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What will we be made of and what will the world be made of?

Sciences and technologies are extending design fields, modifying materials and everything that surround us, even our body, redefining on a perceptive level the boundary between things and us.

To identify the actual evolution of the relationship between sciences, knowledge and design, the Madec (Material Design Culture Research Centre) of Politecnico di Milano, started in 2014 a wide debate with a series of contributions about innovation trajectories with well known scholars of many disciplines, researchers, professionals and companies. This public debate, entitled “Ideas and the matter” opens new options for design action today, new ideas, and the definition of design approaches, contributing to the development of a new methodology of creativity-driven material innovation that, in a world full of opportunities but also problems to be solved, helps design to play a role of “giving new meanings”, through designing materials and things with a critical approach. This is a mission designers cannot abdicate, following the successes of “Design Thinking”, which was opening up to social innovation challenges and achieving creative solutions beyond the reach of conventional structure and method. At the same time, “Open Innovation” is a go-to process stimulating way of creating positive change in production.

This book is the compendium of Madec’s one-year research. The contributors of the book come from several and diverse disciplines (medicine, biotechnology, engineering, art, anthropology, architecture and design), which design thoughts are fed by.

madec
material design culture research centre

POLITECNICO
MILANO 1863

Marinella Ferrara
Giulio Ceppi

IDEAS AND THE MATTER

List

Marinella Ferrara & Giulio Ceppi

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DESIGN EXPERIENCES

IDEAS AND THE MATTER

WHAT WILL WE BE MADE OF AND WHAT WILL THE WORLD BE MADE OF?

MARINELLA FERRARA
GIULIO CEPPI

POLITECNICO
MILANO 1863

DIPARTIMENTO DI DESIGN

madec

material design culture
research centre

Material Design Culture Research Centre is the research center and network dedicated to materials for design of the Design Department of Politecnico di Milano. It deals with the relation design-materials among design history and actuality. The center carries researches on the Italian Culture of Materials Design, intended as the capacity of the Italian design to interpret materials and technologies in order to generate products and environments innovation. The research team is composed by: Marinella Ferrara (coordinator), Giampiero Bosoni, Giulio Ceppi, Sebastiano Ercoli, Chiara Lecce, and Andrea Ratti.

www.madec.polimi.it

CONTENTS

TOWARD THE BIOCENTRIC ERA. OBSERVING DESIGN HYBRIDIZATION

CHIARA LECCE

Madec, Politecnico di Milano, Italy

Go, take your lessons from nature, that's where our future lies
Leonardo da Vinci

Biocentric ethics merged at the end of the 1980s as environmental ethics that "extend the status of moral object from human beings to all living things in nature" (Yu & Lei 2009, p.422) starting from Albert Schweitzer's ethic of reverence for life (1987), Peter Singer's ethics of animal liberation (1990) and Paul Taylor's ethics of *bioegalitarianism* (1986).
This new environmental ethic approach called for a new prospective: "nature does not exist simply to be used or consumed by humans, but that humans are simply one species amongst many" (Bari, 1995), that translated means for *Homo Sapiens* is not superior to other species on Earth.
Biocentric ethics are founded on three main principles: "(1) All living things have an instinct to resist the process of increasing entropy, for keeping their own organization, maintaining their own survival and the wholeness of life; (2) Maintaining their own survival is a central aim for all living things, that is an intrinsic value and 'good'; (3) Although different living things have their own ways of organization and survival (different ways of self-organization and maintaining survival with different organisms), their values are intrinsically the same, and therefore they should have equal rights in morality, which means they should be given moral acknowledgement, concern, and protection". (Yu & Lei 2009, p.422-423)
More recently another exponent of the *biocentric* vision has been Robert Lanza, an American doctor and scientist involved into several researches of the medical use of human embryonic stem cells.
He affirms in his book *Biocentrism: How Life and Consciousness are the Keys to Understanding the Universe followed* (2009) that biology will be the most important above all the other sciences.
"Our theories of the physical world don't work and will not ever work as long as they will start to consider life and consciousness. Life and Consciousness, instead of tardive and secondary products appeared after billions of years of inanimate physical processes, are absolutely essential for our comprehension of the universe. We call this prospective *biocentrism*." (Lanza 2015, pp.13-14)

1. DESIGN HYBRIDIZATION: BRIDGING DIFFERENT DISCIPLES

Definition: in biology *hybridization* is the process of combining different varieties of organisms to create a hybrid. *In situ hybridization* (ISH) is a type of hybridization that uses a labeled complementary DNA, RNA or modified nucleic acids strand (i.e., probe) to localize a specific DNA or RNA sequence in a portion or section of tissue (*in situ*), or, if the tissue is small enough (e.g., plant seeds, Drosophila embryos), in the entire tissue (whole mount ISH), in cells, and in circulating tumor cells (CTCs). *In situ* hybridization is a crucial step for understanding the organization, regulation, and function of genes.[1]
The term hybridization could be applied today to many more fields (per se an explicative phenomenon of disciplines cross-fertilization): chemistry, linguistics, engineering and automotive, globalization theories and media.
I chose biology and genetics definitions because they are closer in their meanings regarding the process of design hybridization that I would like to analyze during this dissertation.
The design profession faced during the last two decades several political, social, economic and environmental conflicts. Accordingly, contemporary design panorama is seeking a great expansion toward many different directions in a continuous transfusion with other disciplines (from economy to computer sciences, from sociology to psychology, from engineering to biomedics), in a sort of attempt to resolve all the problems of the world. Borrowing the words of Paola Antonelli: "In the past 20 years, design has branched out in many new directions that have galvanized young practitioners, sparked business models, and set the worldwide education system on academic fire. There are many different ways in which one can be a designer today, working for instance on interaction, interfaces, the Web, visualization, typefaces, socially-minded infrastructures, 5D spaces, sustainability, games, critical scenarios, and yes, even products and furniture. In the coming decades, the rest of the world will catch up and design will be embraced as a methodology and philosophy by politicians, scientists and economists who are willing to have a human, holistic and constructive perspective on the world." (2011, p.110)
And this is exactly what is already happening. Theories of design-driven-innovation are invading all the managerial master courses, environmental topics are at the basis of all design schools, social design and service design are inseparable from product design strategies.
Complexity is the keyword and designers are asked to use their skills to create a better future.
Here emerges the concept of Hybrid Design: "It's a progressive notion about the multi-dimensional craft of 'doing things', as well as a reflection on the interconnectedness of all kinds of design within the economic and commercial fabric of society. […] Hybrid design breaks these professional silos and asks the design team to be aware,

