Biophilia,

//ACHIEVING HUMAN WELL-BEING

through fashion, nature & technology

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ABSTRACT

The bond between fashion, science and technology becomes tighter by the minute. Fashion today is equally functional as it is aesthetical. It serves as an immediate interface to the environment: a constant transmitter and receiver of emotions, experiences and meanings. Fashion Tech is at the moment in the forefront of a shift towards sustainability. However, it has been shown that sustainable proposals alone are not efficient without the appropriate involvement of sustainable consumers.

How can we stimulate effective change among them and persuade them to adopt the design solutions? Exploring the link between nature and well-being is an answer, with the aim of promoting a more sustainable relationship with fashion. By creating a symbiotic approach where the user perceives a valuable benefit for the environment and for himself, we could lead towards a behavioral change in the sector. Therefore, this research is the translation of Biophilia, understood as the innate love for nature, as a hypothesis into design of the Fashion System. Biophilic design within the fashion system will enable symbiotic relationship of bilateral wellness that merges environmental sustainability and well-being.

This research initiates with the identification of all the types of bio-inspirations that currently exist as design tools; exposing several examples of how they have been used in the context of the fashion industry. Next, the topic of wellness and fashion is explored, focusing on the new global trend of providing design solutions aimed at a more holistic well-being of the individuals. Likewise, the article explains how wellness in fashion is, more than just a market segment, an active attitude that leads the industry to be more conscious in decision-making and attitudes taken within the processes of the system. Finally, Biophilia is identified as a methodology and design tool for the realization of Fashion Tech projects that integrate the human being with his love for nature to obtain beneficial interactions of well-being. Since this is a methodology taken from architecture and interior design, my whole thesis is intended to provide a guide to the fashion designer and the industry to benefit from its revolutionary implementation.

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CONTENT

OBJECTIVES

- To describe the actual Fashion Tech framework related to environmental sustainability.
- To articulate and categorize the relationships between nature, human beings and designs of the fashion system enhanced by technology.
- To describe the wellness and wellbeing actual issues and trends and how they influence fashion.
- To translate the Biophilic Design concept into a Fashion Tech Design scenario, understand the potential opportunities, strategies, and considerations that fashion could harness when using biophilia to improve people's well-being and achieve a collective sustainability.

RESEARCH QUESTION:

Due to the recent pandemic quarantine, How Fashion Tech could be used as a link to connect humans with nature in order to achieve their wellbeing?

BIG TOPICS:

Fashion Tech

Bio-inspired Design

Wellbeing

Nature

Biophilia

.. "A new era of sustainable, ethical, intelligent, healing, more inclusive and meaningful clothing is on the rise!". (McGroarty, 2019)

INTRODUCTION

After spending long days in quarantine many of us found ourselves longing to go outside. We felt an immense desire to go out to meet our friends and family, but also a desire to rediscover with what was irreplaceable during our confinement, contact with nature and the sensations around it. Health and science experts have determined that deepening our connection to nature is extremely important for boosting our overall health, mood, and mental clarity.

In the contemporary world, fashion meets science and technology in a way that increases more and more. Fashion is today both functional and aesthetical as it is the immediate interface to the environment and a constant transmitter and receiver of emotions, experiences and meanings. For this reason, we should perceive technology not as something artificial that generates a distance between the human being and the natural, but on the contrary, as a tool or mean to reconnect with it and, rather than benefit from it, creating a symbiotic relationship where we also contribute to the care of our environment.

For this reason, Fashion meets Nature in multiple ways; from the use of colors, shapes and materials, till the use of more technological tools developing biotechnology. All in all, promoting humans' wellbeing through the healing powers of nature using fashion as medium. The hypothesis that humans have an inherent desire to seek connection with nature, known as biophilia, is being consciously integrated into fashion design. New fashion Biophilic trends emerge connecting fashion with the sense of wellness by leveraging the beauty of the natural world to seduce consumers overwhelmed by the modern digital era. Therefore, this thesis explores how Fashion Tech could be used as a link to connect humans with nature in order to achieve their wellbeing within an Activewear scenario, thus erasing all perceptions of technology as something artificial. The above, taking full benefits from the Biophilia concept combining it with technological materials and/or technological fashion innovations to improve humas' wellbeing.

My Natal country, Colombia, is worldwide recognized for the great importance we give to Nature, even calling it mother nature in our political constitution. The true potential of Colombia resides in our local roots, able to act anywhere as an inspiration. Our role as designers should be to create considering our culture in order to share the great values each culture could contribute to the world. All in all, I would also like to work on sustainability through fashion by «thinking locally, acting globally» and using the Colombian love for nature as a guide and inspiration for my researching.

LITERATURE REVIEW

Fashion //TECH

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"The 21st century will embrace the growing need to bridge the two brain halves; to blend the rational with the intuitive, to discern the mathematical with the instinctive and to fuse the technological with the anthropological". (Edelkoort, s.f.)

The fashion industry historically recognized for its constant novelty in aesthetic concepts has, since the end of the 20th century, also achieved technological innovations. Thus, Fahion-Tech is a term that describes the recent fusion between "fashion" and technology; fashion with technological innovation in materials, design, development and production, and user-generated experiences. For instance, nanotechnology improves the performance of materials, other materials grow in laboratories, it is designed with AI tools, algorithms are used for manufacturing, and fashionable experiences are generated with virtual and augmented reality.

When we talk about linking fashion with technology, we refer to the usage of scientific knowledge to solve problems within the industry. In fashion, technology can be applied to address issues of design, production, communication, retailing, and even marketing and advertising. In his book Fashionable, technology, Seymour states that the reasons for creating fashion with technology range from offering functionality, wanting to generate new forms of communication and personal expression to increasing the sustainability of the industry. (Seymour, 2008)

The Benchmarking Report of Fashion Tech made by E4FT (Education for fashion Tech) in 2017, states that fashion-tech is "a fragmented, disjointed reality that involves and activates various and heterogeneous professionals, disciplines, competences, methodologies, trends, products, and applications". Therefore for a better understanding of the this Fashion reality the same reports exposes three main areas were technology blends with fashion: Smart Textiles, Wearables, and Digital Manufacturing.

Wearables technological devices that are worn on the body that combine aesthetics with functionality. Could be embedded in garments, accessories, or jewelry and are designed to generate an interaction between the wearer and the external surrounding by generating responses o analysis of sensed data.

Smart textiles are defined as "knitted, woven, non-woven fabric systems designed to sense and response to external stimuli (mechanical, thermal, chemical, biological, magnetic and electrical) enabled by advanced, physical and digital technologies" (Education for fashion tech, 2018).

While Digital Manufacturing is a way of production enabled by computational systems reshaping design, production processes, distribution and retailing. Some examples are CAM, 3D technologies, robotics, AI and AR, IoT. Some objectives of using digital manufacturing tools are to enable open platforms and not centered distributed manufacturing that could be in large scale industrial systems, micro factory or DIY services allowed by digital platforms. Some shifts in the manufacturing process due to de introduction of digital manufacturing are on-demand manufacturing, and collaborative and on-site manufacturing (fab-lab and maker space). (Education for fashion tech, 2018)

Consequently, Fashion Design is today a synergy between designers, artists, engineers and scientists that develop innovation to promote all king of benefits for the human being enhancing its life quality. Since we are born, we are dressed in fabrics covering ourselves with the protective and comfort purposes. We use fashion as a second skin as clothes are in constant contact with our bodies. Textile and material science is nowadays developing in a super-fast pace in order to create innovative solutions to meet, exceed and even anticipate our users' demands. Today this benefits not only include performative characteristics as lightweight, insulating, cooling but also pretend to transmit outputs in responses to stimuli such as light, sound or smells. Smart Textiles are also capable of modifying their structure.

Finally, the lasts concerns in the development of Fashion Tech is to include sustainable production methods, some garments are today produced with waterless dying techniques and others that are grown in the laboratory with biological processes.

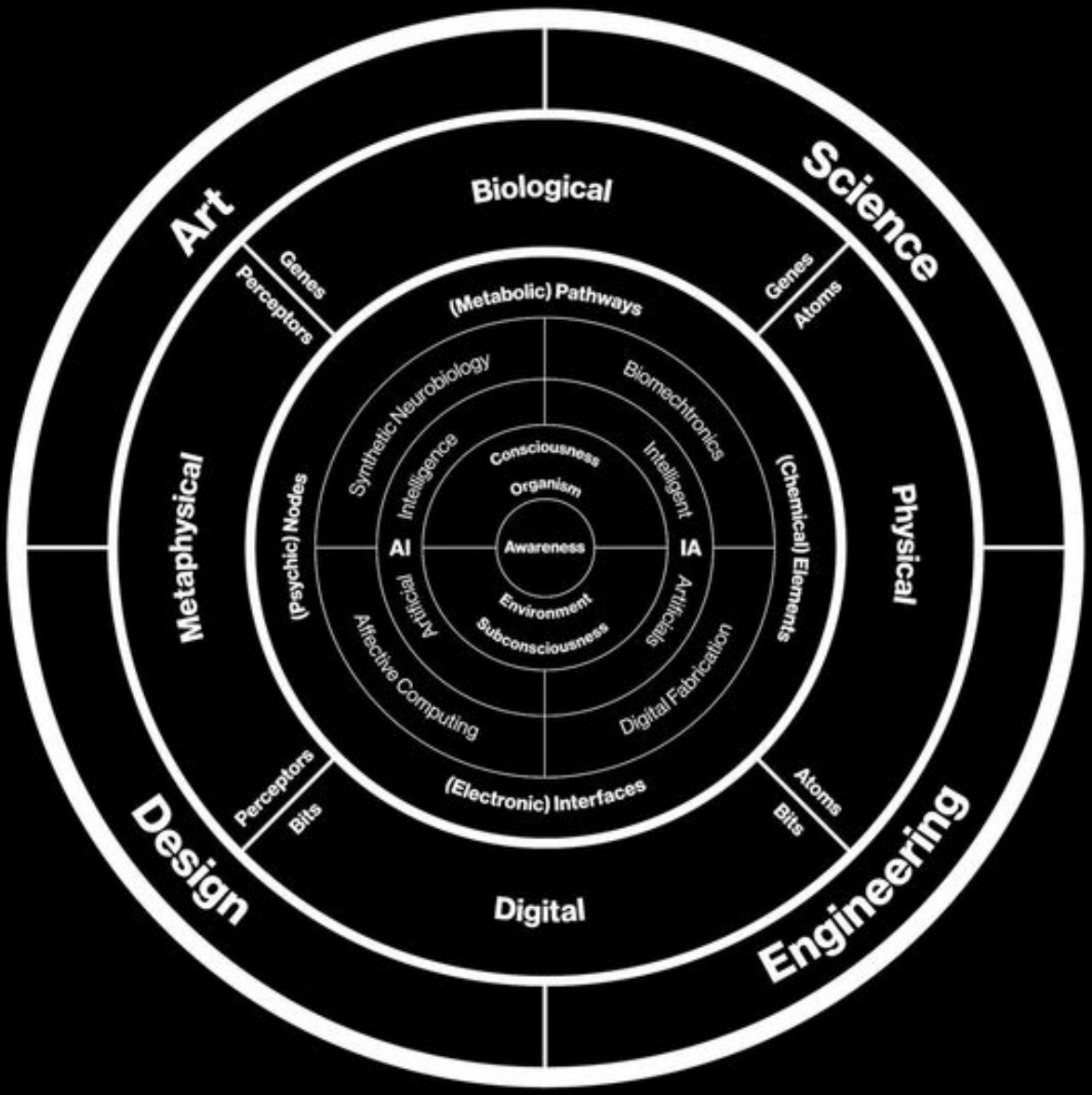
Krebs Cycle of Creativity III

Practice

Neri Oxman, March 2018

Key

Krebs I
Krebs II
Krebs III



FUTURE SCENARIOS FOR FASHION TECH

As Fashion Tech will be the promising future of fashion, the education sector has already shown some initiatives aimed at preparing new professionals with the skills required by this emerging fashion sector. Within the framework of European higher education, the University of Boras - Swedish School of Textiles, the Politecnico di Milano - Dipartimento di Design and the University of the Arts - London College of Fashion, teamed up to create a strategic partnership and developed several "intellectual outputs" to guide students towards a new educational path.

As part of the project, the E4FT (Education for fashion Tech) team published its benchmarking report in 2017 on Fashion Tech. Its main objective was to identify possible future directions for new fashion tech products, consumption habits and markets in the fields of smart textiles, wearable technologies and digital manufacturing. To achieve this, the research group combined trend forecasting methods that include desk research and the results of interviews with companies, research centers and university institutes.

The result was a recollection of 5 macro areas, which represent future scenarios in which products and projects designed and prototyped today should have their application potential: Protection and body enhancement through artificial second skin; Culture driven wearable: art, technology and innovation; Hyper-body: connecting senses and materials; Fashion Tech takes care ; Real/Virtual mixed environments. "These experimentations will envisage the human body as immersed in environments and spaces which are complex, extreme, an ever-changing reality which may be continuously remodeled and reshaped" (Sbordone, 2012)

It is important to emphasize the intention of E4FT to determine the marketability of the recognized future scenario, i.e. whether the designs within this category meet the attractiveness of investors or solve existing social needs or desires.

The same project team later presented a second report, addressed to higher Education institutions and similar stakeholders, which served as a kind of guide to train educators in how to develop integral students with fashion Tech capabilities and skills. This document also provided an updated research on the current status of Fashion Tech Designs and 4 different macro-scenarios for their possible application:

Only three years after the first benchmarking report, the future scenarios for Fashion Tech seemed less hopeful and more focused on taking measures to survive, to adapt, to express oneself or to distinguish oneself as a need to subsist, and since existence as a physical matter is not enough, it is now also a digital state. Therefore, categorizing the future scenarios for fashion Tech with a more user-centered approach, the sustainable scenario, before called "Fashion Cares" became part of a bigger scenario now called "Apocalyptic Life":

Certainly, nature is not satisfied with a crisis of climate and environmental change, but is giving us an additional shock with the unexpected pandemic of 2020.

A dystopian dimension where pollution, viruses, nuclear wars, exodus to new unexplored spaces will question the survival of human beings. (Education for fashion tech, 2020)

The fact that we have to react to a global emergency on the one hand, and to the already existing situation of drastic environmental damage on the other, places us in the context of a future dystopian world in which man has no place. This one, which is precisely the result of his indifferent and passive attitude towards the risk circumstances that have existed up to now. For this reason, design is faced with the task of creating solutions, materials, technologies and behaviors to reduce the chances of this future, or, on the basis of speculative design where there is no turning back, to create solutions that mitigate the damages caused and thus ensure human survival in a world with undesirable conditions.

"Tackling successfully all the complex scenarios mentioned above will be made possible thanks to a new generation of high-performance clothing. These items will be devoted to a wide range of uses, from shielding to filtering, from curing to nourishing the body, and they may even act as a kind of second skin to ensure protection and preserve the existence of humankind" (Education for fashion tech, 2020)

The following research is based on the sustainable path of fashion tech, incorporating fashion changes as a driving force for environmental and behavioral improvements and also

Fashion-Tech, Education and Research Benchmarching Report

#4. FASHION-TECH TAKES CARE

SUSTAINABILITY GOES ACROSS DESIGN, PRODUCTION AND RETAIL COVERING THE ENTIRE SUPPLY CHAIN AND IT IS INTENDED AS EFFICIENCY, RECYCLABILITY, TRANSPARENCY, MISSION ORIENTATION AND ETHICAL UPGRADES.

SOURCE
(area of application)
BIOLOGY
SCIENCE/EXPERIMENTATION ON MATERIALS
SUPPLY CHAIN MANAGEMENT

MAIN COMPETENCES
MATERIALS ENGINEER
TEXTILE ENGINEER
SYNTHETIC BIOLOGY
COMPUTER SCIENCE
FASHION/PRODUCT DESIGN
MANAGEMENT

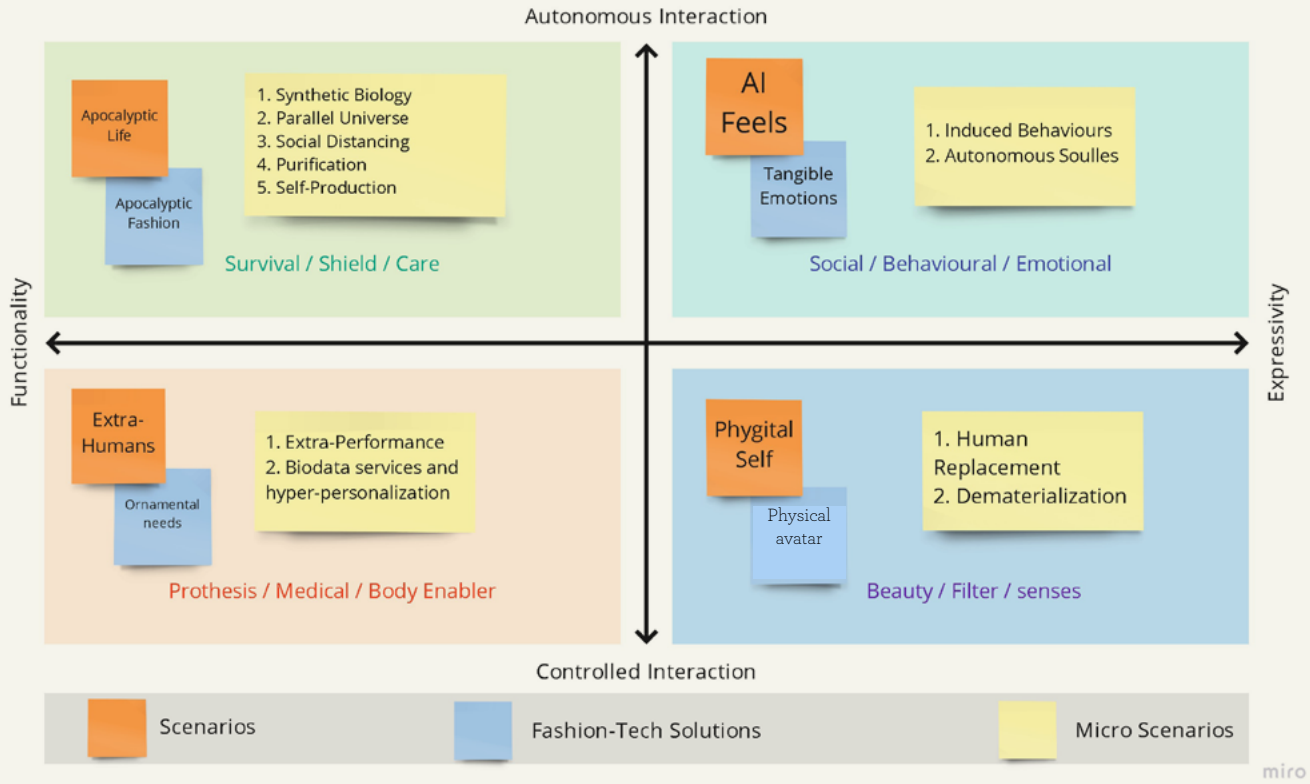
AREA
ST
WEARABLES
DM

LEVEL OF MATURITY

TECHNOLOGY READINESS LEVEL

MARKETABILITY
(consumer demand/industry offer)

APPROACH
TECH DRIVEN
DESIGN DRIVEN

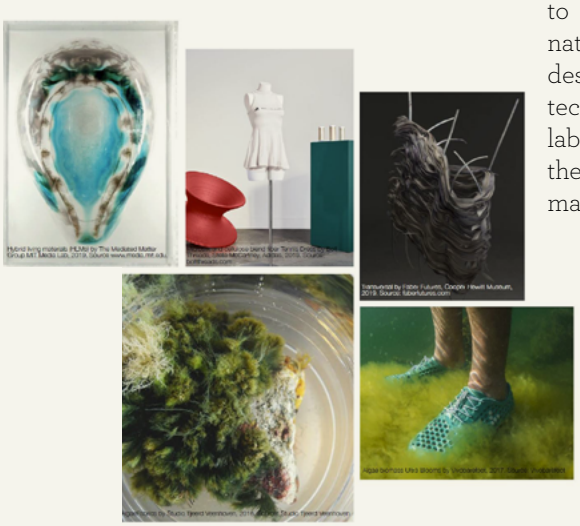


taking into account the increase in the well-being of the individual. In other worlds, this document examines various forward-looking innovations aimed at improving the quality of efficiency, circularity and overall sustainability, from biotechnologies to artificial intelligence applied within fashion in the form of wearables, smart textiles or production processes.

Following this order of ideas and keeping in mind the intention of linking nature with human beings through technology, 3 micro-scenarios from the "Apocalyptic Life" are of interest to the matter and will be explained below:

Purification:

Another Micro-scenario approached by E4FT is related with the possible pandemics due to the hidden viruses around us. It imagines a world that defends itself from them by "hygenization", thus everything, including our bodies, object and spaces, is scrupulously purified.



Synthetic biology:

Is the collaborative work between art, design and science to deal with the apocalyptic environmental context of global warming, pollution and extinction. This scenario is composed by topics such as Dark Ecology, synthetic biology, genetically engineered organisms concerning artists, designers and scientists exploring how to nurse nature back. Therefore, by being inspired by nature's perfection, the intention is to follow its logic and ways of proceeding to artificially emulate spontaneous natural processes. In other words, designers and scientists design new technological innovations by using the laboratory as a project studio where they create, cultivate and grow new materials with living matter.

Self-production:

Described in the report as the capability to be self-sufficient by selecting the right sources and tools even though general resources are limited. The idea of self-assembly technologies and designs may be also related.

This micro-scenario reminds a macro-trend proposed by the Unique Style Platform, a trend service that offers intelligent analysis to the fashion & style industries, about 5 years ago which they called "Creatification". It describes a DIY maker culture that lives in an urban context but has been sensibilized by rural ideologies. Therefore, rudimentary materials are combined with innovative technology to merge materials' science with nature in a framework of contemporary crafts. 3D printing and bioplastics influenced by the skins of fruits and vegetables, scientific exploration entangled with creative experimentation, or science-based material recipes with a DIY approach in the kitchen laboratory are some examples.

The trend-forecaster platform further describes this cultural approach with materials that "are carving out a new place in the textural palette. Bioplastics shift our perceptions of touch, while synthetically engineered plants take on a new lushness. Natural mimics synthetic and vice versa in a sensitive intermingling of tactility" (Lee, 2014). All in all, the whole "Creatification" Macro-trend could be described with using the following keywords: haptic, Balanced, nourish, handmade, original, scientific. To sum up, this cultural behavior describing a new era of makers lays ins the choice of materials' provenance and design intentions that establish preservation, design ecology and revival, in the hope to design for a more sustainable future.

Once understood the importance of Fashion Tech as a tool to guide the industry into a more ecological and sustainable system delivering interactions with a user centered approach but having also Nature as an important element in the formula, let's explore further the Fashion Tech's role in sustainability.

FASHION CARES - SUSTAINABILITY:

The current fashion system can be defined LINEAR in its three subsequent phases: produce, consume/use, dispose. This causes not only unfixable environmental problems but it also determines a huge economical loss. While companies started to reduce the impact of the current system by focusing on the production and disposal phases - using safe or recycled materials and implementing sustainable and effective processes – few initiatives are taken to address also the consumption/usage phase.

However, we are still far from a real change that we believe will happen only by attacking the root cause of the system's wasteful nature: clothing is massively underutilized. Worldwide, clothing utilization (the average number of times a garment is worn before it ceases to be used) has decreased by 36% compared to 15 years ago. Globally, customers miss out on USD 460 billion of value each year by throwing away clothes that they could continue to wear, and some garments are estimated to be discarded after just seven to ten wears (Ellen Macarthur Foundation, 2017). Fashion brands are designing clothes to be durable and long-lasting as a sustainable approach overconsumption, but the buying reason are not because clothes damage too soon because it has been prove that customers don't usually wear them until the end of their lifecycle. And this happens mainly because of fashion seasonality an lack of consumer education.

Given the issue of clothing underutilization, it seems necessary to find new ways to optimize the lifetime of a garment by converting its usage into value or strengthening the relationship and emotional bond of the user with the garment. In other words, it's value is not anymore its newness, but the experiences embodied and shared with several customers and the attachment created with it.

On the other hand, The concept of a curated wardrobe is emerging and is based on the need for wiser purchase decisions whereby each garment is seen as an investment, and thus wardrobe content is constructed slowly with valuable clothes. The smaller content but smarter collection of clothing choices in a wardrobe provides an alternative approach to fast fashion consumption.

Finally, other option to tackle the negative impacts of overconsumption is to work in regenerative materials, nurturing earth instead of generating wastes when cloths are thrown away.

Fashion Tech in the Quest of Material Regeneration

It's not new to hear that we live in a world of fast or disposable fashion, indeed since almost a decade ago there have been new intentions to change this regrettable situation in order to create a slower pace fashion. Among the many reasons why fashion is the second most polluting industry, are that it is increasingly impacting the environment due to the use of toxic chemicals, exaggerated amount of water and energy consumption, heavy transportation and lots of textile waste.

