs for the duration of an entire year. The Dutch designer was also able to work on prototypes through mutual collaboration with scientists, which resulted in progress in both the fields of design and microbiology. In order to obtain replicable industrial scale and affordable, close collaboration between design and science based on mutuality of intent and results is further necessary.
These experiments are a good example of the hybridation between biological and synthetic, slipping out of traditional definition thanks to their perfect integration.
Integration of living organisms in production can offer new opportunities for their multifunctionality and capabilities of growing, transforming, self-repair, sensing and adapting to the environment in an autonomous and sustainable way. They could be applied in a genuine version or modified using engineering tools, borrowed from synthetic biology to enhance these features or obtain programmable functionalities (reference: materials come alive). These biological materials can be composed entirely of living cells or be in the form of biocomposites with synthetic or living components.
Generally, however, product or material design experiences conducted by designers in collaboration with bioscientists remain relegated mainly to academic, niche contexts. These experiments mostly produce speculative artifacts of symbolic and communicative value that are presented in publications or in contemporary art galleries and museum exhibitions. They mostly remain difficult to apply to real production and thus improbably transferable to people's daily lives.
Meanwhile, the combined Covid19-geopolitical crisis of recent years has led bioengineers and biotechnologists to investigate more deeply, and in a more constructive way, the productive opportunities offered by synthetic biology and biodesign through new applications connected with new needs and emergencies such as biofoudries (Vickers, & Freemont, 2022).
A biofoundry is a facility that uses bioengineering principles and technologies to design, produce, and test biological systems for functional and productive purposes. These systems may include living cells, genetic circuits, and metabolic pathways. The goal of a biofoundry is to create new bio-based products and materials, such as biofuels, bioplastics, low-cost manufacturing processes, supplements, drugs, cosmetics, biological circuits, biosensors, and fine foods (Holowko *et al.*, 2021).
Biofoundries are based on the principles and methods of synthetic biology, which is the discipline that designs and manipulates living systems such as cells and enzymes through the development of new biological parts, devices, and systems with specific functions and properties. Researchers working in this field aim to redesign natural organisms and even build entirely new biological entities. Synthetic biology techniques include molecular biology, genetic engineering, metabolic engineering, and protein engineering. The goal of synthetic biology is to create more efficient, sustainable and economical biological systems to improve the quality of human health and the environment.
In recent years many biofoundries are being built and a *Global Biofoundry Alliance* has recently been established to coordinate activities worldwide (Hillson *et al.*, 2019).
In light of the enormous revolution generated by biofundries, an urgent need emerges for designers to have a thorough understanding of these new opportunities and to be able to intervene in these contexts by collaborating with bioengineers and biotechnologists to

reap the benefits of the prefiguration and experimentation work conducted so far in the field of biodesign.
In the book *Synthetic Aesthetics: Investigating Synthetic Biology's Designs on Nature* (2017), the authors anticipated these issues exploring the ways in which human values can shape the intersections of design, science, technology, and nature in the territories of synthetic biology and living matter design. The book includes contributions from synthetic biologists, artists, designers, and sociologists who express their views on the relationship between synthetic biology and design. The issue of the aesthetic impact of synthetic biology is explored by investigating new possible futures and the role of design and art in this transition, noting the similarities between synthetic biologists and designers that reside in the common aptitude for creating new products and applications. According to Alexandra Daisy Ginsberg design should be involved in these design processes in order to apply its visions and values to them.
Unfortunately, most of the projects developed by designers in this area remain fictions that defy the current capabilities of science and technology. However, even as fictions, they can help highlight important issues and even shape the future of this field to offer a contribution to a dimension that is foreshadowed as a possible future of industrial production, a biotechnological revolution that could bring the world closer to achieving the SDGs.
This scenario also represents a promise of authenticity and originality thanks to the detachment of young designers and digital craftsmen from a globalized production in which the product's homologation dominates (Rossi, 2015).