1. https://en.wikipedia.org/wiki/In_situ_hybridization

intelligent and reactive to an eco-system of experts surrounding the design process. Hybrid designers re-design, re-think and, in time, reflect on their work in progressive new ways. Over time the work coming out of a hybrid design team is of a better quality, better suited to a complex physical/non-physical world and better positioned to weather the tests of time, society, and culture." (Amit, 2010)

Approaching design hybridization concepts the words of the American designer and educator Victor Papanek from his book *Design for the Real World* (1985) appear more actual than ever: "Design must become an innovative, highly creative, cross- disciplinary tool responsive to the true needs of men. It must be more research-oriented, and we must stop defiling the earth itself with poorly-designed objects and structures. [...] It is at the border between different techniques or disciplines that most new discoveries are made, most action is inaugurated. It is when two differing areas of knowledge are forcefully brought in contact with one another that, as we have seen in a previous chapter on bionics, a new science may come into being".

For Papanek the interdependence of various disciplines could be explained quoting a story by Buckminster Fuller: "In the last decade, two important papers were presented to learned societies, one on anthropology and the other on biology. And both these researchers were working completely independently. But it happened by chance that I saw both papers. The biological one was looking into all the biological species that have become extinct. The anthropological one was looking into all the human tribes that had become extinct. Both researchers were trying to find a commonality of causes for extinction. Both of them found the same cause independently - extinction is a consequence of over-specialization. As you get more and more over-specialized, you inbreed specialization. It's organic. As you do, you outbreed general adaptability. So here we have the warning that specialization is a way to extinction, and our whole society is thus organized." (1985)

Papanek in conclusion proposes three main tenets: "(1) Design of products and environments, on or off earth, must be accomplished through interdisciplinary teams; (2) biology, bionics, and related fields offer the greatest area for creative new insight by the designer; (3) design of a single product unrelated to its sociological, psychological, cityscape surroundings, is no longer possible or desirable. Therefore, the designer must find analogues, using not only bionics but biological systems design approaches culled from the fields of ecology and ethology."

And it will be exactly this last statement our core argument of the following paragraphs.

2. LESSONS FROM NATURE: FROM BIONICS TO BIO-DESIGN

Since the begging of human history, nature has always been a permanent lesson. Humans apprehended from nature rhythms, balances and energy and above all its uncontainable power of survival and defense.

The words of the famous German architect and engineer Frei Otto will help introducing the relationship between man and nature and its interpretation: "The idea that the objects of nature, especially objects of living nature, can be taken as a model has always moved many people. It is the base of many religions: 'God created the world with it plants, animals and man. What God created cannot be doubted, it is perfect. And the most perfect being – man – is made in his image'. It is certain that most biological objects can look back on a long evolutionary history, and because of this long selection of the less effective they may be considered optimized. Many biological objects, such as a few unicellular organisms (bacteria, radiolarians, algae, etc.) had reached a high degree of perfection already in their early developmental history, changing hardly or not at all ever since.

They have lived for millions of years, distinguishing themselves mainly by a very high adaptability to their surroundings and in particular to their hosts. [...] Many of the organisms living today are extremely complex systems." (Otto 1999, p.48)

And he also introduces *bionics* as the new science, the aim of which is "finally" to learn from nature. As an illuminated man of the XX Century he understands the importance of the nature lesson but he also admits the limits of his century to deeply comprehend all the mysteries of nature:

"[...] History best proves how little the model nature was exploited. No biological objects served as a model of the great inventions of humanity: the hammer, knife, wheel, the woven cloth, the bow, ect. One reason may reside the fact that living nature is so very complex that is difficult to really get to know it. [...] A technician observing living nature just cannot grasp living objects which die so quickly, are so sensitive, so complex and both so inimitable and strange. A biologist looking at technology sees how imperfect technical activity is." (Otto 1999, p.48)

Still at the end of the XX Century the referees to the natural world were associated more from a mechanical or formal point of view because of a lack of adequate technologies that were on their way coming in few years. And this necessity is also well explained in this passage by Giampiero Bosoni with Francesca Picchi: "The history of design in all its expressions - technological, typological, morphological and, we would add, poetic, has in diverse ways and with diverse results measured its strength against this unavoidable model of reference. [...] We do however care deeply about the fact that nature's lesson cannot be read only as an evolutionary mechanical, and in that sense exclusively technical principle. Nor perhaps, can it be learnt even from the mathematical-geometric point of view only, according to an abstract and purely synthetic conception of the system of rules. Nor, still less, can it be properly understood by tritely imitating its forms, emulating the form of organic growth with curved lines, soft masses or rounded figures." (1999, p.55)

2.1 Bionics and biomimetic

The term *bionic* was coined by Jack E. Steele in 1958, from the word *bion* (Ancient Greek: βίος), meaning "unit of life" and the suffix *-ic*, which means "like", so together "like life". Bionics focused on extracting shapes, structures and function from nature to create close copies of natural artefacts: it is oriented to a technological transfer between the natural world (seen as a highly optimized and efficient system) and human manufactures. Typical examples of bionic applications in engineering are the hulls of boats imitating the thick skin of dolphins, sonar, radar, and medical ultrasound imaging imitating animal echolocation or also the dirt- and water-repellent paint (coating) from the observation that the surface of the leaf of the lotus plant (the lotus effect).