"Agricultural and industrial waste form the basis of 21st century design exploration, in the creation of new materials for design application by cultivating waste in the form of a closed loop cycle" (Lee, 2014)

Global fashion brands have been in the quest of turning their companies 100% sustainable since some time ago. The brands are committing to sustainability by turning their processes and products' lifecycles circular. In broad

general terms, this could be achieved by extending the life of a product through new business models that enhance collaborative consumptions as rentals, repair, re-commerce (among others); by upcycling them into new products; or by shifting to sustainable materials and processes since the development phase of their designs.

In the sportswear industry one of the giants, Adidas, is already taking one step forward. In its quest of achieving a world without plastic waste, the company has established a three-goal sustainable strategy regarding materials and development processes: Recycled Loop, Circular Loop and Regenerative loop. The strategy is based in the idea that, in a first instance, the industry must seek for materials already available inside the value chain to recycle them into to new products. This concept has been used in industrial ecology which claims that "industrial processes can be designed to resemble ecosystems wherein every waste product becomes a raw material for another" (Myers, 2018). The same idea further explored in Cradle 2 Cradle.

However, a further step must be to design products that have been engineered so that they can be reused again as raw material of their future productions and thus continue in a completely circular life cycle. The above, in order to avoid still creating products that eventually will end-up in landfill. Finally, Adidas knows that even if they achieve the firsts loops, they must still consider products that wouldn't end up back in the loops. Then, their ultimate goal is to make sure these materials can eventually be returned to nature with minimal environmental harm. Adidas has teamed up Bolt Threads, to create products out of natural materials that can biodegrade. Among them new yarns out of protein are being engineered for specific purposes.

Recycled Loop

Made from Recycled Materials:
Supported by the introduction this year of Primeblue (derived from Parley Ocean Plastic) and Primegreen, a performance fabric which contains no virgin plastic. These 100 percent recycled polyester performance fabrics are unique in being pure on the recycled content.

Circular Loop

Made to be Remade:
Products whose lifecycles continue after each use, like the Futurecraft Loop running shoe which is 100% made from TPU (Thermoplastic Polyurethane).

Bionic Loop

Made with Nature:
Adidas' ambition to create future where every adidas product can have multiple lives and then return to nature. The brand already showcased a tennis dress entirely made of bio-fabricated microsilk designed in collaboration with Stella McCartney.

Hence, one way to remedy the damages would be to make the industry process cleaner and more efficiently. Instead, other solutions would be, to find drastic shifts using lateral thinking and disruptive innovation in order to change the way that the industry is conceived in its totality. It's time we start doing things differently!

Considering that we have been causing damage to the environment and nature for years and knowing that we want to achieve maximum levels of sustainability, what better way to achieve this than by redirecting the question; if the laws of nature were responsible for creating fashion, textiles and clothing, how would they? **It is time to return to our beginnings, to unlearn and re-admire who has always been an innate creator: Nature.**

FASHION INSPIRED BY Nature

Biophilia,
Achieving human well-being through fashion, nature and technology

Over centuries, fashion has been inspired by Nature for its beauty, diversity and power hence flowers, feathers and animal prints are always present alternately in the seasonal trends. Most of the designs involving nature are reverence to the natural world due to the delightfulness and fascination it arouses in human beings. Moreover, **the way nature is expressed and depicted directly reveals a story about the interactive relationship we are having with it in a certain moment of history.**

Fashioned from Nature is an exhibition that explores human relationships with nature through the medium of fashion from 17th to 21st century. Commissioned by Victoria and Albert Museum and ran from April 2018 to January 2019, the exhibition exposed how, despite this fascination for the natural world, fashion is apparently fated to harm it:

In medieval and Renaissance Europe, pattern designers took inspirations from books describing real and imagined animals called bestiaries, books containing descriptions of plants called herbals and then, when the cultivation of ornamental gardens became popular in the 16th century, from books compiling information on flowers and often with illustrations called florilegia.

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'Plato's Atlantis predicted a future in which the ice cap would melt, the waters would rise and life on earth would have to evolve in order to live beneath the sea once more or perish. Humanity would go back to the place from whence it came.' - Alexander McQueen

observation of medicinal plants. Likewise, the exchange and commercialization of specimens became common, as well as the desire to categorize and understand different plant species and reveal how they interacted with each other. This knowledge, acquired only by people of social and economic wealth, were exhibited and illustrated not only in books but in different fashion accessories such as the fan decorated with drawings of the sexual anatomy of plants according to the Carl Linnaeus's classification system of 1735. In the same way, wild animals from distant countries began to be reflected in textiles as rich people were fascinated with them and took them as pets.

Another story told in the exhibition conveys how fashion was linked not only to scientific interactions between human beings and nature, but also to recreational ones. At the end of the 18th century, doctors encouraged people to go for outdoor walks on the seashores for health and recreational purposes. Such excursions led people to collect shells, fossils, and marine plants, combining learning and discovery with fun. Likewise, the patterns and textures of textiles were shaped by sea contexts and the studies of marine organisms.

However, the use of fur, feathers, ivory, turtle shell and other natural inputs that today imply a devastating effect on their presence on the planet, began to become fashion trends that denoted wealth and power. What was even more alarming was that not only the fashionable materials represented a risk for the diversity of nature but also some supplies for the manufacture of clothing such as the whalebone or baleen that was extracted from the jaws of whales. This was used to make accessories, stiffen and shape garments. The whalebone, together with the whale oil that was used to lubricate and repair leather, caused overhunting and therefore the reduction of the whale population in Northern Europe. Not to mention that they were cruelly tortured before their death. This delight of demanding exotic materials from nature did not begin to be alarming until the previous century when, around the 20's, when reptile skin boom caused its notorious negative effects on various species that became endangered. The consecutive era of fast fashion and consumerism urgently required the development of more responsible and conscious relationships between fashion and nature.

The green and ecofriendly fashion practices started to be popular by the 1980s, when some enlightened designers began to use fashion to raise awareness of the damage caused by the industry. Some pioneers of this activism were Vivienne Westwood with her emblematic clothes worn in protest against climate change and Katharine Hamnett with her "Clean Up or Die" collection.

"From the second half of the 20th century to the present day, designers' responses to nature have often been more personal – whether that reflected the simple pleasure of a windy walk or, as in the case of Alexander McQueen, concerns about the harmful impact of human activity on the earth. His last fully realized collection, Plato's Atlantis, imagined a world of climate change, of melting ice caps, submerged land, with human survival dependent on their ability to evolve into amphibious creatures." (Victoria and Albert Museum, 2018).

The relationship between fashion and nature can be described as a love affair with up and downs during history. However, the love is nowadays deeper than ever as fashion is finally concerned for nature's survival and sustainability in the long term. **Fashion interaction with nature is** no longer just about materials, shapes and colors inspirations, or protest and activism but **about a profound mutualism in which fashion is created thanks to Life laws and principles with the objective of sustaining and regenerating the earth.**

Due to the overarching sustainability approach that not only fashion but all areas of design are facing today, the prefix Bio is trendier than ever. Although the use of this prefix is new, the approach is ancient and takes advantage of the fact that living organisms have been thriving on Earth for nearly 4 billion years.

While the planet is constantly changing its energy flow and creating diverse environments, these organisms have managed to adapt and evolve, giving them enormous resilience. These natural evolutive strategies present huge advantages over human technologies and eternally demonstrate that there's no other exceptional creator than Life.

It is therefore not unknown that the greatest source of inspiration for useful, disruptive or meaningful innovations comes from nature. The following chapter looks at the movements of bio-inspired innovations that are presented in the different design areas. In some design areas, some of them are used and exploited more than others, while in the fashion sector they are still underused. Hence, the aim is to classify and define the different ways in which nature inspires us in order to better understand these tools and conceptual sources to harness our future fashion designs while succeeding in the sustainable quest.

"Natural selection ensures that these strategies are energetically and materially prudent, a critical distinction between many human-constructed systems. Any species that is wasteful, pollutes its habitat, or relies on limited, non-renewable resources cannot survive for generations–it must either adapt to the ecosystem's constraints or go extinct through starvation and habitat destruction. Evolution has selected for species that sustain themselves through functional design and scrupulous habits, or in other words, it has selected for sustainability and functionality". (Terrapin, 2017)

FASHION TECH AND BIO-PREFIXES:

Biomimicry and Bio-utilization in fashion are still rough diamond techniques that, when used in design, enable people to withstand climate change, health epidemics and economic and social uncertainties in the form of energy and resource optimized products, processes and even systems. Biomorphism on the other hand, widely explored in fashion is a more aesthetic concept that utilizes nature as a source of inspiration that sometimes enables visual comfort and therefore good reception and acceptance among customers.

However, with the new advancements in technologies these Bio approaches are carried by a lateral thinking perspective, using scientific theories as inspirations and exploiting innovative digital manufacturing tools.

Nature have always had and will continue to have endless potential as a model for design; if used creatively, and identifying the right approach will be the greatest source of inspiration for the future of fashion

Biomimicry

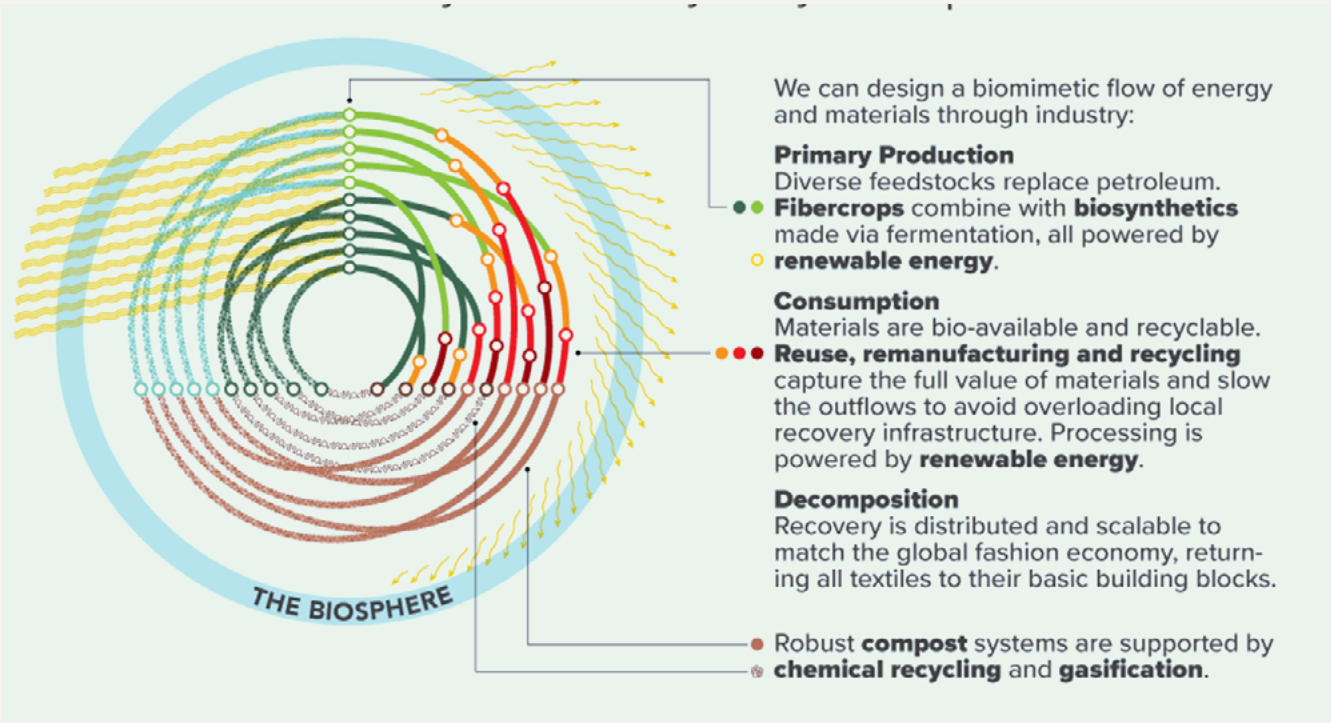
Nature has about 4 billion years of evolution solving problems in a highly efficient and sustainable way, while apes evolved, and the process of hominization only began about 4 million years ago. Thus, If you imagine the history of the earth like a clock, human beings appeared shortly before 24 hours o'clock (Bryson, 2004).

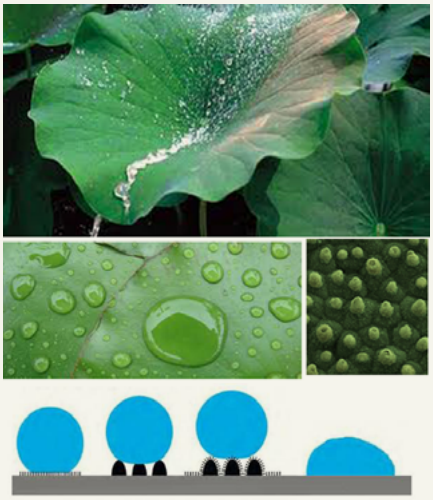
Nature is a teacher when it comes to solving sustainable and technological challenges, and man has the task of consciously simulating this intelligence through forms, patterns and processes that aim to increase or improve a function. **Biomimicry is the imitation of the processes of natural systems to apply them to the solution of human problems in order to optimize available resources. Biomimicry studies biological principles and is used as a tool to create designs that are governed by these laws.** The first step for Biomimicry is to study and understand how nature works and overcome the design or technological challenges that need to be overcome, and then to replicate or take this knowledge as inspiration and apply it to the solution.

Biomimicry is the "mimicry," or more accurately, the emulation of life's engineering. (Terrapin, 2017)

The broadly used "Cradle-to-cradle" sustainable design strategy is a biomimetic approach that considers the way materials and energy flow eternally in natural ecosystems. From the water cycle to the way all organic matter breaks down and becomes natural and nutritious compost, nature has been designed from the cradle to the cradle instead of cradle to grave, which means that in all its stages, the outputs of a cycle become inputs of another. C2C, developed in the 1990s by Prof. Dr. Michael Braungart, William McDonough and the scientists of EPEA in Hamburg, intends that all products and systems produced by human industry operate in the same way, where the materials are considered nutrients that circulate in healthy and safe metabolisms. In this order of ideas, the model proposes designs that are waste free. Even though the model is more commonly used in industrial design and manufacturing; it can be applied to many aspects of human societies such as urban environments, economics and social systems and Fashion.

In fact, the recent boom of the introduction of circular economies in the fashion industry is based on this biomimetic C2C concept. The central idea is to consider the fashion system as a closed-loop system in which each output ingredient could be a biological or a technical nutrient; the first one mentioned is biodegradable and could also be beneficial in restoring the soil, while the second one is intended to be completely recycled into high-quality materials for subsequent product generations.





Lotus leaves symbolize purity in Buddhism. In addition and like so many other leaves that remain dry when it rains or is wet, they have become an icon for biomimetics as a clear example of "form equals function."

Going back to other biomimetic examples besides the C2C focus on fashion. Many innovative textile solutions have appeared with self-cleaning, self-healing, energy-conserving properties, among others. These bio-inspired textiles are the result of fabrics that have functional surfaces, structural colors, self-healing and thermal insulation properties thanks to the observation and learning of how natural mechanisms solve the same problems. The followings are just some examples:

The lotus plants have a magnificent impermeability, when the raindrops fall on their leaves they slide and roll, collecting dirt particles with them. This apparent magic is due to its ingenious waterproof structure. The lotus leaves, when observed under a microscope, reveal that they are made up of rounded nano-mounds and on them they have a second level of small waxed threads. The effect they generate is that when the water particles fall on the leaves they manage to maintain their spherical shape because in reality they have very little area in contact. The waxy coating also helps the droplets slide along the super hydrophobic surface. The interesting thing about this structure is to reproduce it artificially and thus create water-repellent surfaces for fabrics, where tiny nano fibers are attached to the surface of traditional fibers, such as cotton.

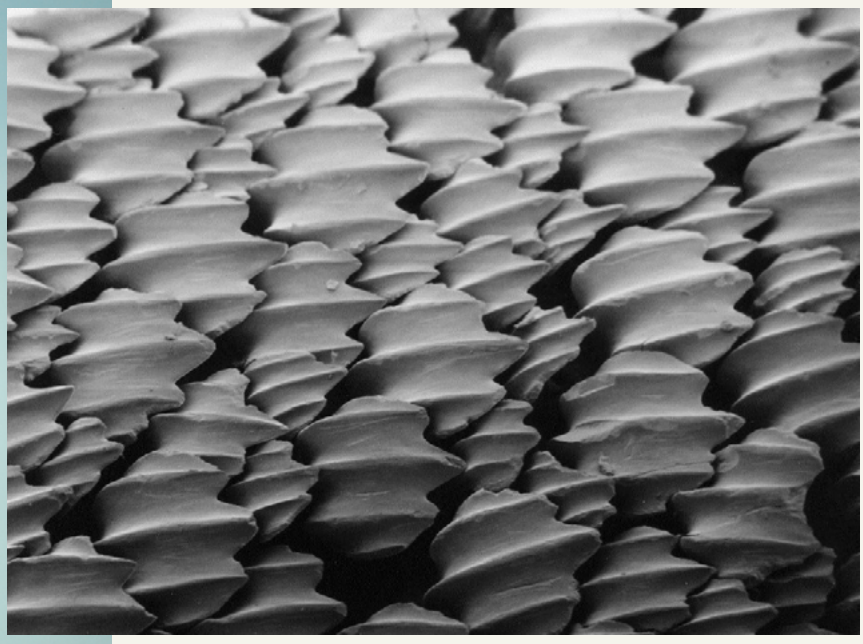
The color of butterfly wings and some beetle shells is not based on pigments and has inspired developers to produce vivid color fabrics without the use of pigments or dyes. The wings of the Morpho menelaus butterfly, for example, the iridescent effect, which changes according to the angle of vision, is produced by the reflection of light on the different structures of these surfaces, similar to the effect of light on a soap bubble . On its surface there are countless tiny nanostructured scales that manipulate light. the order of the nanostructures of those scales makes the reflected light just the wavelengths of the color blue.

While the disorder, in the case of the scales of the beetles of the genus Cyphochilus, is what makes the light totally reflect: they are of a perfect white color. In both cases there is a coloration associated with the nanostructure of the material and not with its chemical components. This is known as structural color, that is, it is not produced by pigments.

The Speedo Fastskin is a full body swimsuit that was designed to maximize swimming speed, reducing friction and turbulence generated by the body. The swimsuit is made with a fabric that emulates the dermal denticles of shark skin in order to reduce friction and turbulence generated by the body. The Fastskin fabric was built taking as reference the denticles that emulate the natural skin of sharks, with an elastic fabric that improves the fit of the fabric towards the swimmer's skin and compresses the muscles. The result is a reduction in muscle resistance and vibration, which increases speed. The new swimsuit was so good at lowering marks that controversy began over whether it could be considered a type of technological doping, as an excessive help to competitors.

Despite the controversy, it seems that everything is not due to that skin based on that of the shark as stated by Dr. George Lauder. For him, the benefit

"Biomimicry will represent a return to our origins if you like. A path that re-employs biological processes and organisms whenever possible, to merge the human body with bio-based fashion elements, in beautiful symbiotic ways." (Laurenti, 2018)



wwt the 2008 Beijing Olympics, most of the winners used a Fastskin LZR Racer. In addition, 130 records were broken in a few months, so finally the FINA (International Swimming Federation) banned its use in 2009.

of these swimsuits is due more to the fact that they reduce the volume of the swimmers' body and that it allows them to maintain the correct body position even if they are tired or with effects of fatigue.

Thus, it is exemplified how the understanding of nature and its processes is a great generator of concepts that promote innovation in smart textiles. The possibilities for scientists, engineers and designers will always be endless as nature is so complex that it continues to amaze us in our little attempt to fully discover it.

"Nature is full of infinite causes that have never occurred in experience", said Leonardo Da Vinci

In short, textile materials that are designed under a biological concept, in addition to being ecological and functional, also present a cooperative function for the user in terms of comfort or satisfaction of a specific need. Hence, bio-inspired textiles and fashion designs are widely used for sportswear, and activewear.

However, is predicted that biomimicry has a great future for fashion not only in Sportswear and activewear, it is about finding ways to mix functionality with the fashion factor to deliver solutions to an increasingly utilitarian consumer, concerned with protecting the environment, by connecting with Earth, by a more conscious consumption, by more significant relationships, by valuing the really essential , being more practical and self-sufficient, in short, a human being interested in maintaining one's well-being, that of his fellowmen and that of the planet amid chaos and uncertainty.

In Japan, Teijin fibers have developed a chromogenic fiber called Morphotex by arranging polyester and nylon fibers in 61 alternating layers. Even though, Morphotex is no longer manufactured, it was used in 2010 by Australian designer Donna Sgro to create an illuminescent dress.

To apply Bio inspiration in a functional way to clothing it's important to have in mind basic nature's concepts:

Nine core concepts of nature:

1. Nature runs on sunlight
2. Nature uses only the energy it needs
3. Nature fits form and function
4. Nature recycles everything.
5. Nature rewards cooperation
6. Nature banks on diversity
7. Nature demands local expertise
8. Nature curbs excesses from within
9. Nature taps the power of limits

Moreover, using the biomimetic thinking we can learn, identify and tackle issues from human-made systems by comparing the natural modus operandi.

Human-Made systems

- Simple wasteful
- Linear flows of natural capital
- Disconnected
- Engineered to maximize one goal
- Resistant to change
- Frequently and long-term use of toxins
- Monocultural and centralized
- Fossil fuel dependent
- Use global resources

Biological Made

- complex
- zero waste
- closed-loop flow
- densely interconnected & symbiotic
- optimize as a whole system
- adapted to constant change
- no long-term toxins used
- distributed and diverse
- run on current solar income
- regenerative
- local resource use

Biomimicry will help us to improve the way we treat toxic substances in the fashion industry. While these substances are common in nature, being naturally produced in small quantities as needed, and completely biodegradable. As Human beings, we have caused their isolation and higher concentrations such as pesticides, it's dangerous for humans, animals, and vegetation. As Human beings, we have caused their isolation and higher concentration that become dangerous for humans, animals, and vegetation. Without respecting the fact that those substances were only in small quantities for a reason, we use these substances in concentrated forms.

Another Nature lesson comes from its complexity and uniqueness. In nature everything is designed and structured as part of a bigger complex and dynamic system. The human ability to understand the complexity and manage large-scale systems is limited, instead in nature even the smallest object is part of substantial ecosystems. Nature has it very clear that every action causes a reaction and that actions performed today would be tomorrow's karma. Nature's principles are encoded in every involved: everything has its own place and function, preserve, build from the bottom up, use the only energy needed and recycle everything.

Instead of imagining futuristic fashion as cybergothic and artificial, with the bio-infused approach applying biomimicry design and materials, the next generation of clothes will draw inspiration from groundbreaking genetic research to cure cancer, alter physiology, appearance, and even the cognitive functions of human beings that will protect as from future dangers. **We will become not only much more sustainable but also connected to our origins and the nature we have evolved from.**

Life Principles for Biomimicry - (Biomimicry 3.8, 2007)

EVOLVE TO SURVIVE	ADAPT TO CHANGING CONDITIONS	BE LOCALLY ATTUNED AND RESPONSIVE	INTEGRATE DEVELOPMENT WITH GROWTH	BE RESOURCE EFFICIENT (MATERIAL AND ENERGY)	USE LIFE-FRIENDLY CHEMISTRY
Continually incorporate and embody information to ensure enduring performance.	Appropriately respond to dynamic contexts.	Fit into and integrate with the surrounding environment.	Invest optimally in strategies that promote both development and growth.	Skillfully and conservatively take advantage of resources and opportunities.	Use chemistry that supports life processes.
Replicate Strategies that Work Repeat successful approaches. **Integrate the Unexpected** Incorporate mistakes in ways that can lead to new forms and functions. **Reshuffle Information** Exchange and alter information to create new options.	**Incorporate Diversity** Include multiple forms, processes, or systems to meet a functional need. **Maintain Integrity through Self-Renewal** Persist by constantly adding energy and matter to heal and improve the system. **Embody Resilience through Variation, Redundancy, and Decentralization** Maintain function following disturbance by incorporating a variety of duplicate forms, processes, or systems that are not located exclusively together.	**Leverage Cyclic Processes** Take advantage of phenomena that repeat themselves. **Use Readily Available Materials and Energy** Build with abundant, accessible materials while harnessing freely available energy. **Use Feedback Loops** Engage in cyclic information flows to modify a reaction appropriately. **Cultivate Cooperative Relationships** Find value through win-win interactions.	**Self-Organize** Create conditions to allow components to interact in concert to move toward an enriched system. **Build from the Bottom Up** Assemble components one unit at a time. **Combine Modular and Nested Components** Fit multiple units within each other progressively from simple to complex.	**Use Low Energy Processes** Minimize energy consumption by reducing requisite temperatures, pressures, and/or time for reactions. **Use Multi-Functional Design** Meet multiple needs with one elegant solution. **Recycle All Materials** Keep all materials in a closed loop. **Fit Form to Function** Select for shape or pattern based on need.	**Break Down Products into Benign Constituents** Use chemistry in which decomposition results in no harmful by-products. **Build Selectively with a Small Subset of Elements** Assemble relatively few elements in elegant ways. **Do Chemistry in Water** Use water as solvent.