4. The bio-autarchic revolution

Before the Covid19 pandemia, the lifestyle adopted in the big cities was based on the presence of shops and services that allow to delocalize the food production phases outside the home, making the self-production of consumer goods unnecessary to respond to people's lack of time and fast-paced, hectic lifestyle. However, in recent years the increase in sensitivity to environmental issues and the quality of the products consumed, as well as the pressing need to introduce a circular economy model, require a complete rethinking of the food system in terms of consumption and production.
The interest for self-production or zero-kilometer food production leads to favoring more controlled and sustainable production systems and products than low-cost imported products, with heavy transport and cultivation costs both in economic and environmental terms. In the same way, the attention, and the search to adopt a sustainable lifestyle starting from nutrition has led to the development of food with a high nutritional content, also by discovering unusual foods such as sprouts, seaweed, or roots. Sensitivity to the nutritional quality of ingredients has repercussions on the rediscovery of ancient foods and processes rooted in the material culture of local territories through the filter of a holistic culture of well-being (Devi & Shetty, 2020). For vegans and vegetarian groups, it is a common practice to self-produce food goods within the home, such as tofu, seitan and food that is not always easily accessible. But today's trend toward self-organization is also

an opportunity to communicate sustainable disruptive messages aimed at demolishing clichés and overcoming people's cultural barriers as *Microgreen Icecream*, an ice cream sprout based, or *Swedish Neatball*, a version of Swedish meatballs produced with insects aimed at raising awareness and reducing meat consumption. A collection of these and other experimental recipes was published under the title *Future Food Today* by *Space10*, demonstrating the great magnitude of this phenomenon (Peruccio & Vrenna, 2019).
The food self-production trend that has spread over the last years of crisis, quarantine, fragility, and consumption revision has led people to prefer the option of controlling and self-managing the food process in order to be able to preserve their health and safety (Pulighe & Lupia, 2020). The DIY approach has manifested itself through the increase of home gardens and microgreens for vegetables; mushroom-growing kits; sprout farms; food waste reuse systems; fermented food such as kombucha, kefir and kimchi; and microalgae cultivation. The need to feel useful and busy during the domestic isolation required by ministerial directives and the use of manual activities were useful to reassure and provide a sense of control. Each activity was also often documented and shared through social networks, transforming the individual activity into a moment of sociability, although virtual.
After the end of quarantine, this trend has persisted and has generated new patterns of behavior and consumption based on self-organization. Rising restaurant and food prices due to the geopolitical crisis have further encouraged the DIY approach. But in this dimension of spontaneous and autonomous self-production, some technical aspects related to safety or efficiency have been neglected. People are hardly able to consciously check the safety of fermented food or yeast preparation processes also because these processes are conducted with inadequate homemade instruments that do not include parameter control or the possible proliferation of pathogenic microorganism.

5. Designing through life

The trend of self-production is evident in the food sector but also in the self-production of cosmetics, household cleaners, accessories, and materials. Food waste such as coffee or fruit peels, efficient microorganisms, plant sponges like loofah, and bacterial cellulose made from kombucha are just some of the self-productions based on biodesign principles that can be made in the domestic environment.
This trend is not a novelty connected to the pandemic and war, but the restrictions induced by the crisis has resulted in an explosion of the phenomenon. While previously the DIY activity was associated to the return at a more sustainable way of living fostered by millennials, shared through blog and videos on digital platforms, the uncontrolled success of biodesign homemade solutions risk to imply the proliferation of pathogenic microorganisms as result of uncontrolled productions based on fermentation or culture processes (Wolinsky, 2009; Delfanti, 2013; Delgado, 2013; Jefferson, Lentzos & Marris, 2014).
This phenomenon should not be interpreted as an unnecessary fad but may prove to be a great opportunity for a paradigm shift toward a new widespread sustainable awareness.

Curiosity and the need to safeguard health, the environment, and home economics leads more and more people to experiment with these practices, but if the results are not satisfactory, they are easily abandoned. For them to become established and to have mass virtuous effects, they must be supported by facilitating tools that can improve the results and safe conditions.