Copying from nature is also the method defined by Roberto Cingolani in this book (pp.) with the term *atomic design*: nature as the most perfect system is the only model to pursue.

The name *biomimetics* was coined by the American biophysicist Otto Schmitt in the 1950s. A clear view of the potentialities of biomimetic approaches is reported by Jean-Pierre Ternaux, French neurobiologist, honorary director of CNRS, in his contribute to the book *The industry of nature: another approach to ecology*: "The use of biomimetics methodologies is above all concerned with scientific research, the aim of which is to facilitate the study of natural systems by laboratory reproduction of phenomena hidden in the complexity of real organisms. […] Apart from its interest in advancing knowledge relating to living organisms, the biomimetics approach offers the possibility of developing innovative therapeutic applications. In this context, current research concerns the development of nano probes and intelligent nano vectors and control systems to allow drugs ti be transported within an organism to target specific cells. Application of biomimetics methodology also concern improvement of diagnostic techniques by the development of high-quality molecular imaging, the production of biomaterials for restorative surgery, the development of new virtual-reality and augmented-reality technologies in the service of both the health and pathology of mankind. Just like mimicry which concerns not only the individuals of a species but also their relatives and their social organizations, biomimetics today takes inspiration from knowledge acquired in the domain of ecosystem organization, or more generally from the functioning of living organisms, to better integrate organizational principles and human technologies in the societal domain." (2012, p.17)
Lastly Ternaux introduces synthetic biology discipline which relies on the same principles of biomimetics: "This relatively new scientific field combines research in the fields of biology with engineering principles, aimed to design and construct (synthesize) new biological forms and systems with controllable functions. In this field, the use of the principles of biological engineering, such as *in vitro* models, standardization, normalization, automation and computer-aided design, all contribute to simpler, faster, less expensive processes to modify living organisms".

2.2 Biomimicry

Since the beginning of the XXI Century progresses in biological research have made great leaps forward. Molecular biology and genetics, "have permitted to unveil logics, principles, languages and codes on which nature is based, from the macro-scale down to the molecular level and beyond. […] In this regard, inspiration from nature has a much broader significance, oriented towards the transfer of biological principles and logics". (Langella 2010, p.295)
Here we can introduce the term biomimicry, from the Greek *bios*, "life", and *mimesis*, "imitation". Biomimicry's main theorist is the American naturalist Janine M. Benyus who proposes for the first time this new approach in 1997 with her book titled *Biomimicry: Innovation Inspired by Nature*.
"The biomimics are discovering what works in the natural world, and more important, what lasts. After 3.8 billion years of research and development, failures are fossils, and what surrounds us is the secret to survival. The more our world looks and functions like this natural world, the more likely we are to be accepted on this home that is ours, but not ours alone."[2]

Benyus explains that she started to understand the "real lessons" from nature studying wildlife habitats and behaviors: "Where ecology meets agriculture, medicine, materials science, energy, computing, and commerce, they are learning that there is more to discover than to invent.
[…] Our fragmentary knowledge of biology is doubling every five years, growing like a pointillist painting to a recognizable whole. Equally unprecedented is the intensity of our gaze: new scopes and satellites allow us to witness nature's patterns from the intercellular to the interstellar. We can probe a buttercup with the eyes of a mite, ride the electron shuttle of photosynthesis, feel the shiver of a neuron in thought, or watch in color as a star is born. We can see, more clearly than ever before, how nature works her miracles. […] We realize that all our inventions have already appeared in nature in a more elegant form and at a lot less cost to the planet. Our most clever architectural struts and beams are already featured in lily pads and bamboo stems. Our central heating and air-conditioning are bested by the termite tower's steady 86 degrees F. Our most stealthy radar is hard of hearing compared to the bat's multifrequency transmission. And our new smart materials can't hold a candle to the dolphin's skin or the butterfly's proboscis. Even the wheel, which we always took to be a uniquely human creation, has been found in the tiny rotary motor that propels the flagellum of the world's most ancient bacteria."[3]
The chapters of the book define all the fields of action of the Biomimicry Institute founded in 2006 by Janine Benyus and Bryony Schwan:

"Nature runs on sunlight.
Nature uses only the energy it needs.
Nature fits form to function.
Nature recycles everything.
Nature rewards cooperation.
Nature banks on diversity.
Nature demands local expertise.
Nature curbs excesses from within."[4]

One of the most interesting and useful contribution of the Biomimicry Institute is the platform called "AskNature" created and launched in 2008 as "an audacious project" seeking to catalog and present all the biological knowledge collected in the form of an open source database for designers, architects, entrepreneurs and all "that non-biologist innovators across disciplines".[5] Their database is structured in two main sections: Biological Strategies and Inspired Ideas (design solutions to human challenges, inspired by biological strategies).
Biomimicry approach has led significant applications developed by laboratories, companies, designers from all around the world.
This approach involves both the natural and the artificial world generating new projects that could include a wide range of typologies: products, materials, energy production, systems, architectures and even organizational and systemic strategies for sustainable solutions (Bistagnino, 2009).
Bio-inspired design is a form of adaptation to the complexity of contemporary age triggering a contamination process between natural sciences, bioengineering, design and many other different disciplines. (Salvia, Rognoli, Levi 2009) This process has been

defined also Hybrid Design by Carla Langella from the Second University of Naples and from the Sapienza University of Rome. (Langella 2007)
"The definition 'hybrid design' derives from the field of tissue engineering: hybrid biomedical tissues are obtained in laboratory using techniques reproducing biological processes of cell growth. When implanted in damaged areas, hybrid tissues, albeit designed, processed and characterized following an engineering approach, are perfectly compatible with the biological organism, responding, therefore, to specific medical needs. In the same conceptual way, hybrid design prefigures artefacts with characteristics which are intermediate between nature and technology, and whose genesis and evolution can in itself be defined as hybrid. Hybrid design, therefore, widely refers to technological transfer from fields with high scientific and technological content. This transfer constitutes not only a procedural and methodological approach, but also an inexhaustible source of available instruments and technologies, through which bio-inspired concepts are translated into hybrid products." (Langella & Santulli 2010, p.295)
The short following selectin of projects have been all generated by biological systems. They seek to a bio-inspired design which could be spread through several disciplines and different kind of applications.