Biomorphism

The imitation of nature forms, shapes and patterns in design is an ancient practice that chases harmony and beauty. Just to recall some examples, it can be traced back to antiquity, to the writing of Vitruvius, as well as to Goethe's work on morphology. Biomorphism renders artistic design evocative of nature and living organisms by modeling elements organically occurring patterns or shapes. It mimics naturally occurring familiar shapes onto functional appliances; thus people recognize them and resonate with them on a primal level.

"Curvilinear rather than rectilinear, decorative rather than structural and romantic rather than classical in its exaltation of mystical, the spontaneous and the irrational." - Alfred H. Barr

In art, the term "biomorphic" was used to describe earlier treatments such as Rococo's common decorative motif resembling shells and acanthus leaves. Later, the Art Nouveau in the 19th century achieved biomorphic highest expression when designers were aesthetically inspired by nature: plants and organic forms intertwine with the central motif; curves and asymmetry were preferred. It is also applied to organic-like forms used in various subsequent art movements. All these represent a "design approach which is form-driven and offers only superficial likeness to the natural world

The designs exploit Biomorphic shapes to express Herpen's amazement and fascination for this animal kingdom which is shared to the public through a symbiotic technique between high technology and haute couture craftsmanship.

for decorative, symbolic, or metaphorical effect" (Myers, 2018).

Although Biomorphism initially emerged as a reaction against rationality and science, the evolution of the latter in contemporary art, design and even architecture has helped us to unite the rational and analytical side of nature with the astonishing natural beauty of what Alfred H. Barr called the biomorphic world "mystical, spontaneous and irrational", also the uncontrollable. In this way we talk about a hybridization between reason and instinct, between humanity and nature.

Biomorphism is another subgroup of bioinspired innovation in design. It mimics natural forms and patterns. It is commonly critiqued for its lack of adherence to biological principles, resulting in designs that do not necessarily perform better or that are sustainable. Being different from biomimicry in its lack of problem solving through the natural inspiration. However, the main function or objective behind Biomorphism are the psychological aesthetic impacts of natural forms and patterns which are a key component of Biophilic design (further discussed in chapter 4 of the literature review), reducing stress and enhancing concentration due to their visual interest.

Nowadays, fashion meets Biomorphism in a more complex technique, not only by recreating patterns and colors from nature but allowing designers to experiment beyond common natures shapes to explore inspirations from nature dynamic elements such as physical forces, air, water, and fundamental structures of organisms in a macro and micro level.

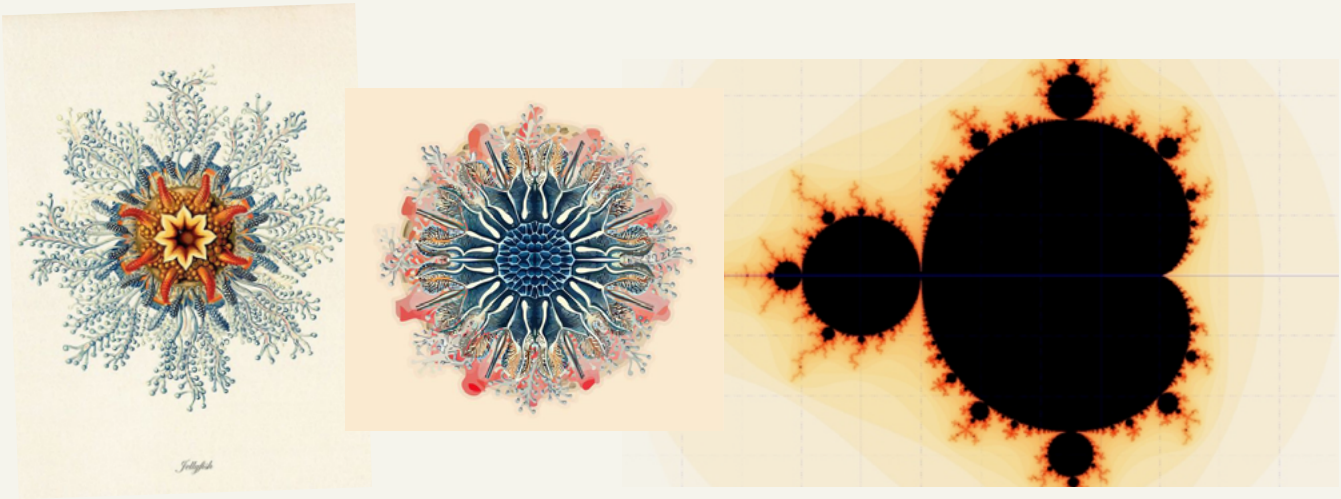
Iris Van Herpen is the great exponent of this kind of work as she describes her creations as deeply rooted within nature. She creates Haute Couture that integrates innovation and craftmanship within the fashion Tech field. The creative director feels strong attraction for forces, phenomena, and intangible characteristics of nature such as movement, fluidity and other invisible forces that are responsible for shaping our reality. She uses these elements to recreate an organic atmosphere and materialize an ethereal physical nature creating a relationship of beauty and harmony between nature and the human body.

In her latest collection "ROOTS OF REBIRTH" exhibited in January 2021 during Paris Fashion Week, the designer explores the tissue of life that lies beneath our feet in the undergrowth referring to forms of fungi, specifically the mycelia that interconnect and nurture other living organisms. Through her collection, the designer stimulates the public with interconnecting textiles that resemble roots, using a palette of earth and amber colors to relate this terrestrial life with the underworld. The Biomorphic inspirational starting point is a reference taken from "Entangled Life", a book written by scientist Merlin Sheldrake which points out that 'fungi is the ecological connective tissue, the living seam by which much of the world is stitched into relation.'

Her designs exploit Biomorphism to create a sense of allure and emotions of delight in her public. All her collection inspirations are taken from scientific research, botanical drawings, personal interests combining them with technological innovations. She profits from the Biomorphic effects in human psychology hypnotizing her publics with natural movements, organic colors, and recreations of fluidity that customers subconsciously connect with the innate love and admiration for nature.

All in all, using Biomorphism in fashion and combining it with technological tools, the inspiring natural elements are, more than the conventional colors, plants, shapes or animal skins, intangible but familiar bio principles, sensations, or even natural laws. **The Biomorphic models in fashion materialized as patterns, textiles or shapes surround the body organically in a changing state, and the visual language they share with the human figures implies that humanity is also connected to the constantly evolving state of nature**

Personally, I believe that when this Biomorphic visual language is used to create a design linked and harmonious to the human body implies in a certain way that humanity is also connected to the state of constantly evolution representative of nature.



Fractals and patterns

Fractal comes from the Latin word Fractus which means fragmented. The fractal is a repeated unit that defines nature. By repeating this unit after a process of growing geometry or by dividing the unit in smaller one, a fractal geometry appears. If the figure is zoomed in each part is like the whole. One of the fractals' principles is precisely self-similarity, that describes that the same form is repeated on a gradually decreasing scale indefinitely to infinity. This is not only applied to visual structures but to rhythms, sounds or trajectories, because all these phenomena can be broken down into self-replicating structures. In other words, fractals translate the living world in a very precise mathematical language.

"Clouds are not spheres, mountains are not cones, coastlines are not circles, and bark is not smooth, nor does lightning travel in a straight line."
Benoit Mandelbrot

Fractals is the study of the shapes of nature through roughness, by breaking every shape in a similar smaller part. You can describe clouds, flowers, or mountains with mathematics, all the things that were already there before us. The most known are trees with their branches repeated smaller and smaller.

There is an order behind the seeming chaos. Using computers tools, Mandelbrot, fractal's discoverer, created with his own mathematical formula an image which follows the principles of fractal self-similarity and is infinitely expandable when the patterns of the edges are zoomed in and reveal smaller scale of the whole. People in art and history recognized this geometry. It explains a visual phenomenon that to the sight nature's structures seems finite, but when deeply analyzed they appear to be infinite. In this way fractals are both simple and complex.

This mathematics formulas were used in graphic design to create the first computer graphics of mountain ranges and imaginative worlds with realistic appearance, later used in special effects. The discovery of fractal geometry in nature not only served to create artistic visuals following nature proportions but allowed scientists to look at nature, measure it and do mathematics and calculations with them for useful and practical purposes.

Fractals are used to calculate how much carbon dioxide can absorb a whole forest by knowing how much a single leaf can absorb. Then, by finding the fractal pattern it is possible to know approximately how much leaves a single tree has. Multiplying the carbon dioxide that a single leaf absorbs by the fractal results, the amount of carbon dioxide absorbed by a single tree is found. This number is replicated in all the trees of the forests which are identically distributed to the distribution of the singular branches. In other words, the relative number of big and small trees approximately matches the relative number between big and small branches.

Why is it that nature requires everything to be done using the fractal geometry to achieve the wanted effect? Understanding the geometry of fractals make you realize that these shapes in biology are all over the universe, nature and within you. People have given fractals a mystical application as it describes a way the infinite universe relates to our limited human experience.

By understand fractals and the connected patterned web that starts repeating itself from the infinite large to the infinitely small, we can start experiencing nature in a spiritual way. The Divine pattern that interconnects all scales of size is repeated both in the attractions of planets and stars and appears at the size of our human consciousness: Rhythms of the heart as a notion that the human body is a machine and other physiological process have been also found to be described as fractals models

- The proportion between the parts of a fractal is related with the way human sight as it has been discovered that, when looking at complex images, our pupils scan the big picture first and then concentrate on increasingly smaller details. These details are not randomly smaller, but they follow a fractal ratio!

What if God is a fractal? Here is how I imagine it. The Divine pattern of life and connection and creativity – It expresses itself in the creative unfolding of the universe... We can find that pattern in our hearts, in our personal experience of life and love and creativity. Thus we can find the mystery in our hearts, as well as in the larger whole (Johnson, 2016)

- It has been observed that birds also use the same technique to scan what they see below them when flying, and that's why their sight is so efficient!

- Used to describe the pathologies in medicine as a predictive tool, scientists found that the ultrasonic sound images of the overall movements of blood in a healthy kidney could be represented in a fractal model very different from the resulting model of a cancerous one. The healthy one generates a structure in which the blood vessels presented a fractal growth neatly bifurcated, while the cancer networks were chaotic and entangled.

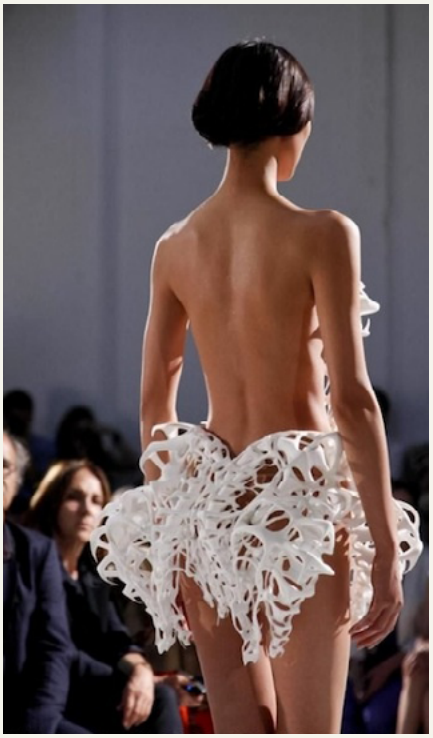
- All the biological networks in the human body, neural system, circulatory system are composed by fractal shapes making it possible that bigger creatures need less energy than smaller ones to survive.

All over history, human beings have always used images to explain or represent the enigmatic wonders of spirituality. Christians have always represented God as the trinity using a geometric figure with the triangle, and modern Jews identify themselves with the hexagram or 6-pointed star known as the Shield of David. But all these shapes are soft static and somehow simple. While if we imagine God as a fractal, according to Myke Johnson, a Unitarian Universalist minister and earth activist in Portland, Maine, who practices and teaches ecological spirituality, we assign him his attributes of multidimensional, infinite, and complex.

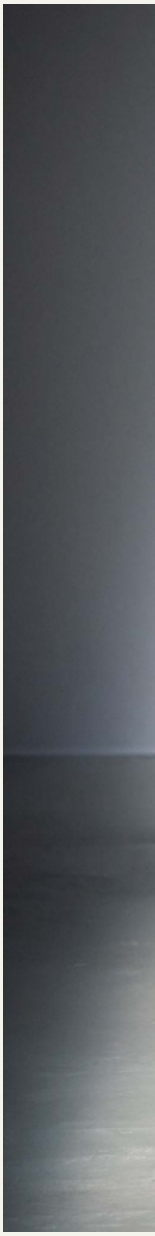
"The laws of nature are but the mathematical thoughts of God" - Euclid of Alexandria

Fractals has been widely explored in design due to their principal trait: the ordered repetition of a single shape. Design uses repetition to lead the eye in the object or space reading. Despite fractals are used already in interior design and architecture, it is still quite new in fashion. Just near their discovery during the 80's artists explored prints and computer aided patterns with fractals. However, fractals in fashion could be introduced by using natural fractal textured materials, by reproducing natural fractals on patterns, or finally making out fractals from geometric shapes that could be applied in the 3D constructions of clothes.

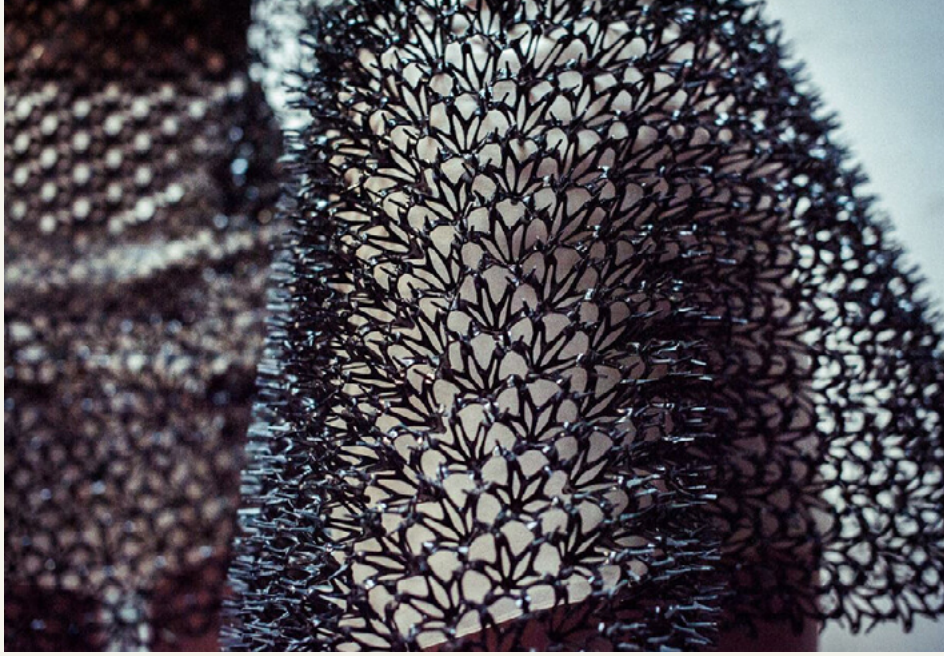
The Dutch designer Iris Van Herpen, who is always at the forefront with experimentation and innovation, has of course already introduced the concept of fractals in her designs. Her pieces habitually incorporate organic themes that reveal her observations of nature and the human body, resulting in original pieces:



The FW 2015 collaboration of the fashion designer with the Architect Philip Beesley brings to reality a halo-like meshwork fabric brilliantly connecting haute-couture with new industrial production possibilities. Part of the collection called “Hacking reality” the dress is described as “black garden of fractal-like geometries.”



Her Skeleton Dress reminds us of the self-similar fractal patterns that can be found within our own biological structure.



"Van Herpen's work reveals the secret structures of our existence giving us a multidimensional experience of what it is to be alive, it is an investigation into the past, present and future in all its primal and mythological forms." Gwendoline Christie

Her Crystallization piece is the result of her study of the scientific process in which liquid is transformed to crystal exploring the beauty found in the fractal-shaped molecules.

By transferring a microscopy image of the crystal onto polyester fabric through digital printing, the researchers created a unique clothing design so striking that they won first place in the National Women's Fashion Design Competition of China.

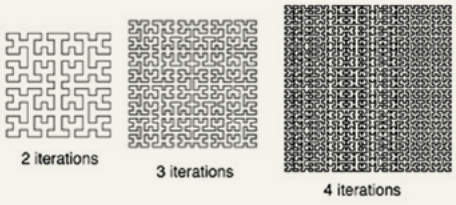
Guoqing Zhang, Xuepeng Zhang and their team at the University of Science and Technology of China won a national fashion competition by using unusual, curved fractal structures accidentally found to design a dress. The prominent patterns came from were never-before-seen organic crystals that they obtained by serendipity instead of the water-based acrylic paints they were trying to create.

Lebanese designer Zuhair Murad uses this self-similarity natural shapes in his couture designs during the "Enchanted Forest" collection. He appealed to the repeating pattern of tree branches to render an ethereal and mysterious elegance. Over 500 years ago, Leonardo Da Vinci had already noticed that the tree branches were split with mathematical precision. The collection is a tribute to the beauty of the mysterious language of nature.

Fractals have also been used as technological and useful tools in functional clothes design. A great example is multi-scale camouflage, which is a military camouflage pattern created with computer-aided tools. Its function is to provide camouflage at different distance ranges in the manner of fractals through the construction of artificial visuals based on images of real-world scenes. Characteristics of these scenarios such as texture, color content, gray levels, pixel correlation, and spatial frequency content are analyzed to generate analogous fractional or fractal shapes.

Engineers accompanied by designers have also explored fractal-like shapes to harness the performance of smart textiles. Taking advantage of the distribution and amplification characteristics of fractals, Dr. Shannon Yee, a researcher at Georgia Institute of Technology used this mathematical principle to create thermoelectric textile materials that are used in wearables. A thermoelectric material converts body heat into electricity so it could have great applications like charging devices such as a cell phone. Thinking further, biometric devices as a heart monitor that could be powered by no more than body heat.

To explain how this TE materials that he created work, we must first talk about Hilbert curves, discovered by David Hilbert, a German mathematician from the beginning of the 20th century. A Hilbert curve is a base curve of fractals that fills spaces. This was a previous idea that led to the establishment of the concept of a fractal with self-similarity.



Researcher Yee realized that to create an efficient thermoelectric material all the elements must be interconnected through the same line and he achieved it with this filling-space curve. With Hilbert curves, it's possible to create what he calls, "fractal-like geometries where sub-modules are repeated geometrically throughout the main module" (Tech Briefs Media Group, 2018). These patterns can be printed over large areas of fabric. Depending on your application the pattern sizes can be adjusted to find the required frequency and voltage. The scientist also intends to find ways to weave these patterns and modules directly into clothing with TE threads. Finally, Yee expresses that the most interesting thing is that the effect also works in reverse, that is, clothing powered by batteries that generate body cooling could be achieved. By having a personal cooling device in contact with the body, the need for cooling large spaces could be reduced hence these materials would be a great substitute solution for air conditioners. It is a nice solution for human beings' comfort, reducing in the need of interiors' refrigeration, savings in energy usage, thus reducing global warming. (Tech Briefs Media Group, 2018)

However, this is just one example of a project based on the amplification powers of fractals, it uses only a similar fractal discovered by men and geometrized, so it is not considered a biomorphic approach or design. Nor could it be an example of biomimicry, since these Hilbert curves did not seem to translate or explain nature, so the solution is not directly inspired by a natural principle. It would be very different to use natural fractal shapes with the intention of achieving the same results but through a biomorphic approach and, therefore, avoiding complex patterns that could tire human sight and instead adding values of harmony and beauty to the discovery.

Still there are some cases where fractals are a Biomorphic approach used to solve a problem, hence mimicking the geometric natural language to have a more effective solution. Antennas were made much smaller using a fractal design and enabled them to receive a much wider range of frequencies. Today, engineers are exploring the need of wearable antennas in smart clothing for communication purposes. For modern wireless applications with body-area-networks (BANs), fractal technology is used to design compact antennas able to integrate multiple communication services into one wearable device. The big challenge is working with the human body since the performance of conventional antennas is poor when they are placed near it and when moistened by sweat, they can even scrunch and stop working as the body moves.

"Fractal geometry is enlarging our ability to create new devices that work better because they follow patterns that resonate with the natural patterns around us." (Johnson, 2016)

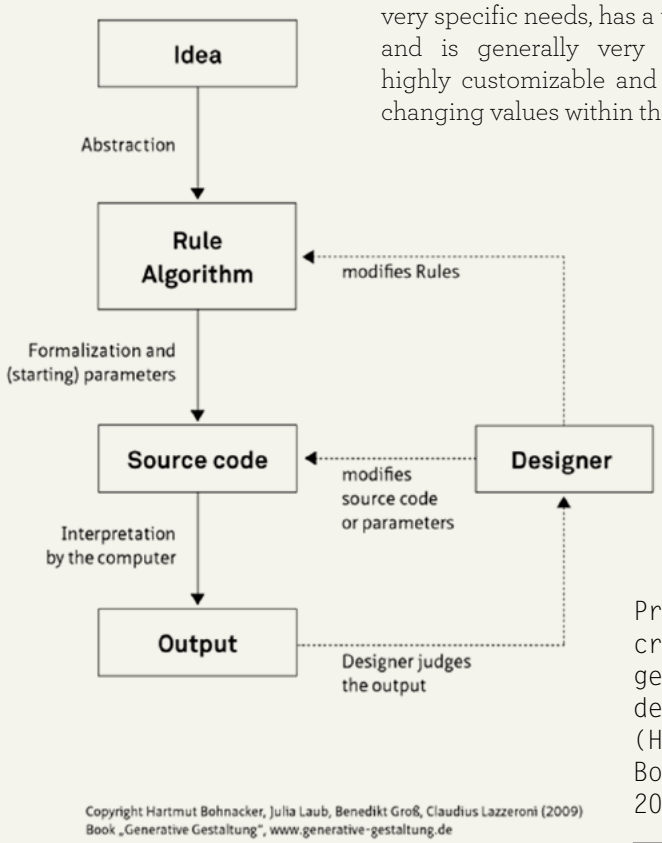
However, fractal antennas, invented by Fractal Antenna Systems, solve these obstacles. "Fractal antennas are built on repeating scales of size (self-similar), and their intricate structure allows them to be robust against detuning and cover many bands, and or be wideband. Fractal antennas can be built into the cloth and conform with it, an invisible part of the clothing itself". (Bedfort, 2017). Moreover, there has been other previous studies inspired in natural fractals to create antennas based on the snakeskin structure. Fractals are today necessary in technology devices to create electronics smaller and cheaper.

Fractals are yet another tool to make fashion stimulating and engaging. Embracing the visual potential of natural fractals will also help to reconnect people with the natural world, to feel the infinite of nature within us. Johnson, in her book "finding our way home" explains that the natural world is a sacred text written in a universal language: "is the place where we search for truth and beauty and goodness". Therefore, by understanding its language we deepen our capacity of appreciation and understanding of the whole mystical wonders of life.

Morphogenesis: Parametric & Generative Design.

With the emergence of new technologies, design today explores new tools that allow it to use and establish innovative unconventional design processes to achieve aesthetic results that without the assisted help of computers could not be possible. These design processes are known as Generative Design or Algorithmic Design, which use algorithms to generate several design variants based on variable inputs that correspond to designer-established design parameters. In other words, it is an iterative design process in which a 3D design software is used to generate a series of outputs according to the parameters and constraints imposed by the designer, who also selects and adjusts the solution space by selecting specific output or changing input values, ranges, and distribution.

Thus, Generative design mimics the evolutive approach of nature in that you find the best design solution by rapidly exploring numbers of possible design variants for the parameters and objectives established in the study setup. This process finds an optimized solution with each iteration that is performed. Thanks to its optimization through complex algorithms, the result is a functional design that adapts to very specific needs, has a unique shape and is generally very organic and highly customizable and adaptable to changing values within the parameters.



Process for creating generative design (Hartmut Bohnacker, 2010)

In this Design Tech industry scenario Biomorphism evolves in a much more complex way; digital modelling technologies are used to achieve generative natural and organic shape development enabled by computation. This innovative design method arises from the biological process in which a cell, tissue or organism develops its natural shape.