This is where the role of design comes into play, which must make up for this lack of awareness. It would be necessary to switch from the spontaneous dimension of the DIY recipe to a scientific-like protocol mediated by the design discipline. Design can translate new needs that have emerged from the emergency and new scientific and technological opportunities into everyday products that can enter people's lives by ensuring efficiency, effectiveness, usability, affordance, safety, acceptability, ergonomics, and integrability. Through the development of devices scrupulously conceived in their structure, morphology, selection of materials and technologies designers are able to facilitate, and guide correct and safe self-production, including dosages, growth control, administration of nutrients, and physical parameter control (humidity, temperature, pressure, time, light) accompanying users in the proper use.

The ability to communicate scientific processes through a simple language and a graphic visualization of data are also other peculiarities of design that can be put at the service of this new tendency. In this way, design intervenes as a facilitating agent for the adoption of healthier and ethical behavioral models, raising the bio-autarchic dimension to a dimension of scientific self-production (Di Renzo, *et al*., 2020).

Based on this scenario several projects were conceived as part of the *Biodesign project* conducted in the Hybrid Design Lab, a research and teaching laboratory dedicated to collaboration between design and science founded in 2006 at the Second University of Naples, since 2023 hosted by the University of Naples Federico II. The lab activities are conducted in collaboration with researchers from different disciplines, universities and research centers.

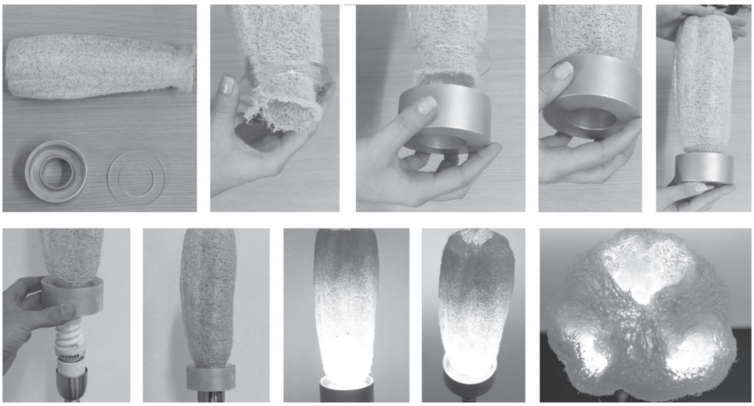
The *Biodesign project* investigate opportunities to interpret through design the tendency to graft natural living matter into self-production processes by facilitating them and making them more efficient and safe.

The design can assist, for example, the cultivation of functional plants such as loofah, a vegetable sponge that can be used for cleaning the body and the home, through self-monitoring greenhouse pots that allow careful control of environmental parameters including a sprouting machine that helps to manage the difficult process of humidification and control of the sprouts. Innovative design solutions can conceive small domestic bioreactors to produce microalgae such as spirulina for nutraceutical use or Effective Microorganisms (EM) that can be used in the self-production of detergents and purifiers for water. Design can prove useful in making the growth processes of functional organisms and their transformation into products more efficient and safer.

In those cases, in particular, in which microorganisms self-production could induce the proliferation of pathogenic microorganisms and require compliance with very rigorous protocols conceive devices that induce people to a correct use, facilitating self-production and making it actually convenient as well as not very burdensome.

The frenetic rhythms that characterize contemporary people's daily lives be compatible with the paradigm of self-production, thus most of the good intentions to self-produce in order to access cheaper, more ethical and healthier products fall due to the lack of time and energy necessary for these complex processes.
Design can also support the final user through products that integrate technologies of simplified automation, as Arduino, partnering them in daily actions and reducing the efforts, or suggest alternative uses for natural grown plants.
This is the case of *Loofah Light*[1], a project developed in the Hybrid Design Lab based on a kit to regenerate and customize old lamps, consisting of a light diffuser made of a vegetable sponge called loofah, a connector that allows to mount it on any type of table lamp and a bag of seeds and related instructions for planting and growing other diffusers.
In this way, design intervenes in encouraging reuse, thus avoiding the costs of disposal and replacement of unused objects, but also allowing the user to customize artificial objects by inserting a biological component obtained through an interaction between man and nature, in which the plant requires care and constancy but at the same time offers the possibility to choose the degree of growth and therefore the size and morphology of the cultivated part *(See Figure 1 and 2)*.