Materials
BioFriend Anti-Microbial (2011) is a molecular filtration technology able to trap and kill microbes. Developed by Filligent (HK) Limited company this material takes form by a biomimicry solution: the sites on human cells which are able to destroys microbes surfaces (viruses) and cell walls (bacteria).
The *insecta* animal class is above all one of the most successful biomimicry subject. The *NanoSphere®* (2011) self-cleaning, and dirt-water-repellent fabric finish by Schoeller Technologies AG company, originated by observing butterflies' wings nano-scale surface structures able to repel water and dirt. Spiber[6] is a Japanese research company focused on proteins based material that should substitute plastics, metals and other synthetic materials in the future. In 2015 Spiber collaborated with The North Face company for the application of a spider fibroin-based protein material that is considerate on of the toughest material on earth, to create a new prototype of outwear clothes called "Moon Parka". Other insects-inspired projects are "fog-catching" materials.
Oxford biologist Andrew Parker and Chris Lawrence of QinetiQ studied tenebrionid (*Stenocara*) beetles in the barren Namibian Desert. The shell of these insects has a corrugated surface texture, these hydrophilic bumps surrounded by hydrophobic troughs allowed the beetles to collect water from fog in order to survive in arid environments. "The materials inspired by these beetles have many potential uses, including tent coverings and roof tiles for collecting water from fog in regions lacking access to fresh water".[7]
From the sea world, the Marine Biological Laboratory Woods Hole (Massachusetts) in 2012 started to study *Optical metamaterials*[8] from squids' skin which is able to perceive light and change color. Over squid's skin occurs a sort of signal processing, then the chromatophores and iridophores produce a colored pattern in response. "Mimicking this complex system could have interesting applications i.e. for camouflage and displays".[9]

Ecosystems
A smart biomimicry approach observes not only chemical and physical proprieties of living creatures but also how their ecosystems work. *Biolytix* water filter (2013) by Biolytix Water Australia Pty Ltd, is a water filtering system cleans without chemicals converting raw sewage, wastewater, and food waste into high quality irrigation water on site taking inspiration from forest wastes decomposing processes. "The system removes solid wastes from wastewater and then selected worms, beetles, and microscopic organisms convert the waste into structured humus, which acts as a filter to turn the waste into garden irrigation."[10]

2. http://www.nytimes.com/books/first/b/benyus-biomimicry.html
3. Ibid.
4. http://biomimicry.org/
5. https://asknature.org/
6. https://www.spiber.jp/en
7. https://asknature.org/idea/fog-catching-materials/#.WOKQ-BKLSi4
8. "Metamaterials" are a new area of research, enabled by advances in sophisticated sensing and materials production. Unlike other materials, these are inhomogeneous composites design to exhibit unique behaviors.
9. https://asknature.org/idea/optical-metamaterials/#.WOKOGxKLSi4
10. http://www.biolytix.com/

Fig.1 Spiber company collaborated with The North Face for the application of a spider fibroin-based protein material to develop a new prototype of outwear clothing called "Moon Parka".

Architecture

Of course architecture is one of the most involved discipline into the process of biomimicry. *Homeostatic facade* by Decker Yeadon (2014) is a self-shading system for buildings. Decker Yeadon designed a homeostasis biological based system made of a double-skin glass façade which reacts to the internal temperature of a building balancing it between through ribbons of an elastomer wrapped over a flexible polymer core.[11]

Plyskin by Lindey Cafsia from the Royal Academy of Art in The Hague (Netherlands) is an insulation material inspired by polar bear skin. "The polar bear can survive extremely low temperatures thanks to its efficient fur and skin which consists of three layers: the outer layer, the fur, consists of guard hair and shorter dense underfur, this fur is slightly translucent, so the heat of the sun can penetrate to the second layer, namely the skin. This skin is black, which absorbs the heat of the sun. The third layer is blubber and functions as insulation".[12] So she designed *Plyskin* insulation membrane which consists of three layers: the outer hairy layer is made from recyclable polyamide; the second layer has a honeycomb structure, which makes the panel tense, absorbing part of the heat radiation; the third is a black, empty layer filled with heat absorbing material, functioning as heat buffer. These two layers are made from PET and biobased PLA.

Energy

Clean energy is maybe at the base of a bio-inspired philosophy. Among many experimentation *Polymer-cellulosic batteries* (2009) by the Angstrom Laboratory (an interdisciplinary laboratory at Uppsala University, Sweden) uses algae cellulosic cell structure. Cellulosic batteries incorporate conductive polymers to form essentially a paper battery, but many problems with a limited surface area for charge storage pushed Angstrom Lab to look at *Cladophora* algae. It is a common type of green algae from the Baltic area and around the world. Algal cellulose actually has a fundamentally different nanostructure from terrestrial plant cellulose forming an excellent template for surface modification to include a conducting polymer.[13]

3. BIO-DESIGN

The exploration of these new stimulating and fascinating sciences chased the cross-pollinations among different disciplines brought to the definition of Bio-design.