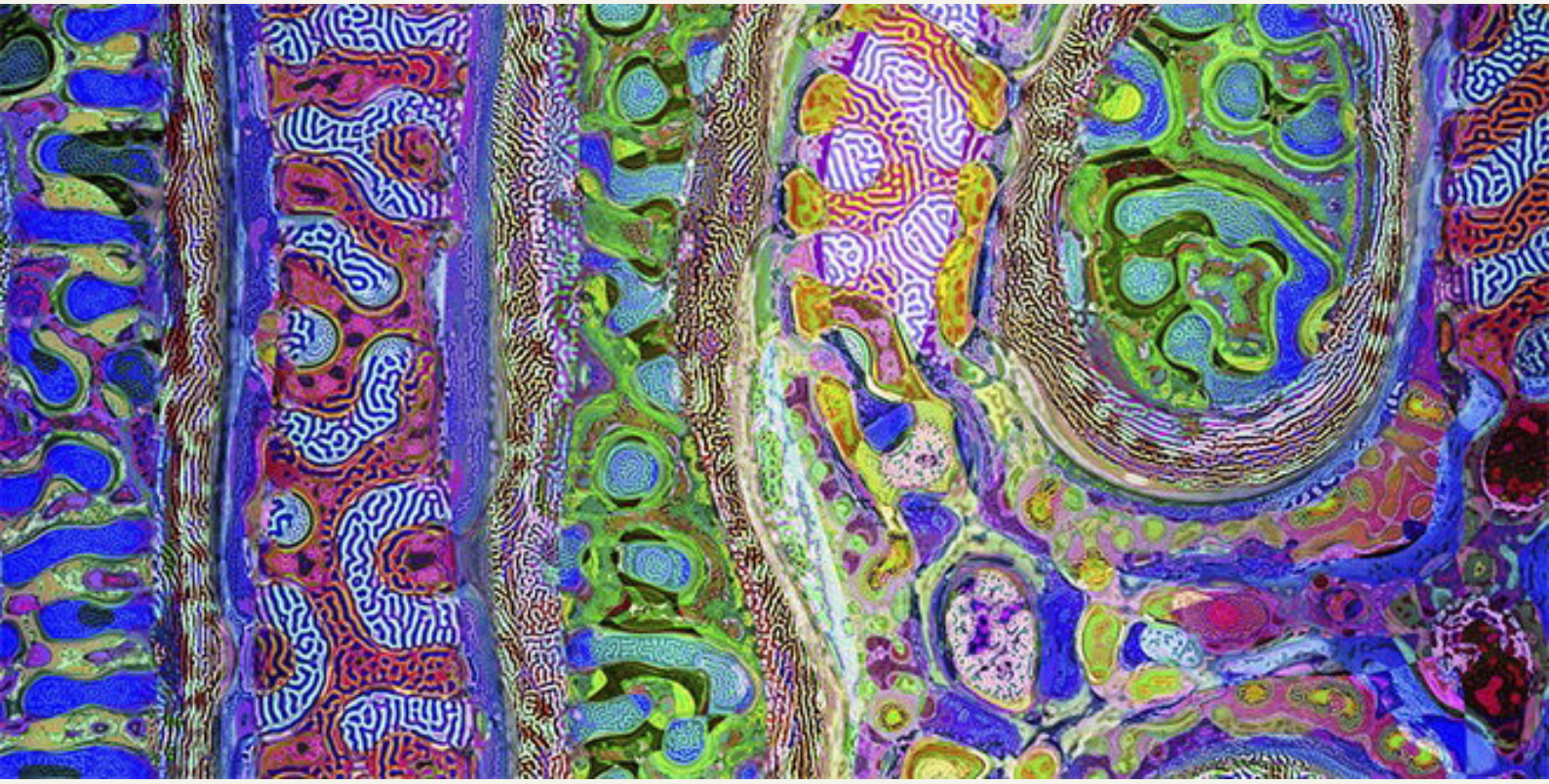
Morphogenesis (from the Greek morphê shape and genesis creation, literally "the generation of form")

Morphogenesis is a huge concept which explains not only 3D-mensional shapes and textures but even colored patterns. For centuries scientists have wonder how identical cells differentiate into a complex organism. While each organism develops and grows, how is it that each living organism develops a unique colored pattern? The origin of biological pattern and form is still largely a mystery.

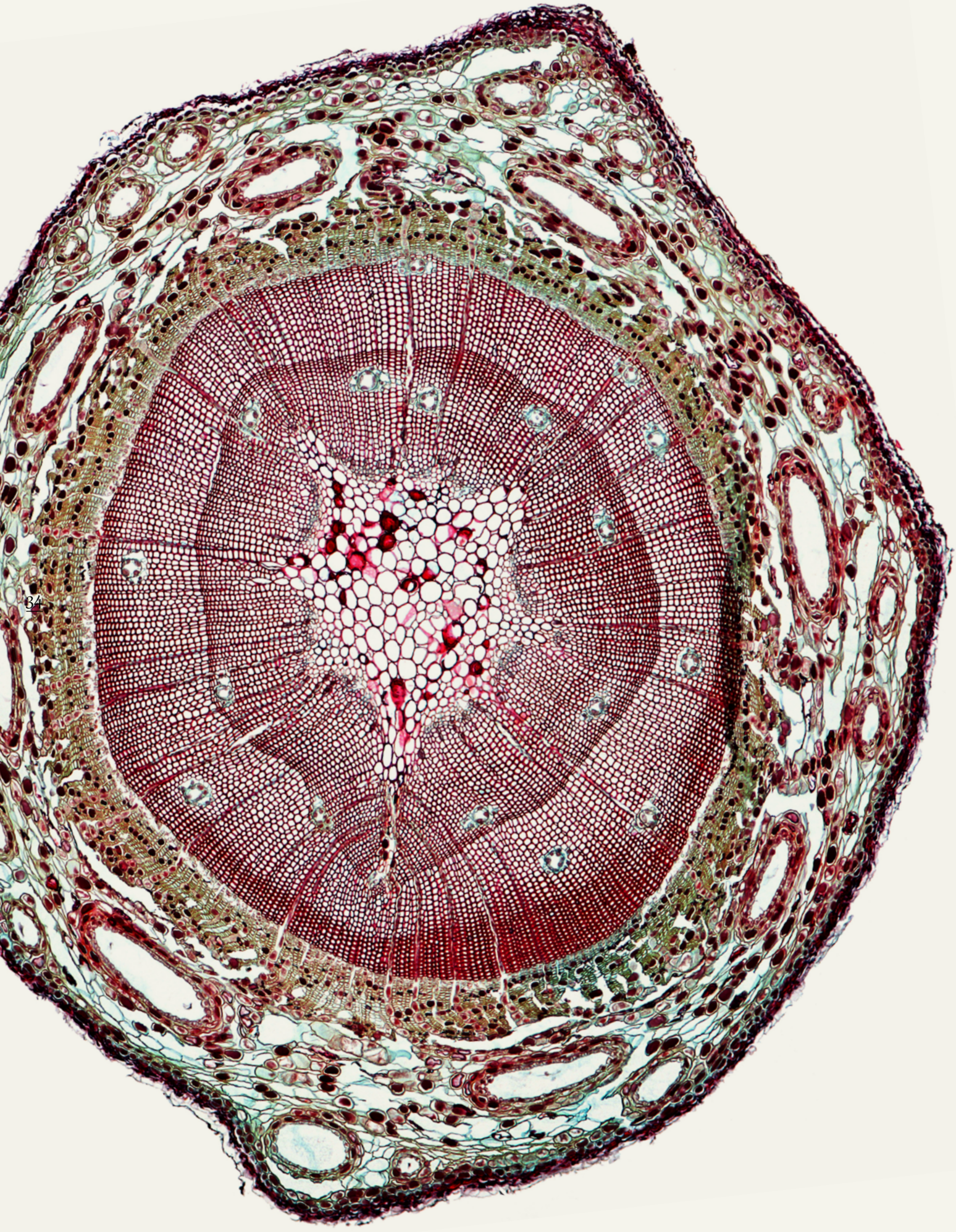
Some of the answers to these questions were answered in a paper titled Chemical Basis of Morphogenesis written by Alan Turing (yes, the same guy who created computers) who explained that our cells start being identical units that turn into complex differentiated structures through a process called Reaction-Diffusion. The paper was an entire theoretical work written by the genius during his last years of life, however during the next decades his speculations were validated by scientists. This discovery implies that many whimsical patterns in nature occurs thanks to a chemical signaling process involving a simple system of chemical interacting a diffusing from each other. (Nanjundiah, 2003)

The so-called reaction-diffusion system is a description of how our cells, starting from uniform, identical units can differentiate into complex structures. Reaction-diffusion is a chemical signaling process occurring in a tissue where a simple system of chemicals is spreading (diffusing) and interacting (reacting) with one another. The whole chemical process can be described with mathematical models. The morphogens which are the chemical substances involved are comped by one Activator that makes more of itself, and one Inhibitor that slows the activator's production. The concentration of one or more chemicals changes in space and time, oscillating between high and low and spreading across an area resulting in complex patterns.

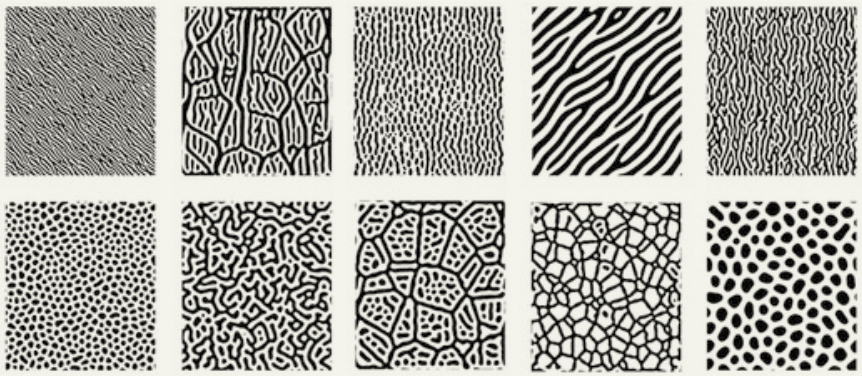
Turing proposed that the interaction of the morphogens is able to produce six different scenarios of patterning. **Reaction-diffusion has been used to prototype the elaborate patterns found on the skin of many types of animals, from the spots of leopards to the radiating stripes of angelfish.**



The extreme variety of patterns from nature can be achieved and mimic through computational tools. The Australian generative artist Jonathan McCabe recreated Turing's theory using pixels instead of pigments. By translating the mathematical formulas into colors, he gave random values to each pixel and applied a set of rules that control how each pixel's value moves in reaction to the ones around it. The original random mix of numbers translated into pixel values begin to change over as the program develops causing amazing clusters of organized shaped- patterns.



Turing patterns can involve not just chemicals, but large, complex systems. For instance, units could be considered cells instead of molecules of pigment. Therefore, this theory has been also proposed as the mechanism in which many biological structures such as limbs and organs are formed. As same as fractals, once understood Turing's patterns, they can be found everywhere in nature: complex systems, the distribution of flora and even the constellations of galaxies.



Nervous System is a generative design studio founded in 2007 by the brilliant minded artists Jessica Rosenkrantz and Jesse Louis-Rosenberg which mission is to blend science, art and technology. Jessica is also a designer, and programmer with biology and architecture degrees from MIT, while Jesse is an artist, computer programmer, and maker who also studied math at MIT. They decided to combine their bright talents to provide affordable and highly customizable design applications and tools of new technologies as generative systems and 3D printing and other digital fabrication techniques. But their valuable differentiator is precisely that they get inspiration from natural phenomena: "we write computer programs based on processes and patterns found in nature and use those programs to create unique and affordable art, jewelry, and housewares". Attracted by complex and unconventional natural geometries, the natural forms and corresponding processes which construct the world around us are at the basis of their design processes. Hence obviously Turing patterns have already been used for the creation of their designs.

"We wrote a computer program to generate 3D forms using a mathematical simulation of Reaction-diffusion, and used this software to grow the designs of the reaction collection. Parameters of the simulation can be varied for differing effects, creating different types or directions of pattern. These parameters are controlled and change through space to express design intent. The process begins on an imported underlying surface, and a 3-dimensional object is formed by embossing or removing material from that surface based on the chemical concentration present at each point in space. Multiple scales of pattern and simulation are used to create more detailed forms. Reaction-diffusion (RD) is a canonical example of complex behavior that emerges from a simple set of rules". (Nervous System, INC, s.f.)

Contemporary fashion designers have been exploring the emerging relationships between code, human form, and fabrication since a little bit more than a decade ago. All the generative designs aesthetics are usually translated from virtual to real world through digital manufacture technics as 3D printing or laser Cut. The New York based designer Francis Bitonti manifests that algorithm is the vernacular of the future therefore to design for the future we must embrace this methodology through the machine. His work is very interdisciplinary combining new manufacturing technologies and computer techniques.

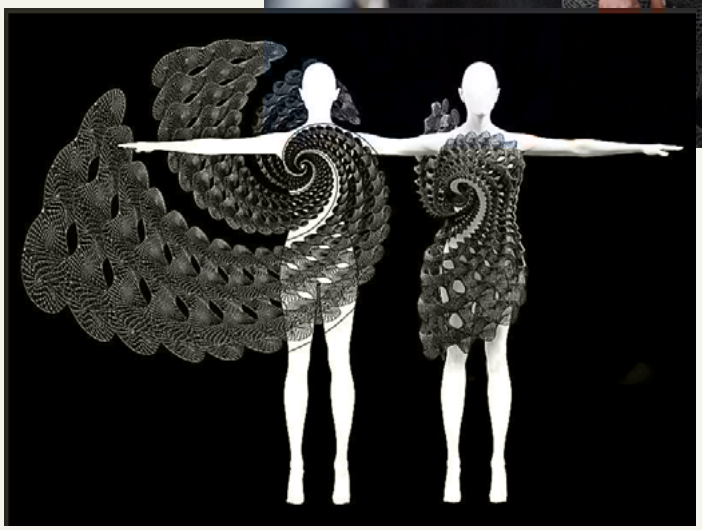
Verlan Dress from New Skins with Francis Bitonti Studio, 2013

Fashion industry is particularly interested because computational design is still a recent and unexplored innovation, closely linked with the spread of 3D printing. This design method has a wide range of applications both functional and aesthetical and of different scale models, including components of accessories, apparel and the creation of fabrics. This last application has been utilized mostly by the footwear industry in which 3D printed fabrics created under the concept of generative (and indirectly morphogenesis) design, are starting to be part of industrialized sportive models.

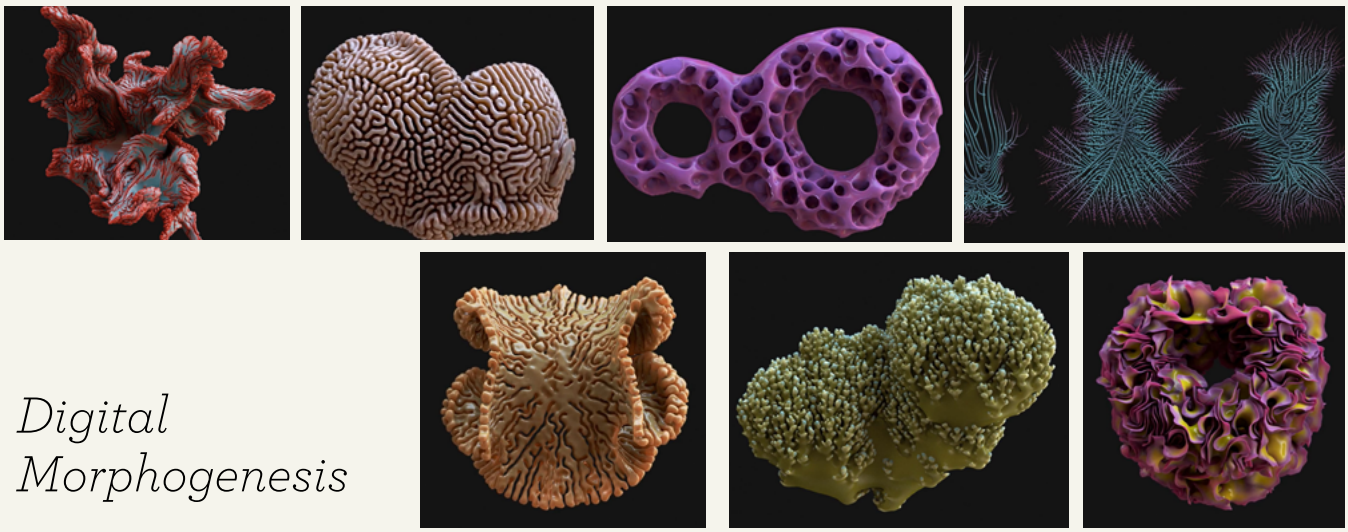
The experimental fashion brand Threeasfour, is a pioneer in using 3D printing tools for industrialized commercial designs. They created the dress Harmonograph in 2016 inspired by the mechanical device that uses pendulums to create geometric harmonious images. This dress combines biology, logarithms and geometry to explore the infinite possibilities evolving at the intersection of fashion, design and technology. This design uses Fibonaci sequence to enroll the body in three golden rate spirals.

Studies has been made to generate 3D-printable patterns for self-forming structures on pre-stretched fabrics to induce a wanted 3D shape. By printing a precise 2-dimensional pattern of different material of varied layer thickness and property, the shape of a fabric can self-transform into pre-programmed shapes after being released from the machine.

Nervous System - Self-forming structures in stretchable textiles



Threeasfour - Harmonograph Dres, 2016



Digital Morphogenesis

Furthermore, in architecture, digital morphogenesis is, more than a biomorphic approach, a biomimicry approach that aims to develop an understanding of how biology can be a model for material, mechanical, spatial and computational systems. It studies the ways organisms have evolved through form, materials, and structures in response to various functions and environments. A study of a natural system (general shape, anatomy, energy flows, geometry, organization, hierarchies and behavior) is carried out, together with an exploration of interrelationships and an abstraction of design principles to contribute to innovative computational processes of architectural design and materialization that will create generative forms and aesthetical shapes, but also will be critical to sustaining human societies through imminent changes.

In the Fashion Tech context, the focus could be on defining new models of ecological intelligence for future garments designed for an altered world. The aim would then be to use this generative natural logic to generate responsive systematic models to design sensitive clothing within contexts of extreme climates and life-threating ecological conditions. According to Lidewij Edelkoort, famous trend researcher and author of the Anti-Fashion manifesto, "we will navigate at the border of organic & digital, intuition & interface. A world where technology and human will be one". There will be a strong long-term trend called the Hybridization in which human beings will be searching to be superhuman through the blending of technology, nature, medicine and design.

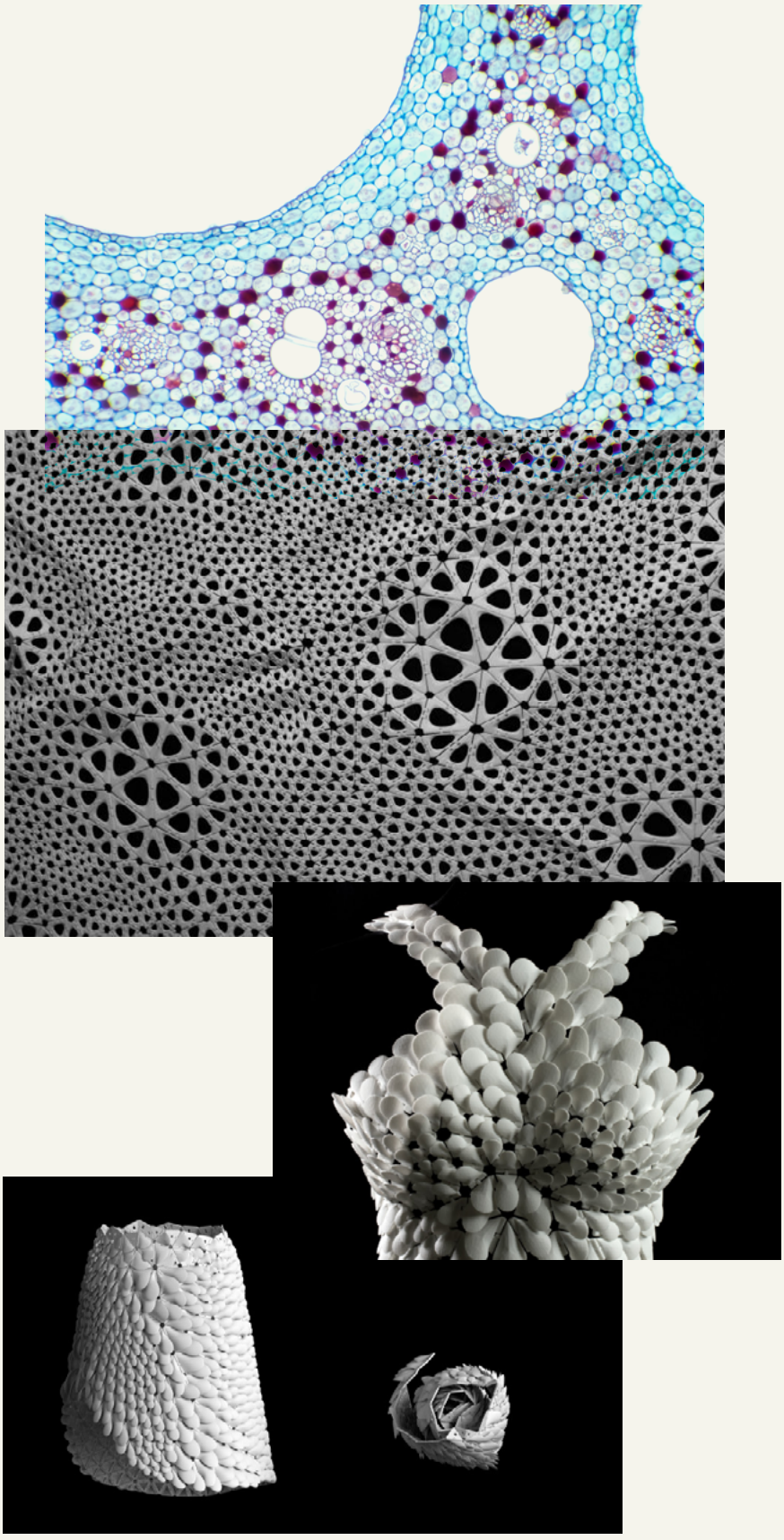
As an early attempt of achieving the above, Neri Oxman explored in 2014 a speculative design that embodies environmental design and digital morphogenesis, with shapes and properties that are determined by their environmental context. With her team at the MIT she develops material research, considering that in the coming future, product production will be closer to nature mimicking self-assembly and self-organizational structures.

She imagined a collection of "wearable skins" that will allow wearers to travel beyond planet earth to deadly environments. The wanderers will have to encounter extreme conditions like complete darkness or extreme temperatures thar could freeze carbon dioxide. The wearable works as an organ system that grows around the weavers body as a physiological augmentation

She studied the bacteria morphogenesis in order to control its flow. She imagined new life forms as periodic table elements.

The 3D printed designs resemble intestinal tracks conformed by capillary channels that contained the flow of liquid synthetically engineered microorganisms that will have a beneficial relationship between them providing the wearer with the life-sustaining elements to survive in those specific environments. One of the designs contain two species of bacteria, one that converts light into sugar coupled with other uses sugar to produce biofilms. Another one has liquid channels of photo synthetical bacteria glowing life. She imagines the bacteria culture growing around the body as the liquid bacteria expands.

"The wearables are designed to interact with a specific environment characteristic of their destination and generate sufficient quantities of biomass, water, air and light necessary for sustaining life: some photosynthesize converting daylight into energy, others bio-mineralize to strengthen and augment human bone, and some fluoresce to light the way in pitch darkness" (Antonelli & Burckhardt, 2020)



Kinematics & 4D printing

Following the idea of printed elements that can respond to external environmental stimuli, such as immersion in water. In 4D printing the fourth dimension is represented by time and the changes materials experiment by it. Kinematics, the science that studies the motion of bodies in time, is a tool to add formal variability in time.

Nervous system, the forementioned design studies used this strategy in their series of Kinematic Petal Dresses printed with Selective Laser Sintering. The dresses are designed through complex interconnected multiple structures. These structures are composed of hundreds of individual rigids parts that when interlocked together have a flexible behavior that can adjust to body movements like a normal fabric. Additionally it has petal or shell like forms which cover the body in a direction landscape of overlapping plumes can also move according to the wearer movement This formal property is used as a manufacturing advantage to reduce the volume needed when printed by printing the dress folded.

Using the principles of parametric design the dress is customizable by the customer who can change sizem digital model, petal sizes and directions. This is possible thanks to an app that was specially created by the same studio. Variable obtained designs also change in stiffness, drape, flexibility, porosity and texture. (Mometti, 2016)

Bio-utilization

There is a proposed term, although not yet officially approved, to describe the epoch of Man and his impact on ecosystem of ther earth. During the Anthropocene the Earth has suffered extreme changes incluing climate change, extinctions, invasive species, technofossils, anthroturbation terraforming of land, and redirection of water, all undoubtedly due to the human signature and even more than the damage all the other natural forces combined could cause. Still, our quest of maintaining our way of living and even seeking a better quality of life will never stop. Then our responsibility must be to find every possible way we could counteract our impact on Earth and protect our environment and even our own existence! Here is when conscious design and eco-living gain tremendous importance.

"Designers are re-evaluating their approach to material consumption by exploring locality and sustainable resources. Unassuming humble materials become the focus of beauty, celebrating the mundane and overlooked" (Lee, 2014). However imitating nature or designing with the cradle-to-cradle principle, among others bio-inspired approaches, are not enough to fully integrate the natural with manufactured inventions. Therefore, designers are starting to think further than mimicry and to discover how to exploit the observed processes of the living world. In order to achieve enhanced ecological performance through integration with natural systems, designers are turning to biologists for their expertise and guidance.