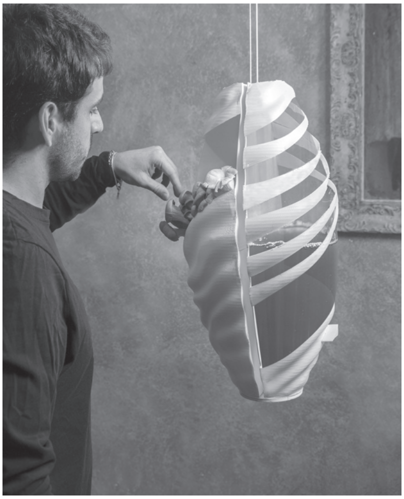
1



2

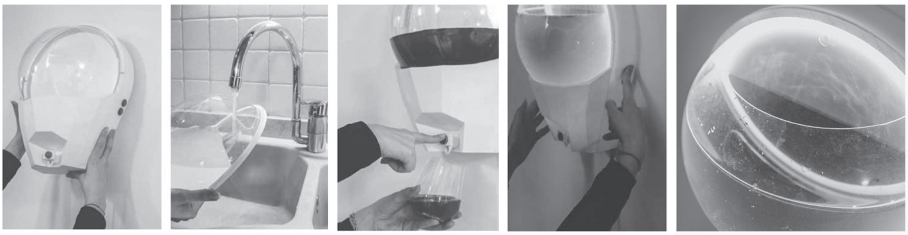
Figure 1. Loofah Light. **Figure 2.** Loofah Light, life cycle scheme.

In response to the need for easy and safe cultivation of microorganisms, the project *Vita*[2] was born. The project proposes an innovative artifact, bioinspired by the marenka gourd, aimed at addressing the emerging need to self-cultivate functional microorganisms for domestic purposes. The device takes the form of a multiple pot that can be suspended from the ceiling and placed in the area of the house most appropriate for light and functional proximity, such as to the kitchen. The object is divided into three sections and must be connected to the household electrical grid like a chandelier as water, nutrients, and possibly light are released into each of the segments according to growing needs.
Each of the three sections is structured to accommodate a different crop. The first segment is dedicated to the cultivation of edible mushrooms of the *Pleurotus* family (*Pleurotus djamor*, *Pleurotus salmoneostramineus*, *Pleurotus ostreatus*, *Pleurotus citrinopileatus*), which are a very viable, sustainable, healthy, and economical food solution since they have high nutritional value, are rich in protein and low in fat and sugar, an ideal food for vegan protein diets that are very successful. Mushrooms also can be grown on food waste substrate such as coffee (Thielke, 1989). The compartment looks like a jar, equipped with a timed water vaporization system, in which the substrate with spores is placed. Slits placed in the small door protect the root and allow portions of the fungus to be cut out as needed for food.
The second compartment is dedicated to micro algae. It has the characteristics of a small electrically powered bioreactor, which maintains the temperature and chemical composition of the water in the required parameter range, with a transparent surface that must face the external light source then possibly the window (Tibor *et al.*, 2022). It is proposed as a tray in which micro algae, particularly spirulina, are placed. Spirulina is a high protein food. It has a high content of protein, vitamins and minerals and can be taken both as a food and as a dietary supplement. Through a tap, it is possible to take desired doses daily and have a continuous source of spirulina. This compartment can also be used to cultivate effective microorganisms (EM) for various uses such as gardening or household cleaning.
The third compartment is dedicated to growing sprouts and features perforated shelves and a vaporized, timed watering system. Sprouts have excellent nutritional characteristics: they contain high percentages of protein, vitamins, minerals, and other beneficial substances such as fiber, essential fatty acids, and metabolic enzymes. They also fall among the detoxifying and antitoxin food and do not lose nutritional content, unlike vegetables that once harvested gradually begin to lose nutritional power (Mir *et al.*, 2021). The same sprout compartment can also be used for hydroponic growing of small vegetables or herbs.
The system is flexible because it allows different types of crops with similar characteristics, needs and growing parameters to be varied for each compartment. In addition, the coexistence of different crops is motivated by the choice of using the waste of some cultures as nutrients for other cultures in this way a symbiotic and sustainable system is created.
Another unique aspect is the modularity of the components, which are easy to repair or upgrade, greatly reducing maintenance costs *(See Figure 3)*.