"Bio-designers are turning their attention to familiar organisms like plants and animals. In some cases, they examine the less accessible world of bacteria and cells, while in others they purpose the creation of new living systems by directly manipulating DNA. This endeavor requires collaboration and interaction among different disciplines and is carried out chiefly in groups, raising implication that collide with our deepest belief. [...] Their work encouraged and celebrated in a few centers of "irradiation" of these new

11. https://materia.nl/article/homeostatic-facade-system/
12. https://materia.nl/article/plyskin-insulation-polar-bear-skin/
13. https://asknature.org/idea/polymer-cellulosic-batteries/#.WOKORhKLSi4

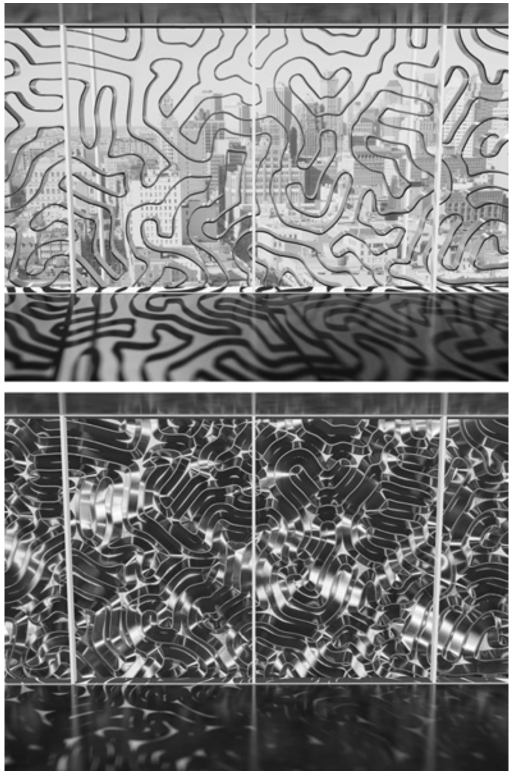

Fig.2 *Homeostatic facade* by Decker Yeadon, 2014.

Fig.3 *Plyskin* insulation membrane by Lindey Cafsia from the Royal Academy of Art in The Hague (Netherlands), 2016.

ideas, such as the Design Interaction program at the Royal College of Art in London, the Science Gallery at Trinity College in Dublin, and the Paris-based Le Laboratorie gallery and research center founded in 2007 by David Edwards, a professor of Biomedical Engineering at Harvard, which helped designer Mathieu Lehanneur propel himself in this realm. Many of them were featured in MoMA's 2008 exhibition *Design and the Elastic Mind* and are now part of the museum's collection." (Antonelli 2011, p.110)
Paola Antonelli recalls a series of works that stay at the border between art, design probes and biology. As in the case of Mathieu Lehanneur who developed between 2006 and 2007 a series of projects observing natural cycles reformulating new functions. He used plants and fishes to conceive new domestic appliances: the *O Oxygen Generator*, was a domestic breathing machine using oxygen-producing Spirulina platensis algae; the *Bel-Air* organic-filtering system, also based on plants - Gerbera, Philodendron, Spathiphyllum and Chlorophytum are among the most effective - absorbing the toxins emitted by manufactured goods in our domestic environment; and *Local River*, a home storage unit for live freshwater fish aquaponically combined with a mini vegetable.
Among many others, Antonelli mentions also the work of Tobie Kerridge, Nikki Stott and Ian Thompson's with *Biojewellery* (2007). They created rings out of the bone cells of a couple, which are extracted, harvested onto a bioactive ceramic scaffold and then combined with precious metals to finish the rings. (Antonelli 2011, p.113)
Neri Oxman is also another leading proponent of this hybrid scenario presenting her renewed opera at the intersection between computational design, digital fabrication, materials science and synthetic biology.

3.1 Bioutilization: Form follows Nature

While biomimicry focuses on the translation of biological principles into human-made technology, *bioutilization* directly leverages organisms or biological materials. Bioutilization is particularly useful in cases where replicating complex biological machinery or processes in our own technologies is unsuccessful, too time-intensive, or too difficult to be cost-effective. This last examples have been all generated using living organism as their material of construction.
Ecovative Design utilizes fungal mycelium (see also the exemplary work of Maurizio Montalti and his Officina Corpuscoli, p.71) to produce environmentally-friendly materials. Using mycelia and agricultural waste like corn stalks, the company has developed a compostable material as an alternative to plastic foam and other environmentally-destructive synthetics. Mycelia are grown on the agricultural waste, forming a matrix that binds the fibers together and results in a solid mass. The mass is heat treated to stop the growing process and then is ready for use. Ecovative's materials are used in packaging, building materials, and even surfboards, all with comparable performance and cost-competitiveness to other materials on the market.
Protein by Tessa Silva turns milk into bioplastic. "The project explores methods of processing the protein that can be extracted from milk, called casein, as a natural alternative to oil-based polymers. Casein can be turned into a bioplastic and it can be treated as a commercial thermoplastic allowing for compression molding, injection molding, or it can also be hand sculpted for a more crafted and organic results."[14]
That's It (2016) is a biodegradable packaging from algae-based material developed

Fig.4 Mathieu Lehanneur, *Local River home system*, 2008.

by Austeja Platukyte. During her final thesis at the Vilnius Academy of Arts (LT), she followed the Zero Waste philosophy searching for biodegradable packaging material. She chose algae based material, the agar, dissolved in water with calcium carbonate, and a vegetable based emulsifying mix that is used to impregnate the material: the result is a bowl-like packaging material. In 2017 the *Living Colour* bio-design research project born from the collaboration between Laura Luchtman and Ilfa Siebenhaar that explores the possibilities of natural dying with living microorganisms: bacteria. Together with the TextileLab in Amsterdam, they investigated on the idea of "Dancing bacteria": "the optimum growth conditions for bacterial pigments, ways to speed up the growth process and the possibilities of growing bacteria in patterns by subjecting them to sound frequencies. Asking 'What effect do sound frequencies have on the growth of bacterial pigments?' and 'Can we control the process of growing bacterial pigments?' This way we hoped to exclude random growth in order to upscale the bacterial dye process. Growing bacteria as a dye factory can lead to a more sustainable way to color the world."[15]