Diana Scherrer, 2018. Combining grown plants roots with Art Nouveau patterns to demosntrate the potential of nature-based geometric forms into living designs.

The four fashion giants Adidas, Kering, Lululemon and Stella McCartney will now have exclusive access to vegan leather from the biotech company: Mylo. The innovative material is made from mycelium, the roots of fungi.

Bio-materials

AlgiKnit's work, Bioyarn is a substance molded from readily abundant biopolymer 'Alginate' (extracted from Kelp, Seaweed or Algae). This Bioyarn, then naturally dyed and knit into a bio-based textile holds the promise of a sustainable material alternative for the footwear and apparel industries

Biodesigner Jen Keane has developed an interesting "microbial weaving" process by manipulating the growth of k. rhaeticus, a type of bacteria typically found in kombucha tea. The resulting material, a synthetic fibre, is stronger than steel and more resistant than Kevlar © Vita Larvo

Cellulose from citrus waste is made into a filament and subsequently an innovative fabric © Orange Fiber

Anke Domaske, a micro-biologist and designer who lives in Hannover, Germany, discovered a in 2011, Qmilch, a silky fabric woven from casein, a protein present in milk.

Mycoflex is a biomaterial made from 100 per cent pure mycelium. It's the main component of high-performance foams that have a wide range of applications, from sports shoes to light insulators for thermal gloves, and much more. Mycoflex is a vegan, non-toxic alternative to traditional synthetic foams and biodegrades naturally after use © Ecovative

BioDesign

"Unlike biomimicry, Cradle to cradle, and the popular but frustratingly vague 'green design', Biodesign refers specifically to the incorporation of living organisms or ecosystems as essential components, enhancing the function of the finished work. It goes beyond mimicry to integration, dissolving boundaries between the natural and built environments and synthesizing new hybrid typologies."

As we have established Nature being our major point of inspiration we wonder, how can we integrate biology and design to project a less harmful future of fashion? Combining biology and design, we are now able to create products that adapt, grow, sense and repair themselves and eventually could be returned to nature. This responds to the new world's urgency of the need to rethink scarce resource management including the fashion system off course. We need to achieve perfect material and energy economies, efficient waste eliminations and biodiversity protection to guarantee our human survival. Almost perfect economies of energy and materials are only achieved by nature. The world's current urgency is to achieve these standards of efficiency as human activity and economic development in the Earth are the big cause of climate changes and natural resources scarcity.

There is a huge difference between this new bio-approach design and the other ones previously discussed, "the emulation of nature is now moving beyond stylistic choice to survival necessity" (Myers, 2018). The emerging Biodesign harnesses living materials and let nature, the best engineer and designers of all times, to run its course. It's an emerging approach to design that interacts with scientific researches and goes beyond any other bio-inspired approaches.

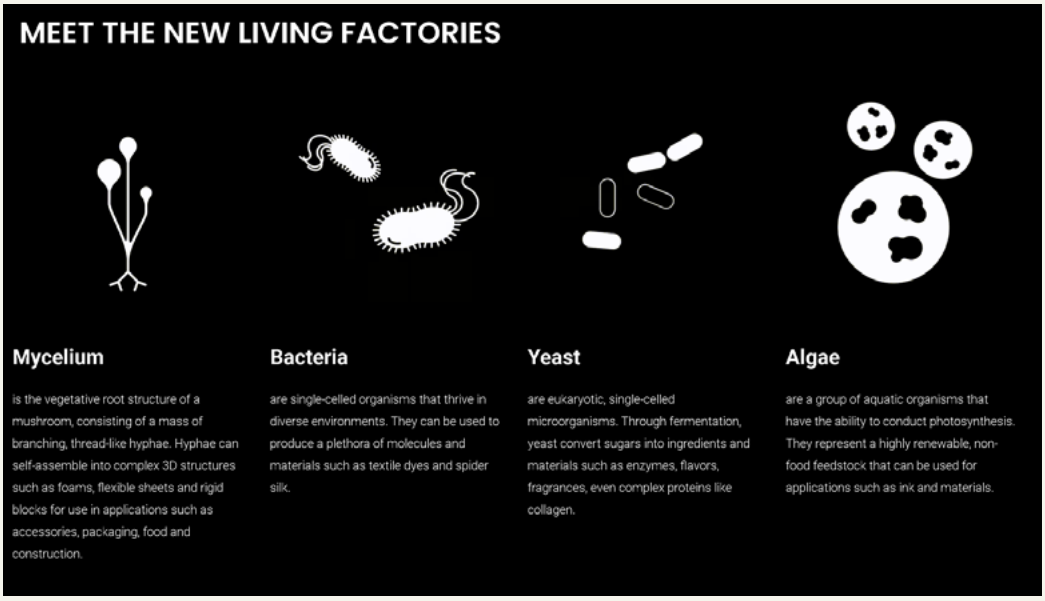
It is now believed that Biodesign would be the next revolution, after the industrial and digital revolutions, Biodesign will replace mechanical and digital process with biological ones seeking a more ecological performance that efficiently manage materials and energy resources. Exploring design integration with biology is now possible thanks to the now emerging affordability of biotechnology tools that have as basis the DNA-modifying techniques. The democratization of these scientific discoveries will have a similar effect to the steel affordability which led to the Industrial Revolution. Following this order of ideas, much consider this the century of Biology. Basic life forms will enable fabrication process and form-giving mechanisms (Myers, 2018).

An essential aspect of Biodesign is the uncertainty meaning that the designer codesigns with natures and renounces to the total control or predictability of the final product. This is due to the spontaneous growing, construction autonomous intelligence of nature and other natural processes that may occur by utilizing living organisms in the fabrication.

In this way, Biodesign is based on the analysis and decoding of the natural system that, understood by man, can be applied to find solutions to ecological problems. In addition, with Biodesign the usual concept of performance, that is, the degree of satisfaction of a need that the user perceives with a product, garment or material, acquires a new dimension of functionality. This new performance is measured by the degree of sustainability, the degree to which the design can offer human connectivity and a form of interaction. Last but not least, the performance of designs can also be measured by the degree of awareness of future technologies and behaviors that the design creates. As we continue to talk about a collaboration between biologists and designers, the last ones overseeing creating a possible figurative utopia on life, Biodesign continues to be a question of a human-centered approach to utility and its performance can translated into the degree of Well-being delivered.

"Biodesign opens up a new area of research and potentials for creating new kind of wearable; using live organisms to sense and respond to the individual user and also to the surrounding environment," said MIT Design Lab director Yihyun Lim "We are imagining products that can adapt to users and the environment in real time, without the user having to do anything, [to] optimise their movement, body and their performance. Products will behave on behalf of the athlete, in real time and effortlessly."

Synthetic Biology:
Enabling new biological functionalities by editing the DNA of cells.



Biofabrication 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.

Some big players of Biodesign nowadays are:

- ***Biofabricate:*** A team of pioneering creatives with big expertise in working with companies interested in Biotech. The group provides strategic consulting services to introduce companies in the emerging fields of Biodesign, biomaterials and bio fabrication. They are also pioneering in organizing events and conferences to discover, link and showcase the latest Bio-innovations. Finally, the group provides a complete resource platform to intensify open-sourced initiatives, information sharing and generate interactions among stakeholders.
- ***Modern Meadow*** grows biofabricated materials that support a healthier planet. In this way, their adaptable material family ZOA, which Suzanne Lee is the chief creative officer for Modern Meadow and a fashion designer by training. She is best known for making clothing out of a kombucha-like bacterium.
- ***Terreform One:*** Terreform is a leader in building with living, self-generating, and sustainable materials.

Moreover, Nature will be use to fabricate materials itself. With synthetic biology and Biodesign products will be made in nature. Designers becoming developers and self-producers representing the new alchemists.

The Biomanufacturated vegan silks that are emerging in the industrial fashion system are just one example. Adidas, being always a pioneer in the innovative sportswear industry, introduced Biosteel fibers developed by German industrial supplier Amsilk into the manufacturing of the upper prototype shoes in 2016. It is a silk-like biopolymer that was obtained decoding spider DNA then applied to a bacterium. The material is 15% lighter in weight than conventional synthetic fibers and it was the first strongest completely natural material available. This combination of properties made this design not only valuable for the environment but also for the athlete's performance.

Later on, Stella McCartney used another vegan spider-style silk, this time by Bolt Threads to create the Biofabric biodegradable Tennis Dress for Adidas. Microsilk is the recreated version of the proteins of the silk web waved by a type of spider in a laboratory.

"In order to do so, scientists at the startup bioengineered genes in the lab and implanted them in yeast - Together with sugar and water, the yeast produces protein through fermentation. Liquid silk proteins are then extracted and spun into yarn to weave for garments - The material was mixed with a cellulose-blended yarn to make the prototype dress" (Block, 2019)

Spiber, on the other hand is a biotech startup that developed the "Moon Parka" jacket in collaboration with The North Face being the first commercially available jacket from emulated spider silk. "In essence, we would create our own DNA based on the DNA that is responsible for producing spider silk, incorporate that it into microorganisms, and then feed them nutrients in large tanks so that they can multiply and produce the protein of interest." said Daniel Meyer, Spiber's head of global corporate planning.

The next age of genetically modified bio-materials won't bestow humans with skin that glows in the dark, spider legs or bat wings, but unleash the potential these technologies contain, to redefine us in rapport to the surrounding environment, in the form of new layers of protection. (Laurenti, 2018)

"Biodesign refers specifically to the incorporation of living organisms or ecosystems as essential components, enhancing the functions of the finished work" (Myers, 2018). Therefore, Biodesign is used when referring to projects, designs, creations and system cover under the umbrella of Bio-utilization. While biomimicry focuses on the translation of biological principles into human-made technology, bio-utilization directly leverages on organisms or biological materials.

Bacteria to create colors: Faber Futures is a company from the UK that has developed a new method for dyeing fabrics and protecting the environment. Using bacteria and a fermentation process, they can create dyes that do not fade over time. Most importantly, the process has proven to use up to 500 times less water than conventional dyeing methods—making the entire process highly sustainable.

Growing Textiles

Taking into account our focus of analysis, Biodesign is a field that is beginning to be explored also in fashion. **Biodesign is contributing lots of textile innovation** in this industry that will definitely change the way we interact with our clothes and take care of them.

For centuries, construction and design have evolved from the very primitive use of products of nature and raw materials, to a sophisticated world where **materials will be engineered and produced in labs.** Products of design and architecture will be configured not to be assembled, but to be one part products for the purpose of optimization of time, materials and cost. **Buildings and objects used to be made out of parts, in the proximal future they will be composed of tissues that vary its properties adapting to the different internal and external conditions.**

With Biodesign powered by biotechnology emerged "Biocouture" a project designed by Suzanne Lee from Central Saint Martins in London. She created **Bacteria-grown clothes which have reduced environmental impact as they relay in microorganisms as raw material.** The designer took advantage of a process that occurs during the fermentation of sugar in which bacteria gain energy, and some strains spun microfibrils of pure cellulose forming a dense flexible layer. In this case, a solution of green tea and sugar was made where some added bacteria grew the layer of flexible materials. This can be removed when still wet and it is then dried acquiring either a dimensional shape or a flat one, that can then be cut and sewn. It is said that the final materials feels as artificial leather. It seems as if she creates a garment out of nothing thank to an organic process!

The main material characteristic is that **it can be composted after its life cycle, however a huge disadvantage is also its short durability and the lack of water resistant** which makes it impossible for performative garments use.

Suzanne is now creating a Biodesign community based in open innovation to encourage the new global movement of makers and innovators. Enabling this open platform the bio-materials innovations will catalyze product developments around different fields that are demanding compostable materials produced with minimal raw materials and energy. The projects will deliver both, DIY recipes that start with microbial cellulose grown in a bucket and could be used to create biodegradable fashion accessories, to scientific method, documentation and educational tools to enable global awareness about biotech.

Neri Oxam claims that this is the era of Evolution by design because designers will be the one in charge of imitating the growing of living things to cultivate new materials. These bioengineered products are made to adapt to the circumstances of their

environmental direct surrounding such as heat, pressure, texture and chemical composition and will assume behaviors of the living organisms which are composed

Programmable Materials - 4D printing

Regarding innovative materials, it is also important to discuss research around 4D printing. Skylar Tibbits, an MIT Researcher, architect, designer, computer scientist and TED Senior Fellow, is working on Biomolecular Self-Assembly and human scale 4D printing as well as a technology called 4D Printing: Multi-material Shape Change Over Time. Inspired by Self-assembly and self-organization nature properties. The idea behind self-assembly is that molecules will always seek to use the minimal energy to survive, whether this means bonding with an adjacent molecule or reorienting physical positions. The same applies to the force that makes a sunflower to orient towards the sun or a the reason why a compass needle always reorient itself in a north-south direction. Seeking the self-assembly properties in a material means to build a material that can naturally organize itself to achieve a wanted effect.

Biological Self-Assembly is a hybrid methodology that combines nature's molecular tools with synthetic nanoscale constructs. It consist in depositing active biomolecules on solid surfaces at nano scales to aid self-assembly of inorganic constructs on unconventional substrates.

Bio E-textiles:

The new interface Bio sensors & actuators.

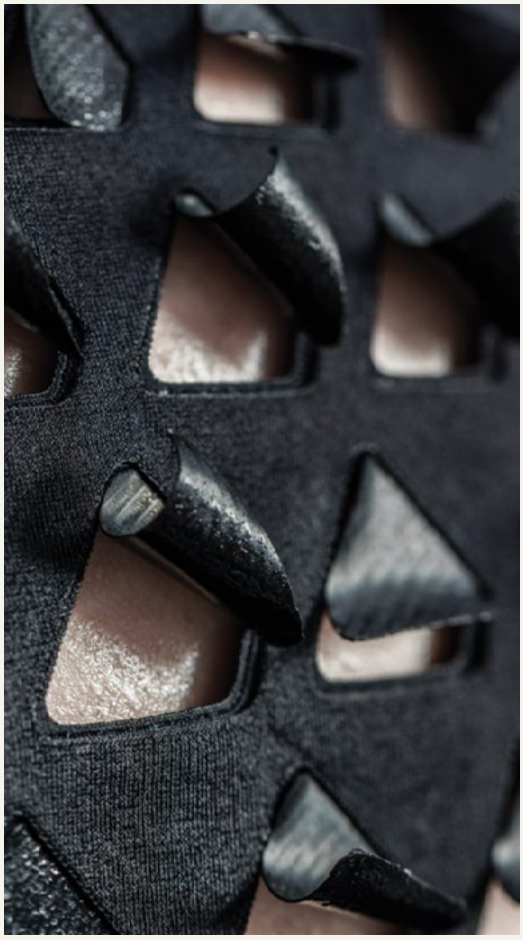
We are entering in an era where bio is the new interface. We are imagining a world where actuators and sensors can be grown rather than manufactured, being derived from nature as opposed to engineered in factories.

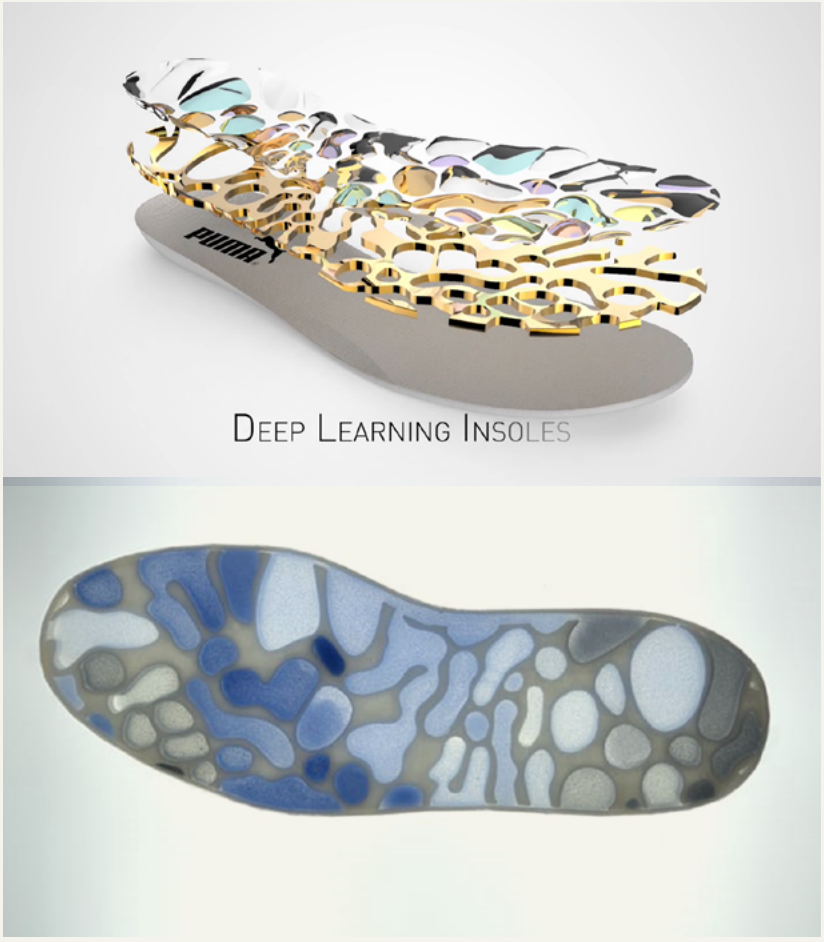
The Second Skin

When thinking about textiles as second skins, smart textiles take advantage of the fact of being in constant contact with our skin. Our bodies are communication devices that constantly gather information from our inside body or from the outside environment and translate it into data that activates a specific response. In the same way that fabrics interact with us as we smell, see, hear, feel and even taste them with our sense, fabrics interact with our bodies and the outer environment gathering information as pressure, temperature, light, current, moisture etc. This data can activate automatically a reaction in the fabric or can be transmitted through chemical reactions, mechanic reactions or by means of computational software.

Reactions can be perceived as extroverted if they deliver an evident external transformation or introverted when they don't necessarily display a visible physical change. The first ones usually consist of fabrics embedded with digital devices and are also referred as E-textiles. While the second group includes technical fabrics not necessarily new, that react to the wearer's body and permit the body to sense a reaction and a sensational change after the fabric is stimulated. As an example, are the fabrics developed to achieve athletes comfort by keeping moisture away from the wearer's skin. The fabric reacts to the body temperature and humidity, absorbs the moisture and reacts wicking it to the textile's surface speeding up the evaporation process. After the fabric reacts, the wearer senses in response a dryer sensation.

Coming back to Bio e-textiles, there have been some bige developments of bio textiles that sensor and act back to stimulus working as second skin. A big pioneer of this was the Japanese project "BioLogic" created by some group of designers and scientists of the MIT and developed almost four years ago. BioLogic seeks a harmonious perspective, where biological and engineering approaches flow in sync. Bacteria harvested in lab are bio printed in a fabric to achieve a responsive garment. BioPrinting is also an innovative process that explores a liquid deposition printing system for natural actuators (Yao, et al., 2015)





Activated by bacteria the garment is intended to respond to moisture by self-transforming its structure. The garment design has some cell made out with cuts in the fabric that when in contact with sweat and body heat, these flaps open permitting sweat to evaporate and so the body can get colder. This project is a real innovation into the world of sportswear.

In these bio-hybrid films, bacteria perform as sensors and actuators. Bacteria are also capable of shape and color changing, emitting light and expulsing several chemical components that can act as data transmitters.

Deep Learning Insoles presented by Puma in collaboration with MIT Design Lab during the context of the Milan Design Week 2018, was a design that uses bacteria for the improvement of the wearer's performance and well-being by preventing fatigue through real-time biofeedback. The insole has some crevices containing bacteria on its upper layer that serve as biosensors by detecting chemical phenomena in the wearer's sweat that indicate fatigue. A layer of electronic circuits, turns the detected compounds into data that is transmitted to the user's smart device using micro-controllers. The data measures the amount of exhaustion.

"Biodesign opens up a new area of research and potentials for creating new kind of wearable; using live organisms to sense and respond to the individual user and also to the surrounding environment," said MIT Design Lab director Yihyun Lim "We are imagining products that can adapt to users and the environment in real time, without the user having to do anything, [to] optimise their movement, body and their performance. Products will behave on behalf of the athlete, in real time and effortlessly."

Furthermore, in the science of Bio e-textiles some organic hydrogels, useful for wearables, are being explored. A hydrogel made of Biomaterials and capable of conducting electrical signals was exposed by which Professor Chen in a 2019 paper published in Scientific Reports. The scientist claims that it is completely organic made with cellulose obtained from Okara – the waste leftover from soybean pulp during the making of soy milk, and is useful for wearable, flexible and stretchable electronics.

HOW WELLNESS & Wellbeing AFFECT FASHION

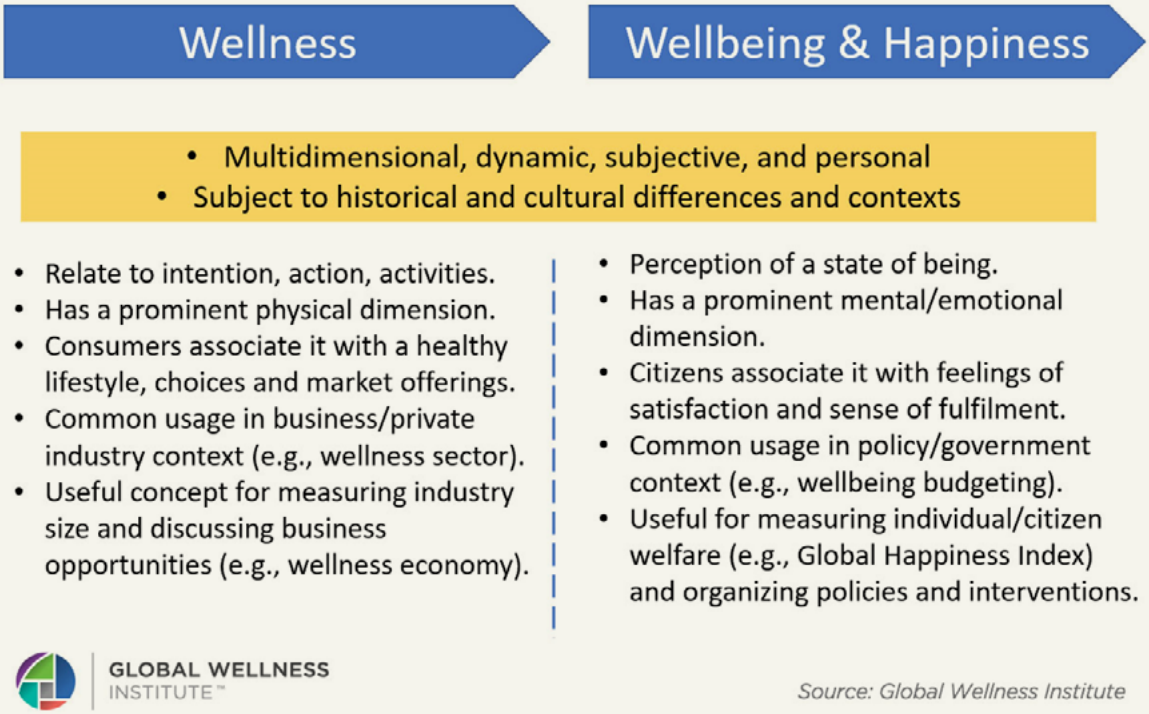
Susana Vallejo Mesa
10642557

The Global Wellness Institute defines wellness as "the active pursuit of activities, choices and lifestyles that lead to a state of holistic health." (Global Wellness Institute)This definitions describes wellness as an individual pursuit that is related with personal choices and actions one makes towards the quest of an optimal state oh health. The institute explains that it incorporates many dimensions that should work in synergy representing our lifestyle, decisions and behaviors that could be strongly influenced by the physical, social and cultural environments in which we live.

The Global Wellness Institute's 6 wellness dimensions:

- Physical: A healthy and strong body through exercise, nutrition, sleep, etc.
- Mental: Engagement with the world through learning, problem-solving, creativity, etc.
- Emotional: Being in touch with, aware of, accepting of, and able to express one's feelings (and those of others).
- Spiritual: Our search for meaning and purpose in human existence.
- Social: Connecting with, interacting with, and contributing to other people and our communities.
- Environmental: A healthy physical environment free of hazards; awareness of the role we play in bettering rather than denigrating the natural environment.

Therefore, the main difference between wellness and wellbeing is that the first is the active process of being aware that our choices will lead to a final outcome of health, the last represents the static state of being.



Source: Global Wellness Institute

Health and wellness has been an increasing consumer priority for a long time, but Covid-19 has added a new facet towards a fulfilling life. As people have a new permanent caution when it comes to safety and hygiene, an evolved attitude to mental health is added to the needs. **"Therefore, consumers are today searching for Wellbeing more than wellness, shifting to a holistic view, looking beyond how the individual feels and towards how they exist in society. It is relational, environmental, and takes external factors into consideration" (WGSN, 2021).** The key point is to remember that even though healthy habits to achieve a physical wellbeing are still very important, we must keep in mind that we are whole beings: mind, body and soul. "Brands will need to incorporate wellbeing into everything, from their design and product development to their marketing and online strategies" (WGSN, 2021).