3

Figure 3. Vita.
Figure 4. Boostglow.



4

The integrability of these tools in home environments is a very important aspect. *Boostglow*[3] is a bioreactor for the domestic cultivation of spirulina algae for food and cosmetics that integrates into the home context thanks to its aesthetic conformation, assimilating it to an illuminating element. The technical properties are not predominant in the project, which fits discreetly into everyday domestic life. The self-production of the alga constantly ready for direct consumption, also increases food awareness in the user *(See Figure 4)*.

6. Conclusions

The lesson we must learn from the integrated crisis (Covid19-War) experience is that improving the quality of life of people and earth must be the common goal of designers, companies, scientists, technologists, and politicians. To proceed in this direction, the culture of design must keep up to date on the paths of science and innovation and propose itself as a bridge of connection with society and with people's daily lives, responding to emerging needs related to the improvement of the quality of contemporary living. People, who were once called consumers, are now actors of change and must be facilitated by designers and scientists to implement this change consciously, through tools and protocols born from the encounter between design and science. Thus, a new generation of hybrid devices is born, designed for the self-production of food, accessories, light, furnishings that predispose users to implement clean, controlled, efficient and effective processes. The experiments described in this paper represent this trend and interpret well the concept of hybridization between design and science, between biological and synthetic, between self-management and predefined protocols since they escape the traditional demarcations of the past to outline a new universe of opportunities and solutions to complex problems. The proposed projects are emblematic of the contribution and role that design can play in biodesign. As it interprets contemporary trends and needs related to the thrusts of sustainability, health, and affordability by translating these needs into novel products that will design the domestic landscapes of the near future sustainable.

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Notas

1. Design: Piera Di Marino, scientific coordination: Carla Langella, Second University of Naples, Hybrid Design Lab.
2. Design: Francesco Gaudino, scientific coordination: Carla Langella, University of Campania Lugi Vanvitelli, Hybrid Design Lab.
3. Design: Ambra Pegoraro, scientific coordination: Carla Langella, Francesca Toso, University of Venice IUAV in collaboration with Hybrid Design Lab.

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Resumen: La pandemia de Covid19 y la guerra entre Rusia y Ucrania han tenido un impacto dramático en la economía y los mercados mundiales. Las fluctuaciones incontrolables del suministro energético y de los recursos materiales, la interrupción de determinadas rutas comerciales y el aumento desproporcionado de los precios de la energía y, en consecuencia, del transporte, han llevado a reevaluar los conceptos de localismo y cadenas de suministro cortas. A la luz de esta transformación radical en el sector del diseño, fenómenos emergentes como el biodiseño, es decir, el uso funcional de organismos vivos en el proceso de producción de artefactos, toman el relevo con un papel fundamental y representan la esperanza de un futuro más sostenible, basado en los valores de la renovabilidad, la autoproducción y la proximidad.

Palabras clave: Biodiseño - Autoproducción - Sostenibilidad - Hibridación - Proximidad - Diseño en crecimiento

Resumo: A pandemia da Covid19 e a guerra Rússia-Ucrânia tiveram um impacto dramático na economia e nos mercados globais. As flutuações incontroláveis no fornecimento de energia e recursos materiais, a ruptura de certas rotas comerciais e o aumento desproporcional dos preços da energia e, conseqüentemente, dos transportes, levaram a uma reavaliação dos conceitos de localismo e de cadeias de abastecimento curtas. À luz desta transformação radical no setor de design, fenômenos emergentes como o biodesign, ou seja, o uso funcional de organismos vivos no processo de produção de artefatos, assumem um papel fundamental e representam a esperança de um futuro mais sustentável, baseado nos valores da renovabilidade, autoprodução e proximidade.

Palavras-chave: Biodesign - Autoprodução - Sustentabilidade - Hibridização - Proximidade - Projeto de crescimento