14. https://materia.nl/article/protein-turning-milk-bioplastic/

15. https://issuu.com/kukkadesign/docs/living_colour-ibook

Several multidisciplinary studios are also working on more artistic and future probing projects.
A strong example is the *Regenerative reliquary* (2016) by media artist Amy Karle. She grows bone along a biofriendly 3D printed lattice using medical CAD and human stem cells, using 3D scan data of bones from the California Academy of Science's collection and then rendering the data and applied generative algorithms to create sculptures. The Austrian Living Studio developed the *Fungi Mutarium* project in collaboration with Utrecht University in order to study a fungi food product able to grown on plastic waste: "growing food on toxic waste".[16]

4. CLOSING THE ISSUE: IS DESIGN A KIND OF MAGIC WAND FOR EVERYTHING?

Concluding this long overview over the world of Bio-suffixed new disciples and their interactions with design professions, I would recall a statement by Paola Antonelli that matches well also my point of view: "Experiments with design are often considered directional or speculative, and designers can indicate new behaviors and unexpected applications, a focus on human life that might at times elude scientists. Although I have shied away from the bombastic declaration that designers can change the world, thanks to these collaborations they just might." (Antonelli 2011, p.113)
Is not possible to pretend from designers to become maximum experts of synthetic biology, robotics, chemistry or materials engineers. And here comes again absolutely pertinent the words of Victor Papanek: "While the designer in any team situation may know far less psychology than the psychologist, far less economics than the economist, and very little about, say, electrical engineering, he will invariably bring a greater understanding of psychology to the design process than that possessed by the electrical engineer. By default, he will be the bridge."
Indeed, designers MIGHT be sensible collectors, attentive observers of both the natural, the artificial and the social world, seeking for open-collaboration, looking to biodiversity in order to avoid sterile self-referencing and waste expanding projects.

16. http://www.livinstudio.com/fungi-mutarium/

Fig.5 Ecovative Design, Mushroom® Packaging, 2015.

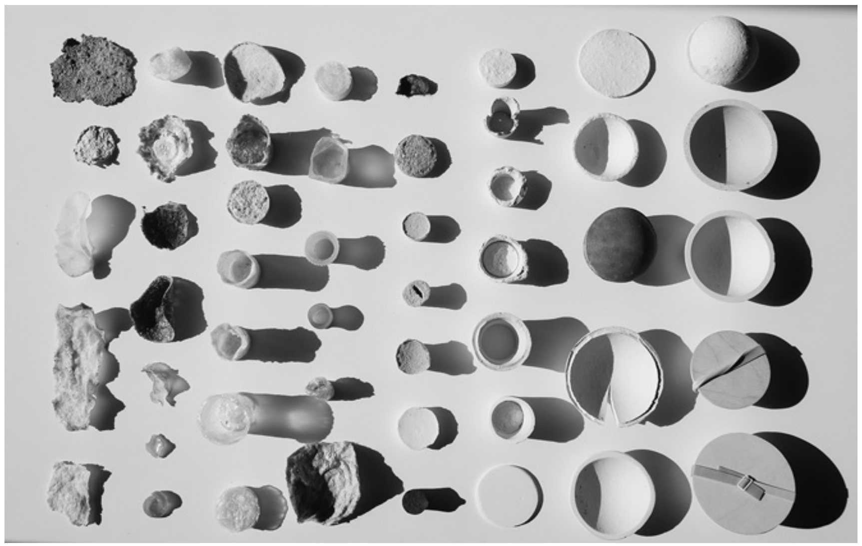

Fig.6 Austeja Platukyte, *That's It*, biodegradable packaging from algae-based material, 2016.

Fig.7 Amy Karle, *Regenerative reliquary*, 2016.

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ETHICS AND DESIGN IN THE 21ST CENTURY

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Reflecting on some of the contributions to the cycle of conferences headed "Ideas and matter"

During the cycle of conferences dedicated to the topic "Ideas and matter – What will we be made of, and what is the world going to be made of?"[1], the ethical question on conducting researches, designing and, especially, applying or producing the results of research and design, has risen time and again, in more or less open terms. The question has been raised in different meta-design contexts and through different thematic approaches, both as regards phases of theoretical research and as regards applied conditions and processes.
Although we all live in an age which, on various occasions and in several ways, summons all of us to social and cultural, if not actually political, commitment, towards certain issues of an essentially ethical nature, such as, for instance, ecological, health, privacy and cohabitation problems generally, the ethical question is not so frequently tackled in the field of design culture, at least not here in Italy. It was accordingly interesting and stimulating to establish a dialogue, within the School of Design of Politecnico di Milano, through a series of contributions, expression of quite a broad range of viewpoints, which offered us and up-to-date critical interpretation of the ethical issue in the field of design.
Let us start from the first contribution, put forward by the geneticist Giuseppe Testa, director of the Stem Cells Epigenetics at the European Institute of Oncology (and also, inter alia, co-founder of the PhD in fundamentals and ethics of Life Sciences), that introduced us to the extremely delicate topic of decoding the human genome, with all the ethical implications that concern the patentability of parts of our DNA, down to the well-known question marks raised around the debate relating to the notorious "embryonic stem cells". To give an idea of the extent of the problem, Professor Testa reminded us that "as stated in a book by the person who generated Dolly, Ian Wilmut, 'we have entered the era of biological control', and control – as Testa underlines – is of course an essential element of design: when one does certain things and designs them, he would then also like to control them somehow."[2] About this fundamental ethical aspect of control by the designer over the results of his own research, Testa warns us

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Marc Augé is one of the most influential anthropologist of the contemporary age. He is a French Ethnologist and anthropologist, he is renewed for his studies on contemporary worlds and his attention to the global and cosmopolite dimension that associate colonial communities and the Western world. He has been director of the École *des hautes* études of Paris. He elaborated the theory of “non-places” to refer to places of transience and de-culturalized that do not hold enough significance to be regarded as “places”. Theory expressed in his most relevant publications: *Un ethnologue dans le métro* (1985) and *Non-lieux: introduction a une anthropologie de la surmodernité* (1992). He has recently published *L'anthropologue et le monde global* (2013), about the paradoxical effects of globalization.