The WGSN article Wellness to Wellbeing: New narratives of care, explains that this holistic shift divides Wellbeing into several aspects: Financial wellbeing, mental wellbeing, physical wellbeing, relational wellbeing, communal wellbeing, and environmental wellbeing.

Mental health began to be of great importance throughout the Covid 19 pandemic: So many days locked in homes with saturation of information, uncertainty, sadness, nostalgia and remote work being the only form of distraction, governments had to resort programs addressing holistic health. Mindfulness applications had an increase in downloads and subscriptions, in social networks meditation techniques and messages of positivism were largely promoted, gratitude and hope became viral. However, the "toxic positivism" was also popularized, in which a positive and happy attitude must be simulated in the midst of circumstances that do not allow it naturally.

Thus there is a great need for tools, objects, techniques and attitudes that provide peace of mind to achieve good mental

health. Psychological treatments and therapies are just one of the ways, the human being must also acquire self-compassion, resilience and acceptance of their own negative emotions.

On the other hand, ***physical wellbeing*** does not focus more on just being physically fit, but rather in having a healthy and strong body to prevent the risk of disease. With the pandemics, consumers around the world got used to workout at home after trying different ways and trainings until finding the most comfortable and pleasant one. Many of these exercises are no longer only functional but seek to generate small moments of joy, distraction, fun or relaxation. Activities like dancing and yoga are now very popular. Fitness strategies should already be more message-based explaining not only external benefits, but internal physical benefits such as increased serotonin, decreased cortisol, and how these help reduce stress and increase happiness.

Since last year, sports in open places, away from the city and the crowds, are gaining strength; trekking, hiking and mountain biking are some examples. Now after all vaccinations against the virus are carried out, when we can finally be out without concern, sports that provide connectivity and relationships in addition to physical health will be the most sought after.

Likewise, after the lockdowns people realize that **well-being is a community issue more than just an individual issue.** The interdependence with society is inevitable, businesses are becoming more social sustainable, giving importance to ensuring their staff wellbeing and enhancing local communities. Industries are turning to collaborative consumptions and lots of communities initiatives are arising to stimulate consumer to consumer interactions. **As people connects with the place there are living, it has been proved that wellbeing is directly affected by the current surroundings. Hence the interest in environmental conservation will increase.**

WELLNESS INNOVATIONS IN THE FASHION INDUSTRY:

The traumas of the pandemic and the concerns of the adjacent recession will bring with them the need to personally and frequently monitor physical and mental health indicators. Each one should be responsible for including therapy and personal healing as habits within our routine. For this, **the industries will provide technologies and tools for monitoring both fitness and physical activity as well as emotions and moods.** In the fashion industry, such aids can come in the form of wearables.

It is predicted that people will seek environments, activities and products that help them lift their moods for their own good. **Fashion focused on wellness should seek to offer consumers mentally, emotionally and spiritually healthy benefits at home, at work and outdoors.** "As mood-regulating tech matures, the potential for innovation via collaboration will grow" (WGSN, 2021)

One way to achieve **the spiritual connection and the desired mental and emotional tranquility will be by retaking ancestral knowledge of indigenous communities and ancient cultures.** Moreover, intuitive and pre-industrial medicine will be embraced by those who seek alternatives to classical medicine as they need a break and rest from the system and desire enlightenment and connection with the roots of the human being. At a functional level, the fashion industry uses textile dyeing with medicinal plants that provide healing when the garment is used. On an aesthetical level, ancestral wisdom is translated into prints, lines, texts and tribal compositions, of high symbolic content and related to alchemy.

By regaining ancestral knowledge, the search for well-being is accessed through brews, medicinal plants and natural psychedelic solutions. As science begins to endorse psychedelics as possible treatments for certain illnesses, **consumers are open to undergoing new sensory experiences that positively alter their moods through nature-powered materials, herbs, oils, and crystals.** Physically, these therapies also seek to relieve pain and tension from daily activities. A great example of this in fashion is exploring CBD-infused textiles and clothing.

Continuing with the search for new strategies for reconnecting with feelings, the new romantic consumers seek sensory moments that connect them with the internal and external world. Being again in a busy reality generates exhaustion and needs for moments of disconnection and introspection. A design by the German Elsa Molinard, seeks to satisfy this need with a stoneware vessel designed to be filled with water and hugged. **"In this ever-faster world, ritualized moments of connection can bring us back to the here and now"** expresses the designer. Fashion and clothing can also be the subject of rituals through materials or performance activities with such clothing.

Sport also has benefits on a spiritual level, so for many people, doing a sport that is carried out individually can be considered a ritual of personal recharge. These moments also help to carry out an emotional cleansing and to deal with stress, anxiety, insomnia and disconnection.

Why Fitness as a Spiritual Practice:

- for greater happiness and fulfillment.
- as time to reflect.
- to test your will.
- To engage your heart.
- to expand your comfort zone.
- to change your karma.
- to release emotion and energy.
- to take a moment a breathe.

SMART CLOTHES THAT BOOST YOUR HEALTH & WELLBEING:

For centuries the functionality of clothing was nothing more than covering and keeping us warm. However, during the last century clothing design had a revolutionary shift of focus towards a more functional goal and all thanks to material innovation. With the invention of technology and the digital age, countless technologies have appeared allowing clothing to be smart through IOT, body-mapping technologies, embedded hardware-software among others. The purpose of smart clothing is to optimize the well-being of those who wear it, delivering various already known benefits such as adaptability to different environments but also others that have arisen due to current contexts such as healing, antibacterial protection, self-healing materials, or emotional communication by helping to express your mood.

The design section of Zaha Hadid Architects, Zaha Hadid Design and the Swiss company Odlo have presented their new spring / summer collection of women's sportswear, Women's Activewear 2019. The new designs were developed for sportswear from a functional perspective based on the Layered Space system, distinguished by smooth transitions and layered construction, which generate better performance and optimal design, adapting to the anatomy and physiology of the human body. The Zaha line consists of a parka, leggings and a bralette that uses translucent and breathable fabrics, suitable for the gym and daily life. The interior flock print ensures that the garments do not adhere to the skin and gives freedom of movement; while the perforated structure of its polyamide fabric gives the correct ventilation to the body.

Start-up Lumiton has just created a sunlight-activated Wear Healthy line powered by laser technology that is designed to deliver multiple wellness benefits: The UV-protecting fabrics are infused with laser dyes that get energized with sunlight to produce red and near-infrared light, whose wavelengths, they argue, increase collagen and muscle growth and reduce pain/inflammation.

For intense sports, Aexos has created garments that use bio mapping and new materials that protect during impact to reduce whiplash and concussion (Hello, football world). For instance, its Halo shirt has a high collar that remains soft and flexible normally but stiffens and protects on impact. This innovation could have other applications in the medicine industry for bone-fragile elderly people,, offering strenght, protection with clothing for hard falls.

Clothing brand Become uses techwear fabrics to help menopausal women manage hot flashes and night sweats.

If the world is mad for collagen as an ingestible beauty supplement, now wearable collagen is a thing. Tech sportswear brand Buki has released a chemical-free Collagen Collection, which embeds collagen into fabrics to provide all-day moisturizing, and the effect never wears out because the collagen powder is infused in to a cellulose fiber.

There are clothes that help our bodies heal and sleep better. Under Armour's Athlete Recovery Sleepwear (created with quarterback Tom Brady) uses bioceramic technology embedded in the pijamas to absorb infrared wavelengths emitted by the body. This energy is reflected back as far infrared energy, to help the body recover faster and sleep better.

"Another trend is weaving "ancient wellness" healing and herbal properties into fabrics and clothing collections". (Global Wellness Institute, 2019) Eco-chic Australian label Kitx uses Ayurvedic recipes with herbs that have antibacterial properties to dye their collection; The trendy footwear designer Astara has created "earthing shoes", using crystals, such as black onyx and blue apatite, so that the shoes resonate at the same vibration as Earth's magnetic field (7.83 hertz).

By analyzing the actual global drivers we can understand the increasing growth of some fashion markets within the fashion industry: The Global 2023 driver stated by WGSN **"Environment; from urgency to emergency", the continues rise of Wellness and the still existent Covid- 19 lockdowns are shifting the demands of fashion consumers towards a more sustainable and comfortable fashion.**

1. On one hand, the growth of the sustainable Athleisure fashion Market due to the increasing fitness and conscious attitudes of consumers, has influence the whole industry changing aesthetics and introducing functionality to almost every sector of the market. Wearing casual but stylish outfits for nearly every occasion and implementing a sporty lifestyle is not only a common practice but a continuously growing market segment of the fashion industry today.
2. On the other, Fashion is moving towards a "mindful glamour" and the concept of wellness in fashion is explained as how the mindsets of fashion and the whole system can transform from being unhealthy to the planet to becoming more beneficial; by taking active processes, changing behaviors, choices and actions within the system.

WELLNESS IN FASHION:

As consumers are giving higher importance to mental and physical health, the fitness trends equally increase their popularity boosting the demand for sports, athletic and active wear. According to a report delivered by Million Insights, the global Athleisure Market size is projected to touch USD 517.5 billion by the year 2025. It is anticipated to grow at a CAGR of 8.1% through the forecast period of 2019-2025, due to the increasing adaption of fashionable and stylish athleisure clothing in offices & workplaces (Million Insights, 2021)

Athleisure has become part of an urban fashion movement that worships, comfort, style, and functionality. During and after the pandemic, a majority of people got used to wearing comfortable casual wear to work, hence athleisure also finds its application in the corporate culture. Ever since people started going back to the offices, the working population presented a preference for an ideal mix of elegance and functionality, which is encouraging them to purchase more athleisure outfits.

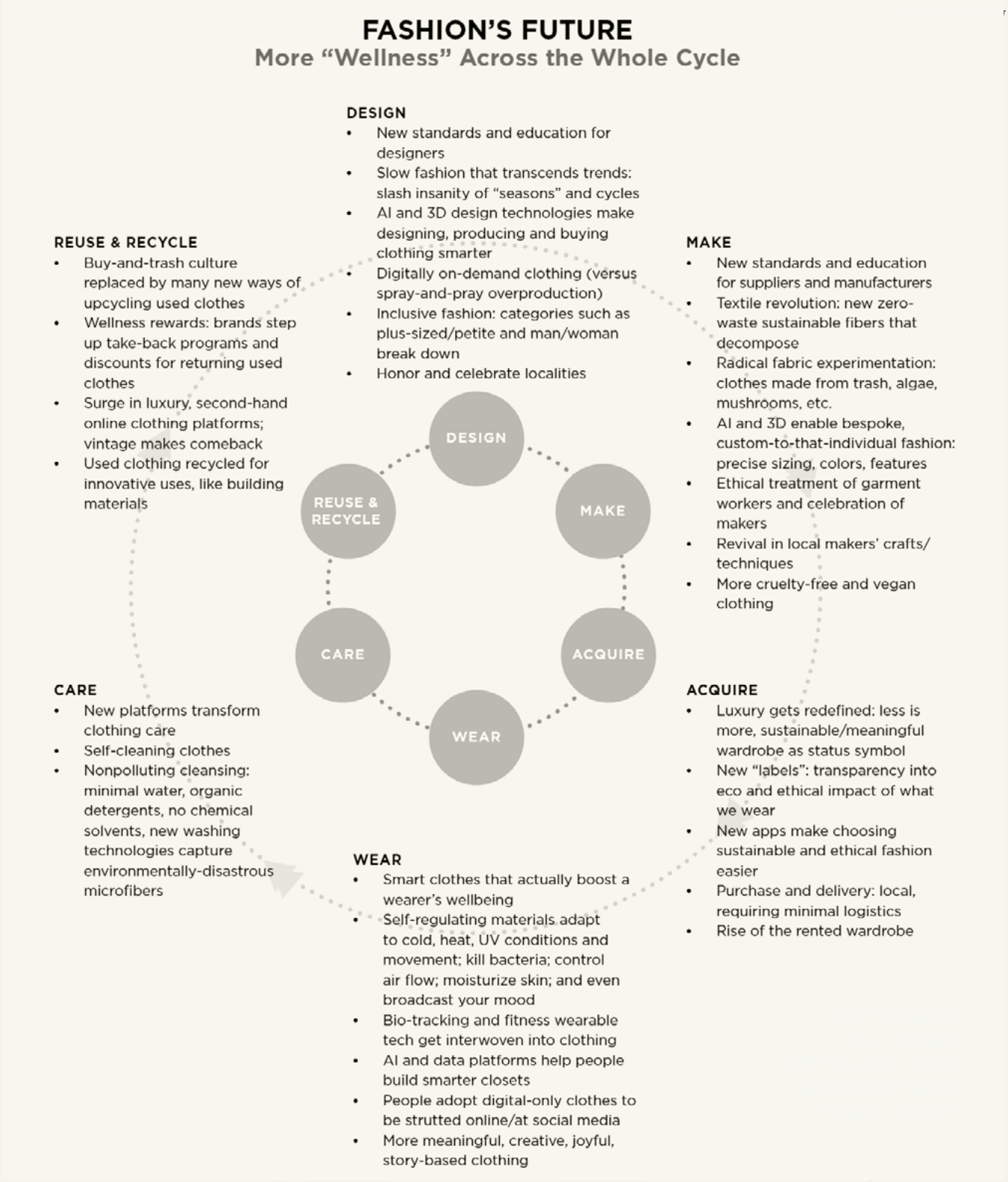
The rising awareness regarding physical fitness and personal grooming among millennials, coupled with their inclination toward sustainable development, are the reason why the global sustainable athleisure market size was valued at USD 79.41 billion in 2019 and is expected to reach $126.9 billion by 2026. It is estimated to expand at a compound annual growth rate (CAGR) of 5.0% from 2020 to 2027 (Grand View Research, 2020). The strategies of various apparel brands from this fashion market are to be involved in ethical trade practices and to close the loop of the lifecycle of their products to deliver high-performance activewear for the individual while keeping up the environment safe.

The major players in the industry include Adidas AG; Under Armour, Inc.; Lululemon Athletica, Inc.; Nike, Inc.; AJIO Company; HUMAN PERFORMANCE ENGINEERING; Esprit Retail B.V. & Co. KG.; Under Armour Inc.; and PUMA SE. The forecasting report exposes that innovation of products and expansion of product portfolio are expected to propel the demand in the market in the coming years.

Sustainable fashion is well supported by celebrities and is actually trendy in Hollywood. The top model Elsa Hosk recommends the brand "Sporty & Rich" fostering retro sportswear from '80s and '90s in cool activewear pieces that have a cult following among the celeb and fashion set. The brand exposes their effort of extending the longevity of their products by offering a collection of simple, yet thoughtfully designed products that emphasize longevity over momentary relevance. To demonstrate their commitment with mother earth, the brand has partnered with leading environmental non-profit organizations to help reduce and balance the damage that producing garments does to our planet.

Even thought, athleisure has taken the apparel world by storm.

"Wellness is playing a bigger role in fashion, from workleisure, to connected apparel, to eco-friendly clothes. Consumers are increasingly seeking clothing that promote well-being and healthy habits, with modern-day "wellness" referring to holistic healthy living characterized by physical, mental, social, spiritual and environmental well-being" (CB Insights, 2019).



The new intersection between wellness and fashion will bring: clothing that can optimize our wellbeing—that regulates heat and airflow or helps us sleep or heal; fashion retailers delivering all kinds of wellness experiences into the store and offering wellness education/ experiences (such as Mindfulness-Based Stress Reduction). Moreover, as designers, one of our vital roles is to encourage people to assume better behaviors that will improve their long-term health & wellbeing. Therefore, **the future role of fashion brands will be to promote more wellness across the whole industry cycle**: from how brands design and make our clothes to how we buy, care for, experience and dispose of them.

However, it has been shown that **sustainable proposals alone are not efficient without the appropriate involvement of sustainable consumers.** So how can we stimulate effective change among consumers or persuade them to adopt the design solutions? In the following chapter, **the relationship between nature and well-being will be explored, with the aim of promoting more sustainable relationships with fashion by creating a symbiotic approach where the user perceives a valuable benefit for the environment and for himself, leading to a behavioral change in the sector.**

"If one truly loves nature, one finds beauty everywhere"
Vincent Van Gogh

FASHION & Biophilia

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WHAT IS BIOPHILIA?

Biophilia translates literally "Love of life and of all that is alive" – Bio meaning life and philia love - and it is connected to the hypothesis that humans have a desire to be in constant interaction with other forms of live. Edward O. Wilson, an American biologist, naturalist and writer, firs introduced the term in his book Biophilia in 1984.

Wilson describes Biophilia as the main essence of our humanity therefore giving it an ethical importance "to an extent still undervalued in philosophy and religion, our existence depends on this propensity, our spirit is woven from it, hopes rise on its currents." (Wilson, 1984). However, he maintains that demonstrating the scientific reason and the veracity of this human propension is still a task that can't be achieved. Instead he gives examples to support his hypothesis.

Later on, the Biophilia Hypothesis was further developed in company with a psychological approach by Erich Fromm, a German social psychologist, psychoanalyst, sociologist, and humanistic philosopher. They claimed that human beings will nurture loving attitudes when deepening their connections with nature, thus leaving aside any feeling of fear. This is how the awareness of nature's power boosts every person's wellbeing and ambitions.

Promoting Biophilia in society generates visible and proven benefits. For instance the Japanese culture puts it in practice when carrying out the practice of "forest bathing" which they call Shinrin-yoku and describes an immersion in the woods that involves all five senses. The measurable health benefits of this therapy are known to "lower concentrations of cortisol, lower pulse rate, lower blood pressure, greater parasympathetic nerve activity, and lower sympathetic nerve activity". (Park, Tsunetsugu, Kasetani, Kagawa, & Miyazaki, 2010)

> ***Do human beings have within them an innate sense of connection to other forms of life? If so, can this natural feeling, this "biophilia," both enhance our respect for ourselves as human and reinforce our sense of obligation to treat other forms of life with loving care?— T. H. Watkins***

The mutual caring of the living systems of which we are part and upon which we depend, is the result of the practice of Biophilia by demonstrating active love and connection with life. "Through Biophilia, that which we love guides us to protect those with no voice or vote: plants, animals, and future generations with whom we share a common destiny" (Cubista). In other words is the awareness of our innate love for life what must guide our actions in every attempt to achieve positive contributions to the natural world.

Biophilia is the term coined by the Harvard naturalist Dr. Edward O. Wilson to describe what he saw as humanity's "innate tendency to focus on life and lifelike processes," and to be drawn toward nature, to feel an affinity for it, a love, a craving.— Natalie Angier

THE POSITIVE EFFECTS OF NATURE ON OUR WELL-BEING

The effects of Biophilia have been studied for years by scientists, doctors and psychologists, Studies have been found that guarantee that with just 25 minutes a day outdoors surrounded by nature, up to 3 more years of life can be gained as DNA is repaired reducing risks of heart disease, diabetes, osteoporosis among others. It should be noted that many of these studies have been conducted in laboratories that monitor the body-mind systems and the impacts that natural environments generate on these systems. In the same way, these studies should be carried out to verify how, and to what extent, the natural elements embedded in fashion generate the same benefits. Nature can help us to heal and to increase longevity. (Coulthard, 2020)

"The art of healing comes from nature, not from the physician." Paracelsus, the 16th-century German-Swiss physician

Cognitive Benefits:

Lots of benefits for the Brain has been discovered with studies that analyze brain activity when one gets in contact with nature, directly and indirectly. The studies report activation of brain systems that aid divergent thinking. All in all, these mental benefits are part of the cognitive functionalities which comprehend our ability to think, or mental agility and our capability of producing logical and creative outputs.

Moreover, the admiration and fascination of nature always makes us wonder about how it perfectly works, hence being outside contemplating nature stimulates our interest, curiosity, imagination and creativity. Disconnection from technology and immersion in nature or at least contact with it lead to increased ability to deal with problems creatively.

Our concentration and our ability to focus is a valuable capability and a scarce one during these days of immense contact with digital and internet sources and saturation of information. Directed attention is energy intensive, and over time can result in mental fatigue and depleted cognitive resources (Kaplan & Berman, 2010). Connection and routinary ritual with nature provide mental restoration, and re-deliver focus to someone that was experiencing cognitive weakness.

The above, is described in the article Creativity in the Wild: Improving Creative Reasoning through Immersion in Natural Settings as a Default-Mode: "The default mode network is a set of brain areas that are active during restful introspection and that have been implicated in efficient performance on tasks requiring frontal lobe function such as the divergent thinking task used here. On a hike or during exposure to natural stimuli which produce soft-fascination, the mind may be more able to enter a state of introspection and mind wandering which can engage the default mode. (Atchley, Strayer, & Atchley, 2012)

To sum up, brain benefits from being in contact with nature include: a decrease in stress and anxiety, increase in short-term memory, restoration of mental energy, increase in cognition and focus, and increase in creativity. (Coulthard, 2020)

Phycological Benefits

Phycological responses relate with our emotions and mood, thus they influence in our adaptability skills and alertness. It has been proved that our phycological construction is linked with our hereditary qualities, but is also influenced with past experiences, cultural constructs and social norms. By nurturing our experiences with a more consciously view of our environment, involving all of our senses and

a wonder attitude we can observe nature and feel that we are part of something bigger. Being part of a system and community makes us realize that we have a role to play in life, therefor it stimulates a positive mindset, it delivers bigger sense of gratitude and increase our helping disposition.

Positive behavioral change and phycological benefits from nature connection include better coping and mastery skills, improved social interaction, less hostility and aggression, boost self-esteem. As well, our tension, anxieties, anger, negative thoughts and confusion are reduced

Physiological Benefits

When we speak of physiological impacts, we refer to responses related to the functioning of our body systems, musculoskeletal, respiratory, aural and physical comfort. In the wellness sector, the importance of monitoring our body for the prevention of damage at a physiological level has always been highlighted, however working on the prevention of these is now more important than just the cure. In Park's 2009 study, it was exposed that the relationship with natural elements directly or indirectly has physiological responses related to the relaxation of the muscles, the decrease in heart rate and the levels of stress hormones. (as cited in Brownig, Ryan, & Clancy, 2014)

More specifically, there are natural elements that have direct benefits for humans, such as sunlight, which nourishes our bodies with vitamin D, which prevents diseases such as diabetes, hypertension, depression, and neurodegenerative diseases. Plants also act as purifiers of the air we breathe.

Physical outcomes include enhanced physical fitness, lower blood pressure, increased comfort and satisfaction, fewer illness symptoms by elevating white blood cells counts.

According to the Global Wellness Institute, getting Nature prescribed instead of a prescription for some pharmaceutical medicine is a long-term trend stablished since 2019. This trend also expands into a "back to nature" shift across the wellness world. (Global Wellness Institute, 2019) Nature prescriptions offer better mind-body benefits and bring our awareness back to the cycle of nourishment derived from the Earth. Whether prescribed or chosen, more time in nature is the most simple and effective thing to living a richer human experience.

Some examples are the growth of "green exercise" meaning outdoors sports or working out in parks, the continued flow in bringing nature and biophilic design into our homes, schools, offices and hospitals, the nonstop growth in forest bathing programs at wellness travel destinations, and the new offerings of sustainable conscious tourism where the buyer gets involved in planned environmental activism while travelling. (WGSN, 2021).

Since more people live in cities, the possibility of being outdoors every day is not accessible for everyone. Hence, without having the opportunity of getting benefits form outdoors people are starting to bring the outside in by creating ideals of nature indoors, at home, at workplaces and communal spaces.

Millennials are a generation that has focused on the growing trend of indoor gardening, taking advantage of botany to satisfy their creative needs, sharing the images on Instagram and communicating their tendency to a hippie attitude and concerned about the environment. In 2017 the National Garden Survey reported that the Americans involved in the DYI planter were within the age range of 18-34 years. Figure that visibly increased during lockdowns with indoor gardening.

Nevertheless, more specific studies show that some of these benefits are not only obtained with direct contact with nature but also in indirect ways. The great reason for this is that the shapes, smells, and sensations produced by nature are innately recorded in our brains. Our sensory structures, by identifying images, patterns and colors of nature, remember, evoke and imitate those positive emotions already encoded in our DNA.

BIOPHILIC DESIGN

The term Biophilia is used to describe humans' inherent biological and emotional connection with nature, while Biophilic design is replicating experiences of nature through design to reinforce that connection. As a result, **Biophilic Design is a bridge between design, nature and wellbeing** so, when applied - for example - to spaces or interior design solutions, helps to create areas that energetically boost health and wellbeing.

Human beings are instinctively biophilic. Biophilia has a direct impact on their wellbeing – physical, mental, emotional, and spiritual. Wilson describes it as "the connections that human beings subconsciously seek with the rest of life". Being exposed to nature and to all the natural things is almost a human need. The use of Biophilia in architectural design makes it suitable to the users and at the same time, has a direct and positive impact on their wellbeing. Some evidence-based examples show that green walls serve to purify the interior air and also help to reduce stress and increase the focus.