Giampiero Bosoni, Full professor of Interior Architecture and Exhibition Design at the School of Design of Politecnico di Milano. Architect and expert of Design History and Theory, he collaborated with Figini and Pollini architects, Vittorio Gregotti and Enzo Mari. He has realized several articles and collaborated with specialized journals and magazines: *Domus, Lotus, Abitare, Casabella, Interni, Ottagono, Crossing, Progex* (director), *Print, Rassegna* (editor), *Brutus Casa, Pluriverso* and others. He curated the exhibitions: “Museo del Design”, giving birth to the first core of the historic collection of Italian Design of the Triennale di Milano; “Made in Cassina” (Triennale di Milano, Tokyo, Paris and New York); “Il modo italiano. Italian design and Avant-garde in the 20th Century” (MBAM Montreal, ROM Toronto, MART, Rovereto). He is author of several books for Skira and MoMa among others.

Clino Trini Castelli, designer and design theorist. Frome the 70s he is pioneer of the emotional development of products identity and of the esthetic sustainability of the industrial sector. With Castelli Design studio he is involved into international activity concerning product design, strategic design and CMF planning and design. He is author of several publications and books about these topics and he perceives teaching activities by the main international schools of design. His work has been award with European, American and Japanese rewards, including ADI Compasso d'oro, the IBD Gold Award and IF Product Design Gold Award.

Giulio Ceppi, architect, designer and PhD. From 1990 to 1997, he was the coordinator of the Domus Academy Research Center, and from 2004 to 2007 the first director of the DA Master in Business Design. Since 1995 he is a researcher at Politecnico di Milano and a professor of Industrial Design in the Design School. His activities are focused on sensorial design, new materials and technologies, and design strategy. After the experience of senior design consultant at Philips Design (1998-2001), in 1999 he funded Total Tool, a design network (Milan, Buenos Aires and Tokyo) consulting and designing new business ideas, exhibitions. He's author of a number of books about innovation practice: Children, space, relationship (1997), Oggetti esistibili (2005), Design epigenetic (2009), Design Storytelling (2011), Awareness Design (2012).

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Fortunato D'Amico, graduated in Architecture, deals with transdisciplinary connections: art and architecture, philosophy and science, etc. He has been working on catalogs of various international publishers and has been producing some television broadcasts for the SKY network, such as Archibalena. He is among the organizers of the Dedalo Minosse International Award. He is the curator of the exhibitions such as: Vergilius d'Oro Prize and exhibition in Mantova, 2010; Architecture Laboratory in Milan, 2010; Nino Mustica: Pittura solida in Pietrasanta, 2010; Think Green, Milan, 2010; Chiara Dynys: Labirinti di memoria - Più luce su tutto - in Rome, 2010; Culture_Nature 2010, at Venice Architecture Biennale; Urban Solutions 2009 in Milan; Arte in Luce 2009 in Turin. He has been teaching with a temporary appointmente at the Politecnico di Torino, the Politecnico di Milano and the Accademia di Brera.

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Marinella Ferrara, architect, PhD, associate professor of Industrial Design at Politecnico di Milano, and the coordinator of MADEC (www. madec.polimi.it). Her research and teaching interests focuses on the relationship between design and scientific/technological innovation, with a particular focus on emerging materials. In the last years she has been engaged in the EU project *Design for Enterprises*, and in the Executive Board of *ADI*, coordinating the scientific committee for long-term professional development of designers. As an expert in the communication of the design contents, from 2011 she has been the editor in chief of the scientific journal *PAD. Pages on Arts & Design* and guest editor of *AIS/Design. Storia e Ricerche*. She is the author of over 100 publications among books, essays and articles in international journals.

Chiara Lecce, MSc, PhD in Interior Architecture & Exhibition Design. Since 2008 she is involved in History of Design classes and Interior Design Studios at the Design School of the Politecnico di Milano. Since 2009 she collaborates for the Fondazione Franco Albini and with other well known Italian design archives, other than continuing to work as a freelance interior designer. From 2013 she is the managing editor of the scientific Journal PAD (Pages on Arts and Design) and member of the AIS/Design (Italian Association of Design Historians), as well as author for several scientific design Journals. She is currently research fellow and lecturer at the Design Department of the Politecnico di Milano. Since 2016 she is a tutor among the European project “Design for Enterprises”.

Stefano Marzano, has been the former Chief Design Officer of Royal Philips Electronics for 20 years since 1991. He is the Founding Dean of THNK, the Amsterdam School of Creative Leadership.
Author and editor of several publications about design, till 1998 he has been professor at the Domus Academy in Milan and visiting professor from 1999 to 2001 of the Politecnico di Milano. He is member of the European Design Leadership Board. He received the honorary PhD in Design from the Sapienza University in Rome and from the Hong Kong University Polytechnic. In 2005 Businessweek nominated Marzano one of the four “Best Leaders: Innovators” in the world and in 2001 he has been awarded of the World Technology Award for Design from the World Technology Network.

Maurizio Montalti, is a designer, researcher, artist, and engineer. In 2010 he founds Officina Corpuscoli, a multidisciplinary studio based in Amsterdam inspired by living systems and organisms. The studio’s work has been internationally shown in museums, exhibitions and festivals. He is the co-founder of Mycoplast, a company focused on industrial scale-up of mycelium based materials. Currently he is co-heading the MAD Master at Sandberg Instituut, holding a Research position at Design Academy Eindhoven (DAE), as well as teaching in different national and international academies and universities. He is also co-founder and forming part of the Amsterdam-based WNDRLUST collective, alongside Mike Thompson, Sonja Bäumel and Susana Cámara Leret.

Michelangelo Pistoletto, Italian painter and sculptor, relevant exponent of pop art and Arte Povera, since the Sixties he has developed original artistic solutions, experimenting several materials and techniques, in order to actively involve the public inside his opera. Among the numerous recognitions received: the Leone d’Oro for his lifetime achievements at the 50° Biennale di Venezia (2003); the Wolf Foundation Prize in Arts (2007); the Praemium Imperiale of the Japan Art Association (2013).

Francesco Samorè, PhD in business history and business finance. Its main areas of research are: the structure and protagonists of the contemporary Italian economy and the analysis of energy utilities. He is the scientific director of Fondazione Giannino Bassetti, with the mission of promoting responsibility in innovation, following the relationship with affiliated institutions, both in Italy and abroad, on the four main operating areas: Innovation and Governance Responsibility; Responsibility for Innovation and Life Sciences; Responsibility for innovation and enterprise; Responsibility for innovation and risk. He has been collaborating with the Department of History Studies of the University of Milan (since 2006) and with the Department of Sociology of the Università Cattolica (since 2008). He is a member of the Italian Society of Economic Historians (SISE). Since 2006 she has been a researcher for the Business Culture Center in Milan.

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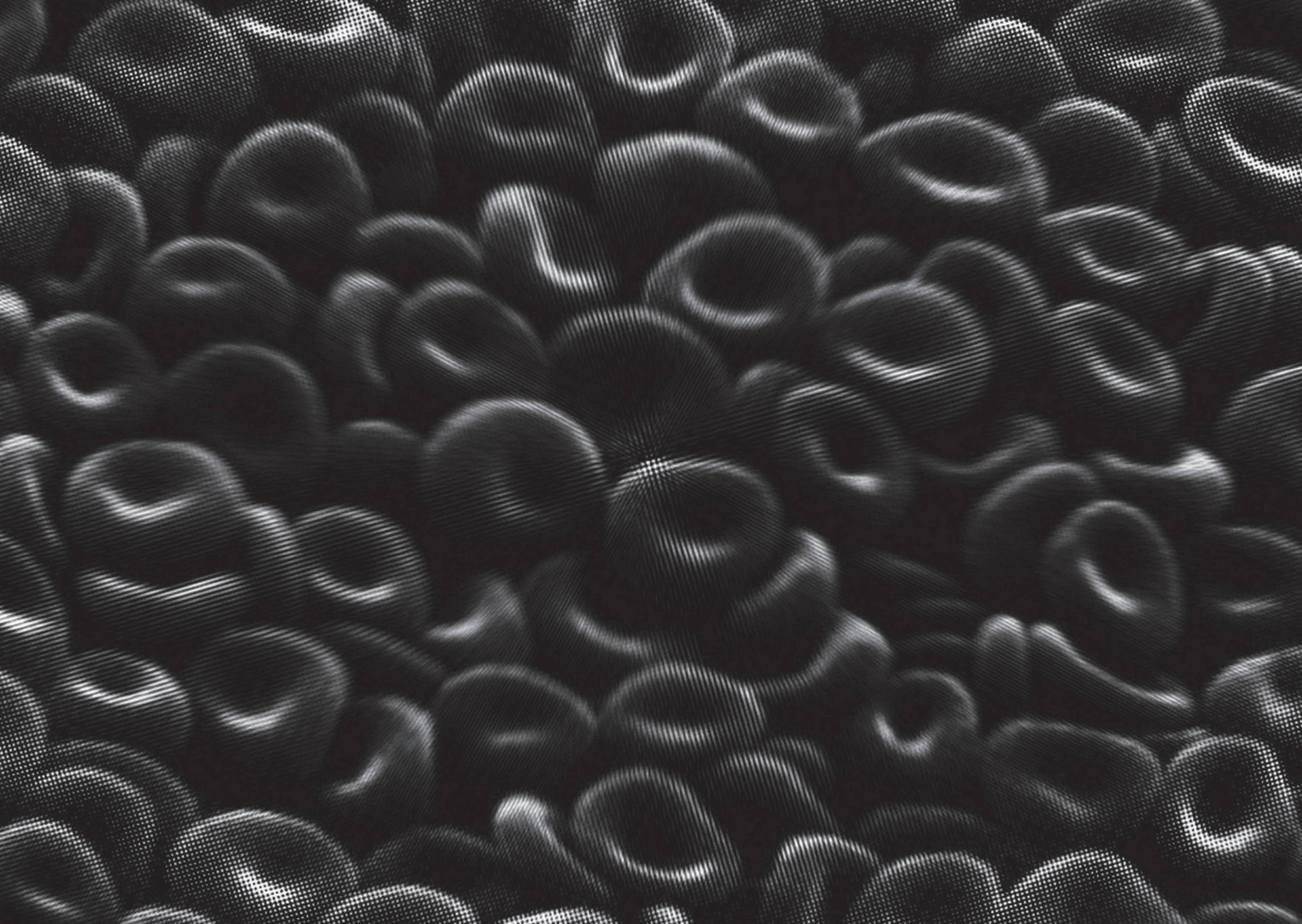

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