Tim Beatley is an architecture professor at the University of Virginia and executive director of the Biophilic Cities Project, a group that works with city collaborators to implement biophilic design across the world, exposes that "Humans are more generous, cooperative, and forward-thinking when surrounded by nature". (Global Wellness Institute, 2019). According to a study by the University of Exeter, offices with plants "could increase productivity by 15 percent" as well as "lower physiological stress, increase attention span and improve wellbeing." (Global Wellness Institute, 2019)

"Nature holds the key to our aesthetic, intellectual, cognitive and even spiritual satisfaction." - E. O. Wilson

Biophilia Design is usually mixed or confused with the other Bio-inspired design tools mentioned in chapter 2. All of them use a natural feature as a basis to start the design process, either as an inspiration to perform the How, or as a conceptual guide to define the Why. For instance, Biomimicry is an innovation method to achieve better performance; **biophilic design is an evidence-based design method to improve health and wellbeing.** However, the main difference that is important to highlight is precisely that **Biophilia "recognizes the health benefits of mankind's biological connectedness with nature" (Terrapin, 2017).** This movement may use the other bio-inspired tools to achieve its goal. Another important thing to be noted is that Biophilia results to be a philosophy more than an style.

Anne Prahl is an independent trend and forecasting PhD researcher and consultant with over 20 years of experience in the global sportswear and fashion industry, who has dedicated her career to researching future sustainable design innovations. During her lecture in the context of the "Performance days" affair 2017 in Munich, she already spoke about **biophilic design as a strategy for "embedding nature" in designs to increase the wearer's well-being during and after sports.** The growing desire of consumers to connect deeply with nature through active outdoor experiences such as wilderness yoga & fitness retreats, outdoor fitness clubs, running clubs, boot camps and endurance events could be promoted, improved or even satisfied by embedding nature in design solutions.

As has already been explained, biophilic design in general integrates the use of natural vegetation, colors, natural/biobased materials, shapes, scents and sounds. Therefore, Anne claims that a good starting point would be to work with bio-based textiles, i.e., fabrics that are wholly or partially derived from renewable resources, living (or previously living) materials such as plants, trees and animals. This would be similar to the concept of bio-utilization, but the slight difference is that **the purpose is not only to be sustainable in terms of environmental friendliness, but also to seek the well-being of the users. The biophilic approach to design would be a kind of symbiotic relationship.**

"To take the biophilic approach further, I have started to develop some initial design concepts, which include 'Growth & Decay', 'Respond + Adapt' and 'NUTRIENTex'" - Anne Prahl

The consistency of natural themes in historic structures and places suggests that biophilic design is not a new phenomenon; rather, as a field of applied science, it is the codification of history, human intuition and neural sciences showing that connections with nature are vital to maintaining a healthful and vibrant existence as an urban species. (Brownig, Ryan, & Clancy, 2014)

BIOPHILIA // INCORPORATING IT TO THE FASHION INDUSTRY.

Personally, I support that leveraging fashion design not only with high-performance and systemic thinking, but also with Biophilic Design, bioinspired innovations and ecological design will help people to reconnect with their natural environment which will lead to a healthier, more wealthy and regenerative future. The Biophilic Foundation well expresses: “Biophilic Design fosters wellbeing in society and a love of nature that can translate into increased health and committed care for the planet”.

14 PATTERNS OF BIOPHILIC Design

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Through this document, several approaches of taking nature as an inspiration have been addressed, and until this point it is understood that this means much more than just adding green to the designs. Nature is a rich collection of colors, textures, smells, temperature variations, space configurations and sensations that all impact the way we feel.

Research in environmental psychology and neuroscience continues to demonstrate that certain elements and conditions in nature have significant benefits to our health and wellbeing. **Biophilic elements have been shown to reduce stress, improve cognitive performance, and support positive emotions and mood.**

This theory has already been explored and proved in the interior design field, and for applying it the designer must incorporate some of the 14 patterns already stablished constituted by features of the natural world that have proven to be beneficial to us.

The report "14 Patterns of Biophilic Design" was written by the Terrapin Bright Green group in 2014, an environmental consulting and strategic planning firm, **to articulate a series of tools for understanding design opportunities in the built environment contexts**:

"New research supports measurable, positive impacts of biophilic design on health, strengthening the empirical evidence for the human-nature connection and raising its priority level within both design research and design practice; however, little guidance for implementation exists. This paper is intended to help close the gap between current research and implementation." (Brownig, Ryan, & Clancy, 2014).

The Terrapin's written guide remarks that "While informed by science, biophilic design patterns are not formulas; they are meant to inform, guide and assist in the design process and should be thought of as another tool in the designer's toolkit. The purpose of defining these patterns is to articulate connections between aspects of the built and natural environments and how people react to and benefit from them." (Brownig, Ryan, & Clancy, 2014).

HYPOTHESIS

If in the context of built environment, Biophilia is a concept with little guidance on how to implement it despite having been used for years, **in fashion it is a new term for many designers with enormous potential to be explored.**

Therefore, **my objective is to relate Biophilic Design with the fashion industry and translate its methodology and patterns into the fashion context. Applying the concept of Biophilia to fashion design means that the design must nurture a deep love for the garment created,** with which the wearer would feel a deep connection and a desire of conservation and caring towards it. **Biophilic design will create aspirational, restorative, and healthy fashion, enhancing a functional aspect of the ecosystem in which it is created.**

The way one experiences each pattern will vary as combinations of culture and demographics impact the experiences of interacting with fashion.

The following table was made in order to expose all the characteristics, expected experiences of each pattern of the biophilic design. Fashion design elements that can be used to achieve the expected benefits were also added, and what bio-inspired approach concepts can be linked to each pattern.

	PATTERN	DESCRIPTION	EXPERIENCES	OVERLAPPING PATTERNS	DESIGN ELEMENTS	BIO-INSPIRED APPROACHES
Nature in the space // Nature in Fashion	*1. Visual Connection with Nature*	Use of living things, living systems & natural processes. Use of natural landscapes	Delivers relaxation, reduces cognitive fatigue, stress reduction. -Caringness	[P2] [P3] [P5] [P8] [P11]	Realistic or simulated nature prints and patterns - Outdoor Runways - Simulated displayed views of nature	BioDesign, Biomorphisim, Bio-utilization.
	2. Non-Visual Connection with Nature	Other senses than seeing - hearing, feeling, smelling, tasting that cause an intended and positive reference to nature, living systems or processes.	Tirggers familiar & comfortable memmo-ries. Nature reminiscen-ce. Freshness - Calmness	[P1] [P3] [P4] [P9] [P5] [P13]	Aromatherapy - Ayurveda - CBD infussions Furry textiles.	BioDesign, Bio-utilization, Bio e-textiles,
	3. Non-Rhytmic Sensori Stimuli	Random, unpredictable, temporary & attention grabbersconnections with nature	Replenishes cognitive functions. Decreases physiological stressors.	[P1] [P4] [P5] [P10] [P13]	Unpredictable Scents - Sounds and Lighting - Biofeedback - Shimmering textiles	BioDesign, Bio-utilization, Bio e-textiles, Biomimicry
	4. Thermal - Air Variability //Thermal Comfort - Ventilation - Breathability - Purification	Subtle changes in air temperature, humidity, airflow across the skin, and surface temperatures that mimic natural environments. Air purification	Thermal comfort. Freshness. Physiological wellness. Insulation. Body mapping	[P6] [P7] [P3] [P5] [P13]	Breathable materials Purifying wearables Antibacterial textiles	Biomimicry, BioDesign, Bio e-textiles, Biomorphisim
	5. Presence of Water	Introducing water, or water features like refflections.	Tranquility feelings - lower heart rate and blood pressure. - improvements ins self-esteem and mood	[P1] [P2] [P7] [P11] [P14]	Water patterns and prints, Water reflections - Fractals, Parametric and generative design	Biomorphisim, Bio-utilization.
	6. Dynamic & Diffuse Light	leverages varying intensities of light and shadow that change over time to create conditions that occur in nature.	Intrigue and attraction - Sense of time and movement - sleep cycle regulation	[P1] [P3] [P4] [P7] [P8]	Circadian Rhythm - Human Centric Lighting - Biofeedback - Smart Lighting	Biomimicry, BioDesign, Bio e-textiles
	7. Connection with Natural Systems	Deep connection and awareness of natural systems	Evoked feeling of being part of a greater whole - relaxation, nostalgia, and enlightening	[P1] [P2] [P3] [P5] [P4] [P6] [P13]	Bacterial dyes - Biodegradable textiles - Fractals - scents.	Biomimicry, BioDesign, Bio e-textiles, Biomorphisim
Natural Analogues	*8. Biomorphic Forms & Patterns.*	Symbolic references to contours, patterns, textures or numerical arrangements that exist in nature.	Atracttion- Nostalgia - Delight - Enjoyment - Relaxation - Enhanced concentration	[P1] [P10]	Bio-inspired Colors - Textures - Prints and patterns.	Biomorphisim Bio-utilization BioDesign
	9. Material Connec-tion with Nature	Material and elements from nature that, through minimal processing, reflect the local ecology or geology to create a distinct sense of place.	Increased Cognitive performance - Confort - Physiological positive impacts - Caringness	[P1] [P2] [P8] [P10]	Fractals, Parametric and generative design, Natural textures and materials	Biomorphisim Bio-utilization Biomimicry
	10. Complexity & Order	Rich sensory information that holds to a configurational hierarchy similar to those encountered in nature	Stress Reduction - Allure Relaxation - Increased Focus..	[P1] [P2] [P8] [P9]	Self - Assembly & Self - Organization, Fractals - Parametric and generative design	BioDesign, Biomorphisim
Nature of the Space // Nature of Fashion Analogous experiences	*11. Prospect*	An unblocked view over a distance for surveillance & planning.	Safety and control - Awareness - Hope - Stress Reduction - Decreased hart rate and blood preassure	[P1] [P5] [P12] [P13] [P14]	Traceability & Transparency, Biofeedback,	Biomimicry, Bio e-textiles,
	12. Refuge	A place for withdrawal, from environ-mental conditions or the main flow of activity, in which the individual is protected from behind and overhead	safety - Decreased irritation , cognitive fatigue Impoved concentration - increased emotional health	[P4] [P6] [P11] [P13]	AR & VR - Smart textiles - E-textiles, Textile performance - Covering shapes. - Camouflage	Biomimicry, BioDesign, Biomorphisim
	13. Mystery	The individual's desire of acquiring more information about something that has stimulated his curiosity	Intrigue, surprise & attraction relish feelings of expectancy & exploration - Allure	[P1] [P2] [P3] [P6] [P7] [P10] [P11] [P12]	Self - Assembly & Self - Organization, Smart Lighting, Unpredictable Scents, Sounds & Lighting	Biomimicry, BioDesign, Bio e-textiles, Biomorphisim
	14. Risk / Peril	An identifiable threat coupled with a reliable safeguard.	Excitement - boosted brain power - Pleasure - Icreased courage - Amusement - Amazement	[P1] [P5] [P11]	Smart Lighting,, Bio sensors and actuators Unpredictable Scents, Sounds & Lighting	Biomimicry, BioDesign, Bio e-textiles, Biomorphisim

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The Terrapin Bright Green Firm structured a visual aid to guide readers interested in Biophilia establishing interesting connections between hormones and neurotransmitters, environmental stressors, and biophilic design strategies. This table exposes the nature-health relationships between biophilic design patterns and mind-body impacts in an architectural and environmental context:

TABLE 1. BIOPHILIC DESIGN PATTERNS & BIOLOGICAL RESPONSES

Table 1 illustrates the functions of each of the 14 Patterns in supporting stress reduction, cognitive performance, emotion and mood enhancement and the human body. Patterns that are supported by more rigourous emphirical data are marked with up to three asterisks (***), indicating that the quantity and quality of available peer-reviewed evidence is robust and the potential for impact is great, and no asterisk indicates that there is minimal research to support the biological relationship between health and design, but the anecdotal information is compelling and adequate for hypothesizing its potential impact and importance as a unique pattern.

	14 PATTERNS	*	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
NATURE IN THE SPACE	Visual Connection with Nature	***	**Lowered blood pressure and heart rate** (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005)	**Improved mental engagement/ attentiveness** (Biederman & Vessel, 2006)	**Positively impacted attitude and overall happiness** (Barton & Pretty, 2010)
	Non-Visual Connection with Nature	**	**Reduced systolic blood pressure and stress hormones** (Park, Tsunetsugu, Kasetani et al., 2009; Hartig, Evans, Jamner et al., 2003; Orsega-Smith, Mowen, Payne et al., 2004; Ulrich, Simons, Losito et al., 1991)	**Positively impacted on cognitive performance** (Mehta, Zhu & Cheema, 2012; Ljungberg, Neely, & Lundström, 2004)	**Perceived improvements in mental health and tranquility** (Li, Kobayashi, Inagaki et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, & Miyazaki, 2010; Kim, Ren, & Fielding, 2007; Stigsdotter & Grahn, 2003)
	Non-Rhythmic Sensory Stimuli	**	**Positively impacted on heart rate, systolic blood pressure and sympathetic nervous system activity** (Li, 2009; Park et al, 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991)	**Observed and quantified behavioral measures of attention and exploration** (Windhager et al., 2011)	
	Thermal & Airflow Variability	**	**Positively impacted comfort, well-being and productivity** (Heerwagen, 2006; Tham & Willem, 2005; Wigö, 2005)	**Positively impacted concentration** (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989)	**Improved perception of temporal and spatial pleasure (alliesthesia)** (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huizenga & Han, 2010; Arens, Zhang & Huizenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Heschong, 1979)
	Presence of Water	**	**Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure** (Alvarsson, Wiens, & Nilsson, 2010; Pheasant, Fisher, Watts et al., 2010; Biederman & Vessel, 2006)	**Improved concentration and memory restoration** (Alvarsson et al., 2010; Biederman & Vessel, 2006) **Enhanced perception and psychological responsiveness** (Alvarsson et al., 2010; Hunter et al., 2010)	**Observed preferences and positive emotional responses** (Windhager, 2011; Barton & Pretty, 2010; White, Smith, Humphryes et al., 2010; Karmanov & Hamel, 2008; Biederman & Vessel, 2006; Heerwagen & Orians, 1993; Ruso & Atzwanger, 2003; Ulrich, 1983)
	Dynamic & Diffuse Light	**	**Positively impacted circadian system functioning** (Figueiro, Brons, Plitnick et al., 2011; Beckett & Roden, 2009) **Increased visual comfort** (Elyezadi, 2012; Kim & Kim, 2007)		
	Connection with Natural Systems				**Enhanced positive health responses; Shifted perception of environment** (Kellert et al., 2008)
NATURAL ANALOGUES	Biomorphic Forms & Patterns	*			**Observed view preference** (Vessel, 2012; Joye, 2007)
	Material Connection with Nature			**Decreased diastolic blood pressure** (Tsunetsugu, Miyazaki & Sato, 2007) **Improved creative performance** (Lichtenfeld et al., 2012)	**Improved comfort** (Tsunetsugu, Miyazaki & Sato 2007)
	Complexity & Order	**	**Positively impacted perceptual and physiological stress responses** (Salingaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988)		**Observed view preference** (Salingaros, 2012; Hägerhäll, Laike, Taylor et al., 2008; Hägerhäll, Purcella, & Taylor, 2004; Taylor, 2006)
NATURE OF THE SPACE	Prospect	***	**Reduced stress** (Grahn & Stigsdotter, 2010)	**Reduced boredom, irritation, fatigue** (Clearwater & Coss, 1991)	**Improved comfort and perceived safety** (Herzog & Bryce, 2007; Wang & Taylor, 2006; Petherick, 2000)
	Refuge	***		**Improved concentration, attention and perception of safety** (Grahn & Stigsdotter, 2010; Wang & Taylor, 2006; Wang & Taylor, 2006; Petherick, 2000; Ulrich et al., 1993)	
	Mystery	**			**Induced strong pleasure response** (Biederman, 2011; Salimpoor, Benovoy, Larcher et al., 2011; Ikemi, 2005; Blood & Zatorre, 2001)
	Risk/Peril	*			**Resulted in strong dopamine or pleasure responses** (Kohno et al., 2013; Wang & Tsien, 2011; Zald et al., 2008)

IMPPLEMENTATION EXAMPLES

Nature in the space // Nature in Fashion

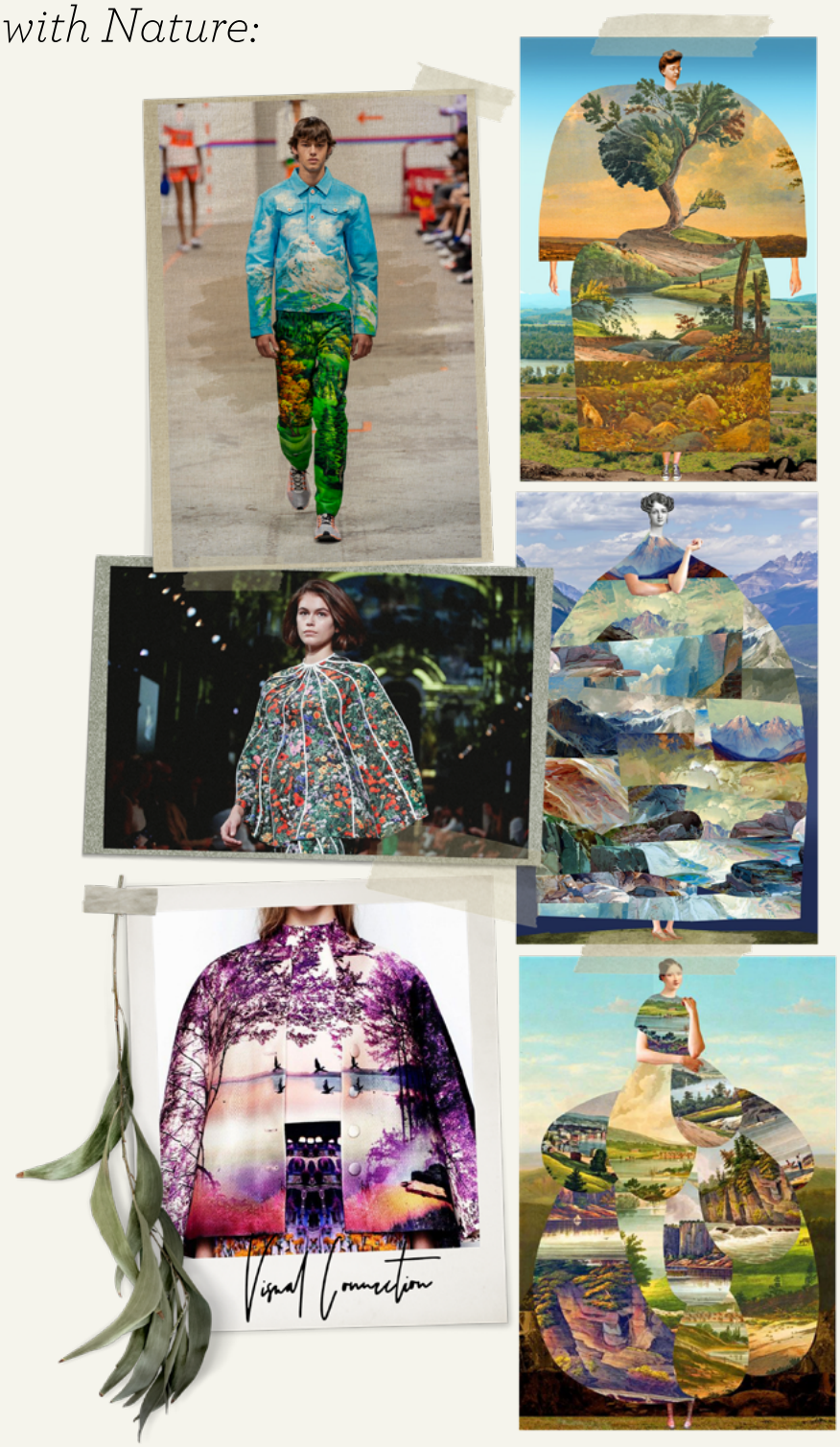
Would address the direct, physical and brief presence of nature in clothing.

1. Visual connection with Nature:

The Visual Connection with Nature pattern delivers relaxation of the eye muscles and reduces temper cognitive fatigue as the user can shift its focus into the nature related element. There is also evidence for stress reduction related to both experiencing real nature and simulated images of nature, although in a lower effectiveness. Kahn's report called "A Plasma Display Window? The Shifting Baseline Problem in a Technology Mediated Natural World" affirms that the difference between seeing natural views and simulated views is that nature has greater stimulation in the brain activating more pleasure receptors that result in a longer interest and thus the fatigue recovery occurs 1.6 times faster than viewing a simulated landscape. The studies also confirm that the viewer doesn't drastically loose interest over time when the view is natural. (as cited in Brownig, Ryan, & Clancy, 2014).

According to Orians's and Heerwagen's studies, some elements are more beneficial than others; usually there's a visual preference to shade of trees, flowering plants, calm non-threatening animals, indications of human habitation, and bodies of clean water (as cited in Brownig, Ryan, & Clancy, 2014).

Landscapes and natural views are aesthetical elements that have been present in Fashion. Nowadays, designers are able to integrate realistic nature in their collection patterns using digital or sublimation printing. The landscapes prints were even a 2019 trend in menswear according to The Impressionist.



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Biophilia,
Achieving human well-being through fashion, nature and technology

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Naturally Occurring
- Natural flow of a body of water
- Vegetation, including food baring plants
- Animals, insects
- Fossils
- Terrain, soil, earth

Simulated or Constructed
- Mechanical flow of a body of water
- Koi pond, aquarium
- Green wall
- Artwork depicting nature scenes
- Video depicting nature scenes
- Highly designed landscapes

However, the effectiveness of this pattern in fashion is not yet valid and its psychological effects have not been studied. Considering that the clothing is worn and the wearer is generally unable to see himself while wearing it, a comforting and relaxing effect resulting from wearing landscape-patterned garments could not be guaranteed.

However, an option through Fashion Tech could be through accessories with screens or displays that can show images of these beneficial landscapes for well-being and in this way the users could direct their contemplation when they require such benefits. The designer

This reminds me of Cassandra Verity Green's Neptune's Daughter collection, who in a naive and playful approach includes water and alive fish in her collection accessories. Will the user have a positive effect of connection with nature by carrying their pets with them and being able to observe them during the day at any time? Would designs of this type be elements of union between human beings and nature, promoting the importance of being aware of their care?

The fashion industry is also applying this pattern in their communication, retailing and even fashion runways. In the quest towards sustainability, the fashion shops are including living materials and Biophilic interior design to their shops. During the pandemic, fashion brands performed some streamed fashion shows that were transmitted from open remote natural places however some believe that even after, outdoor fashion shows will run the future events. "The outdoor runway would place fashion, one of the most notorious polluters, in direct organic connection with the environment. Under wide open skies, leafy canopies, or city smog, we would be reminded of what we stand to lose if we do not restore our relationship with Mother Nature and place eco-friendly measures at every step of clothes creation" declares Jackie Mallon in the fashion article - The great escape: are outdoor runways the way of the future – written at the end of 2020 for Fashion United.

Outdoor runways could be a great opportunity to relate nature and fashion in order to achieve wellness experiences after Covid days, people could assist to fashion shows again feeling safe and adding the outdoor experience benefits of feeling fresh air on our faces again: **A new way to escape from the lockdown exhausting reality we are just living behind and remember that the future is wide open!**

Visual connection with nature in a fashion implementation is linked with Bio-utilization and Biodesign as it involves the direct connection to living things. Relating it with Fashion would be the utilization of living materials in fashion designs.

Susan McLeary is an American florist and a jewelry designer who offers living growing jewels. The actual wearable succulent plants are hand-selected for each handmade jewelry piece. The plants are attached to the accessories which then grow up to 2 or 4 weeks, and after this time pass the customer can replant the greenery in pots and keep it for more years to go.

Jacob Olmedo is a recent graduate of the MFA Textiles program at Parsons New School of Design who is interested in environmental activism, natural fibers and biomaterials. He developed in 2017 a new growing biomaterials made of wheat grass that was planted in a neutral-toned organic material combined with layers of beeswax for waterproofing. The layered materials hold moisture, and the wood pulp holding the seeds storing the nutrients needed for the plants to flourish. With this fabric he created a trio of wearable gardens.

"I engineered a hydroponic growing textile: a textile that supports and promotes plant life," he told Dezeen. "I use a material that I engineered through months of research and technical trial and error... I ended up growing wheat grass, but I can also grow micro greens and I would ultimately one day like to grow flowers."

Looking after something living that needs sustain and care to thrive gives the wearer, especially young people, the opportunity to reconnect with something tangible and real being. A perfect antidote for our technological driven lives.

Even though, there are some examples that can be found, **the visual connection with nature pattern has greater potential in the virtual fashion tech world.** In the pursuit of having a fashion industry with lower wastes, and mores sustainable, fashion is moving to Digital where designers can be completely crazy creating surreal environments and surroundings for the fashion industry communication or even runways. **Also garments can achieve textures inspired by natural principles of growth but with enhanced shapes and colors.** Imagine a chameleonic digital dress that changes its landscape print according to the avatar or wearer in the virtual world.

Will consumers experiencing fashion in the virtual world will also achieve the same body-mind system benefits from watching and experimenting virtual nature?

Will a fashion runway of 20 minutes long carried out in a virtual or augmented reality outdoor surrounding with artificial nature will deliver such benefits to the attendants?

Relation to other Patterns

Visual Connection with Nature is often paired with a number of other patterns. Common overlaps with the most significant potential impact:

[P2] Non-Visual Connection with Nature
[P3] Non-Rhythmic Sensory Stimuli
[P5] Presence of Water
[P8] Biomorphic Forms & Patterns
[P11] Prospect

Centrestage 2020, Hong Kong, https://centrestage2020.hktdc.com/en/phygital-runway/

Shishigami shoes from the digital brand Auroboros: watch your surroundings grow and unfold around you. Inspired by studio Ghibli's infamous forest spirit, there is life and death in every step you make.

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Applying Ayurveda to fabric dyes is one healing fashion approach through touch. Ayurveda meaning "life knowledge" is a concept of wellness that has its origins back in the 6000 BCE. There's a rising trend today in which fashions goes back to ancient wisdom of nature seeking for healing methods that could be also eco-friendly. Ayurvedic apparel is a way of associating non-toxic, immunity boosting herbs with clothing. The healing properties and therapeutic benefits of the plant-based medical herbs are infused into de fabrics and transferred to the wearer. This dyeing process is often done in dye baths that are boiled in a controlled temperature. "As the skin is the largest human organ, by wearing fabrics that carry these benefits, the medicinal properties can be directly absorbed into our bodies" (Phuong, 2020)

Different Herbs used for dyes can include sandalwood, mimosa, pudica, cumin seeds, champa flowers, neem and shoe flowers. It is believed that to transfer the healing properties, only trained ayurvedic practitioners can create ayurvastra. In India Vedic chanting is done to energize the garment and it is believed that prana, or life force, can be infused into the clothing. "Prana connects to the trust and belief in the consciousness of the plant, and thus uses its living color, taste and medicinal qualities to heal". Unfortunately, very few traditional dye-houses remain in its birthplace of India.

2. Non-Visual connection with Nature:

Naturally Occurring
- Fragrant herbs and flowers
- Flowing water
- Natural ventilation (operable windows, breezeways)
- Textured materials (stone, wood, fur)
- Sun patches
- Warm/cool surfaces

Simulated or Constructed
- Digital simulations of nature sounds
- Mechanically released natural plant oils
- Highly textured fabrics/ textiles that mimic natural material textures
- Audible and/or physically accessible water feature
- Music with fractal qualities
- Horticulture/gardening, including edible plants
- Domesticated animals/pets
- Honeybee apiary

This pattern involves using the remaining 4 human senses being nature haptic, auditory, olfactory, and gustatory.

Despite our human tendency to favor the visual sense, other sensory responses to nature are of great significance to us: sound, smell, taste, time, and motion. Hearing water, touching plants, smelling flowers, sensing the movement of the air often moves us both emotionally and intellectually. **Bio*Touch:***

There are several therapies involving feeling animals' fur, touch real plants, bathing in water and hugging trees. These actions are thought to induce profound relaxation through a change in the brain's flow rates.

Sound:
Nature sounds as river or raining sounds boost phycological and physiological renovation, reduce cognitive fatigue, lift energy and motivation.

Smell:
Triggers very powerful memories connected with previous lived experiences; in Kim's report is mentioned that plant oils have a positive effect in the immunologic system and calm and energize people. (as cited in Brownig, Ryan, & Clancy, 2014) smell is still a huge unexploited opportunity for emotional regulation.

Taste:
Its considered a way of seeking information used since our origins of time. Our ancestors survived in the wild by tasting unknown resources therefore discovering new properties of food.

Likewise, CBD infusions in textiles has been explored and are believed to offer relief, reduce anxiety and even improve acne. Few brands in the fashion market have tried it, however it is a trend with potential growth considering that we are living the era of the pursuit of wellness in which consumers want to discover a cure for their psychological and physical disorders.

In fashion using scent, texture and other sensory experiences can be used to uplift people moods by offer them a transportive moment to pleasant lived experiences and familiar places like home. A Project involving the olfactory sense was designed by the textile designer Pallavi Padukone. The ReminiSCENT series of textiles uses aromatherapy with scents such as jasmine, rose, clove and vetiver to activate feelings of calm and comfort. She integrated the scents into handwoven and embroidered textiles and combined them with scented wax beads which create an immersive experience that reconnects the wearer with nature and nostalgia when smelled.

Jewelry wearables using aromatherapy to increase mental wellbeing.

While the scents of flowers help calming the wearer, artificial prints of flowers in clothing were used to attract bees and encourage them to carry their pollination processes. Dr Karen Ingham of Swansea Metropolitan University aimed to expose the decline of populations of pollinators insects like bees, butterflies and moths and the plants on which they depend, due to harmful human activity with her "Pollinator Frocks". The purpose was also to involve human beings to helping insects survive the urban landscape by wearing a dress that blends art, science and technology.

To make this project she created an interdisciplinary group of entomologists, botanists, microscopists, surface pattern technologists and print and coating engineers. The dress had prints of petals and pollen imitating scanned microscopic images of plant pollen grains. Then the patterns were enhanced with coated iridescent sheen, replicating the way that insects would view the flowers. The fabrics were treated with substances which imitate nectars such as sucrose, fructose and xantham gum. The result was a collection of fabric that performed as wearable gardens.

Dr Ingham said her eco-fashion attracts some of the world's most endangered pollinators as it efficacy was tested with several prototypes. "Pollinators play a vital role in food production and are tied to the health and biodiversity of our flora...As these insects disappear, so do the dependent plants, meadows and landscapes which they pollinate. The best way to help the pollinators is to protect their natural habitats and to radically reconsider the way we design and utilize our urban spaces to allow feeding and habitat corridors," she declared. The dress serves to raise public awareness of the issues and aimed to generate mutual relationships between nature and the wearer.

Here I introduce the concept of "eScent", an emotionally responsive wearable technology that picks up on your emotions and vital signs and sends a personalisable 'scent bubble' to your nose. It combines sensing and dispensing aromatics for immersive experiences and multiple health benefits. It presents an empowering, sensory intervention and resilience builder that emits mood-enhancing aromas in a controllable way, depending on biofeedback. (Tillotson, 2009).

3. Non-Rhythmic sensory stimuli

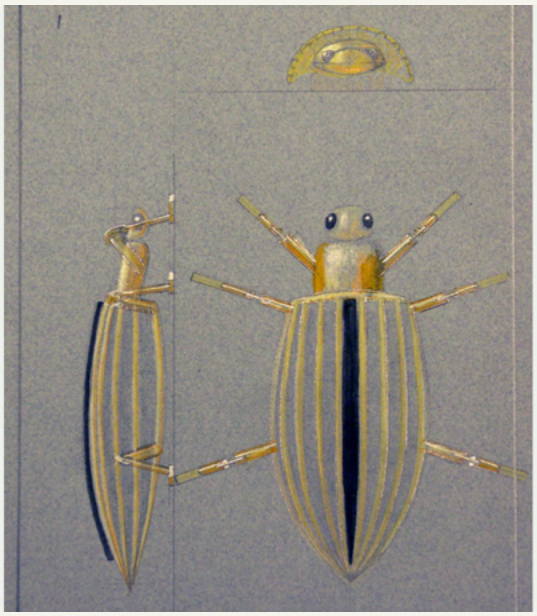
The main goal of this pattern is to replenish individuals' concentration capacity from mental fatigue or phycological stressors by generating random & temporary connections with nature that may attract attention. **These inconspicuously sensory stimuli shouldn't be predicted, non-rhythmic.** Some examples could be unpredictable movement or periodic experience of scents or sounds.

The analogue in natures is experiencing stimuli as birds, leaves rustlings, flowers scents in the air. Stimuli could be seasonal.

Finding analogues ways to implement this patter In Fashion Tech, the idea of wearable scent dispensers has been already explored. Jenny Tillotson exposed her project of creatin a "Scent Bubble" through fashion by using Scentsory design and Aroma-chology to develop responsive fashion that changes according to the data delivered by the biometric sensors and brings emotional wellbeing in return. (Tillotson, 2009). Her project was developed further for some years and in 2015 she developed a start-up for this "sensing and dispensing" wearable tech which is still in prototyping phase. The sensors track stress, anxiety, heart rate and body odor to create personalized non-rhythmic scent bubbles that are delivered unpredictably when the body needs them. The PHD Designer believes that smell improve sleep, enhance concentration and reduce anxiety meaning that smell could be a mood booster.

Naturally Occurring
- Cloud movement
- Breezes
- Plant life rustling
- Water babbling
- Insect and animal movement
- Birds chirping
- Fragrant flowers, trees and herbs

Simulated or Constructed
- Billowy fabric or screen materials that move or glisten with light or breezes
- Reflections of water on a surface
- Shadows or dappled light that change with movement or time
- Nature sounds broadcasted at unpredictable intervals
- Mechanically released plant oils



"Through these organism-enhanced products we aim to create a stronger link between the user and the environment, by bringing awareness to the invisible organisms that are supporting our life cycle," said MIT Design Lab director Yihyun Lim. "Through this perhaps we can cultivate an emotional relationship with our products, a new user-centred experience where our organism-enhanced products become our 'pets', where it needs to be caressed and taken care of."

4. Thermal - Air Variability //Thermal Comfort - Ventilation - Breathability - Purification

This pattern is about subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments. The main objective applying it to the fashion industry will be to make the wearer feel refreshing, and thermal comfortable.

Therefore this is a well explored pattern, mostly in the sportswear sector with innovations in breathable materials, and biomimicry inspiration for generating new concepts.

Being Puma other of the world's leading sports brands, it is not behind in the quest of researching how to make better athletes through Biodesign, at the same time as finding new ways to reduce the environmental impact of sportswear. The company has been working with MIT Design Lab and other design studios to drastically change both, customers experiences and the way products are developed in the sports industry. Even though these projects haven't achieved yet a commercial phase, they are considered important advances towards a more sustainable future. the next generation of athletic footwear, apparel and wearables can adapt in real- time by using living organisms to enhance performance.

Puma's natural will is to play the sports field as the fastest athletes on Earth, and this is why they also keep a fast pace in R&D. Puma is innovating strongly utilizing Biodesign to achieve performance and Human wellbeing. The brand is also aware that in sustainable terms, fabricating with bacteria and other living organisms is simultaneously becoming a technological possibility but also a necessity.

During the past Milan Design Week 2018, Puma presented a mix of research results developed since June 2017 in collaboration with MIT Design Lab that aimed to bring biological science and technologies closer to our daily lives through sport products. The company's product development team has been working in mind-blowing topics as breathing sports shoes, learning insoles and responsive t-shirts.

Carbon Eaters was a concept presented of a t-shirt that uses bacteria to provide awareness to the wearer that some conditions in the surrounding changed. The T-shirt is actively respondent to the environment by shifting the color of the buttons containing living organisms in response to changes in the air quality.

In this way the athlete wearing it will be informed about the presence of high levels of substances that might affect performance.

In Built environment designers use the analogy of purified air of outdoor inside homes, offices and communal spaces. When we spent so much time in indoors spaces we must be aware to keep them purified as sometimes indoor can be more polluted due to dust or VOCs (volatile organic compounds). According to the Royal society of chemistry, VOCs are chemical compounds that are not necessarily harmful, but those that are in interior are released by cleaning products, paints, insulating materials, or burning reactions coming from stoves, candles and incenses. Harmful VOCs contribute to indoors pollution making the air less healthy to breath causing headache, irritation of mucous membranes (eyes, nose, throat) and

dizziness. Besides, long-term exposure can even result in respiratory or heart diseases.

Interior designers are countering indoor pollution with greenery as the use of some species of plants as Aloe Vera, snake plant or Spider plant have the ability to absorb harmful VOCs while releasing oxygen. Besides using living plants that serve as air filters, living flowers deliver parfums to the atmosphere. In the fashion industry this could be achieved with the bio-designed innovative textiles made of living plants like algae.

In 2011, long before all this great global need to seek purifiers or to sanitize the environment, "Herself Dress", is a conceptual dress designed as an air purifier by the Catalytic Clothing company. The dress incorporates pollutant-absorbent concrete to purify the air, the same technology already used in construction. The dress is a prototype that uses titanium oxide coating, it can remove nitrogen oxides, such as those released by cars, turning them into harmless nitrate. As the dress absorbs the pollution, its patterns turn a blue that will acquire greater intensity. Later, the company launched CatClo, a substance based on titanium dioxide particles that adheres to the fibers of clothing when they are washed. When they come into contact with the nitrogen oxide molecules in the air, the nanoparticles trap them in the tissue, and thus remove it from the atmosphere. Its creators state that the more people use this additive, the greater the contribution to the purification of the environment.

This is an excellent approach to the Biophilic pattern by applying Biomimicry to achieve the wanted effect and the individual wellbeing. By observing the biochemical interactions of particles and integrating them with fashion a solution for the problem can be found.

Naturally Occurring
- Solar heat gain
- Shadow and shade
- Radiant surface materials
- Body mapping
- Vegetation with seasonal densification

Simulated or Constructed
- HVAC delivery strategy
- Systems controls
- Ventilation

"In the current product experience, customization happens prior to actual use. With Biodesign we see this user-led upgrade and customization to occur throughout the product experience." Declared the MIT Design Lab director Yihyun Lim.

Another project developed by Puma and presented during the past Milan Design Week 2018 in collaboration with MIT Design Lab, was the Breathing Shoe. A conceptual designs that use bacteria for the active co-creation of the shoe and to contribute to the well-being of the wearer

To Keep the foot cool, the Breathing shoes grows its own air passageways enabling a personalized ventilation. This is believed to be the first growing shoe biologically active that boosts the frontiers of bio fabrication as it is made in co-creation with the user's sweating patterns.

The breathable shoe is made of a biologically active material as it has cavities that are the habitat of microorganisms. These living organisms learn the specific heat pattern of each user. In hottest areas, bacteria eat material to create air passages that are unique vents for each user. Through Biodesign the user achieves a strong connection with his shoe as it's manufacture was completed only after the interaction with the wearer's body, hence the user becomes a prosumer that participates in the co-creation process of the design and construction. The user will appreciate the product more since it is a representation of his own biology, and also connects him with a natural world of almost imperceptible living beings that have worked together for his well-being. The design represents a user-nature interaction through materials, life and experience.

The ventilation pattern is crafted by your own feet, it is the uique expression of your body!

Again Iris Van Herpern has already explored water and its various associations — waves, bubbles, splashing, flotation in her 2017 fall collection.

5. Presence of water

This pattern overlaps with patterns 1, 2, 7, 11, and 14. In architectural an interior design context this pattern is easily achieved by introducing water into the built environment. Environment containing water elements reduce stress, increase tranquility feelings and lower heart rate and blood pressure. **All in all, the effects achieved are improvements in self-esteem and mood. The experiences produced by seeing, hearing, touching water are felt powerful, fascinating and attractive. However the fashion industry requires it to be more creative.**

Water features can be simulated with water textures, or water reflections. Also introducing imagery of water compositions.

Again Iris Van Herpern has already explored water and its various associations — waves, bubbles, splashing, flotation in her 2017 fall collection. Additionally, She also created previously in 2010 a "Water Dress" part of her Crystallization Collection. The inspiration behind this dress was to evoke an inmmersion into a warm bath with splash of water falling around the wearer's body. Does this biomorphic approach to water will generate same body-mind system benefits to the wearer? The answer is yet unexplored.

"The water-dress symbolizes for me the incomprehensible magic of the body. I often wonder if we will keep on wearing fabrics in future, or if dressing will become something non-material, something that is visible, but not tangible or touchable. This project will be an attempt to explore this idea" Iris Van Herpen

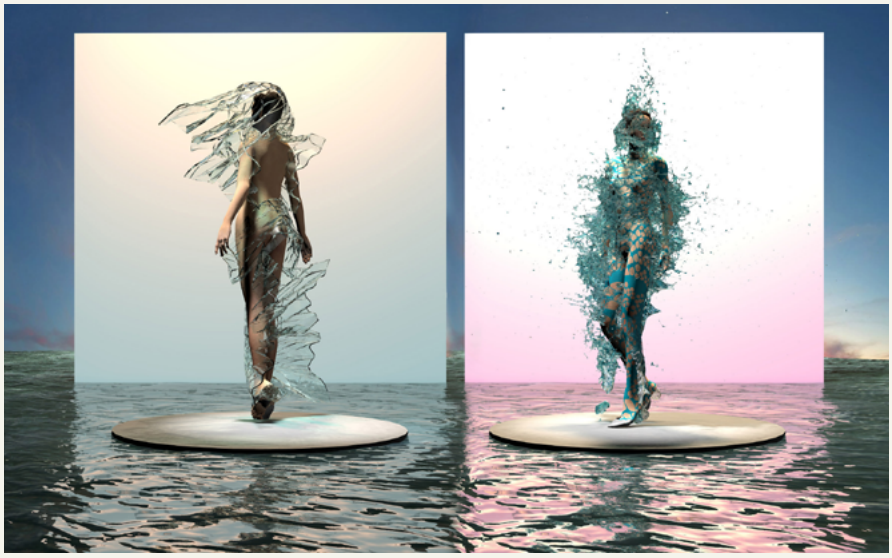
However, recently the Central Saint Martins graduate student Scarlett Yang presented a crystal-like dress with grown biomaterial that biodegradates within 24 hours. The dress has also a Biomorphic approach to water moving splashes as it changes it shape with humidity and temperatures variations.

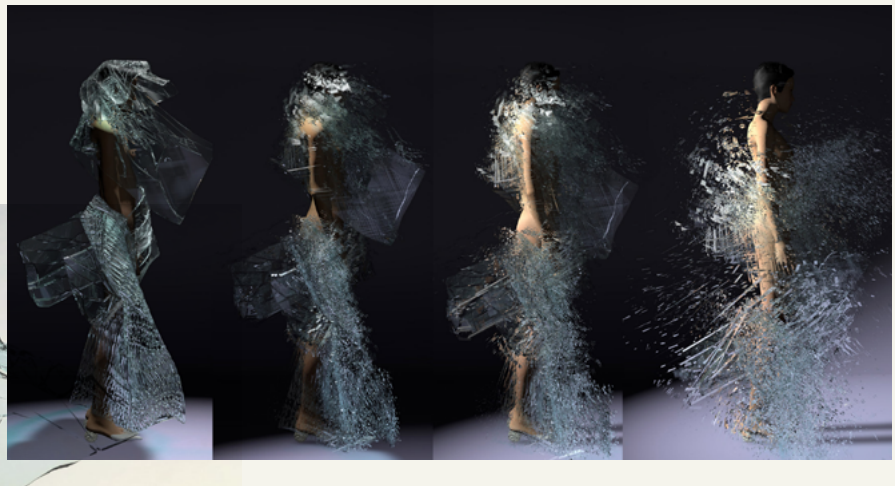
Naturally Occurring
- River, stream, ocean, pond, wetland
- Visual access to rainfall and flows
- Seasonal arroyos

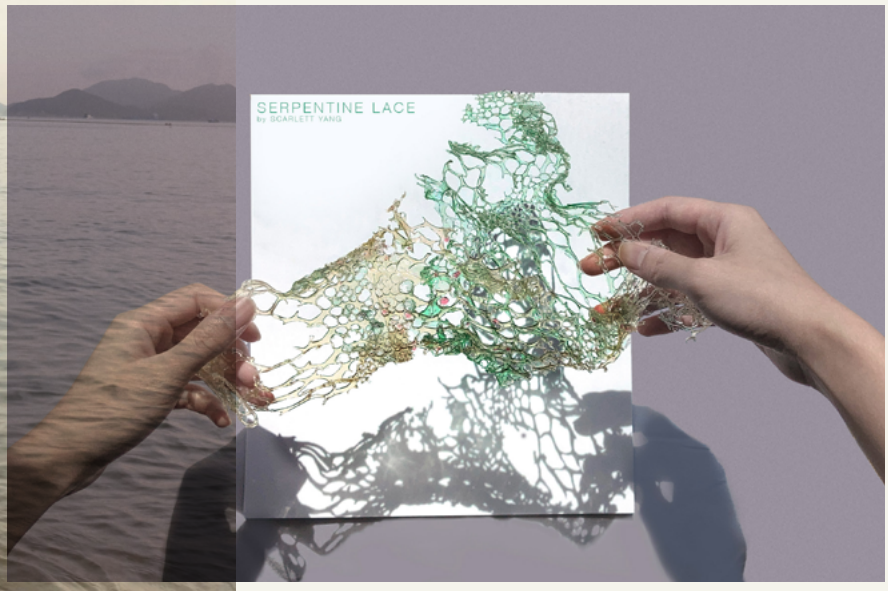
Simulated or Constructed
- Reflections of water (real or simulated) on another surface
- Imagery with water in the Composition

There also some geopgraphic variables like season that will influence the twists and creases of it. Besides being inspired by water, the dress, when in contact with this element, would be naturally degraded. This is a beautiful example of how the relationship between the water inspiration, the natural water presence and the wearer achieve symbiotic benefits out of the BioTech outfit.

"My garments display the beauty of natural life forms, aiming to challenge audiences' perception of the concept of material life cycles... Consumer products made with this biomaterial have the ability to degrade after the intended time of use, or alternatively it can change in size, shape and texture". Scarlett Yang







6 . Dynamic & diffuse light:

This pattern focuses in creating light conditions similar to the ones that appear in nature by light intensity variations or generating shadows that change over time. This help us to feel related with our surrounding by sensing the pass of time and movement, by feeling intrigue or attracted.

Our innate biological clock called Circadian Rhythm is the base of our overall wellbeing and is highly influenced by light. Therefore we are awake during the day and sleepy when the night comes.

The Human Centric Lighting is a wellbeing-oriented approach that uses light's temperature and intensity according to natural lightning patterns in other to follow the natural cycle of day light.

The amount of day light and artificial light we receive influence our sleeping patterns, our mood and our hormone cycles. Getting too much light in the evening interferes with a good night's sleep, instead not getting enough light during the day makes you feel without energy.

The researchers at EPFL's Laboratory of Integrated Performance in Design (LIPID) have teamed up with teachers and students from Geneva School of Art and Design (HEAD - Genève) to develop a ***light-hygiene sensor concept.*** It's a wearable devise that is intended to surround the neck and rest over the shoulders as a pair of headphones, otherwise can be attached as a magnetic pin to be worn all day long. The prototype will be tested by 2021, but it is expected of being able to measure and classify light exposure to advice the user the amount of light received either dangerous, artificial or beneficial. Hence helping to the body's sleep cycle regulation.

Naturally Occurring
- Daylight from multiple angles
- Direct sunlight
- Diurnal and seasonal light
- Moonlight and star light
- Bioluminescence

Simulated or Constructed
- Multiple low glare electric light sources
- Illuminance
- Light distribution
- Ambient diffuse lighting on walls and ceiling
- Day light preserving window treatments
- Task and personal lighting
- Accent lighting
- Personal user dimming controls
- Circadian color reference (white light during the day and lack of blue light at night
- Color tuning lighting that produces white light during the day, and minimizes blue light at night

EPFL's Laboratory of Integrated Performance in Design (LIPID) - Geneva School of Art and Design (HEAD - Genève) light-hygiene sensor concept, 2020

7. Connection to Natural systems

This pattern describes the evoked feeling of being part of a greater whole. It is caused by the deep connection and awareness of natural systems. As a result the induvial experiences relaxation, nostalgia, and enlightening. Kellert's study revealed that seeing and understanding natural processes enhance positive health responses and delivers a enlighten perception of an experience lived. (as cited in Brownig, Ryan, & Clancy, 2014).

"Nature is always changing and in flux, life especially reflecting the dynamic forces of growth and aging. People respond positively to these dynamic forces and the associated patina of time, revealing nature's capacity to respond adaptively to ever changing conditions". **Through design it is possible to create the sense of time passing by using for instance naturally aging materials.**

Puma's most recent project related with Biodesign ***"Design to fade"*** was made with the Swedish design studio Streamateria and in collaboration with the Dutch project "Living Colour". These are two collections that integrate the inherent concept of the passing of time of nature in their designs.

The first one carried out with the Streamateria study, integrates the circular economy and is designed thinking about alternatives to close the loop of the fashion system. It involves the use of a 3D printed PLA biodegradable mesh covered with a bioplastic fabric-like tissue made up of cellulose, alcohol, fats and industrial food waste. The motto of this collection is "No good things last forever" because they are garments that begin to die from the moment they have been created. **The intention is to begin to consider the garments as temporary experiences that should be enjoyed to the fullest and not as useless treasures occupying closets for a lifetime.** The sports brand makes an analogy with the experiences provided by the music, film and video game industries in which you pay for a temporary and ephemeral experience.

The Second Project "Living Color" uses bacteria to dye textiles. It is a collection of sportswear that consists of 6 outfits. The bacteria used to dye the garments are in charge of protecting the salamanders from deadly fungi. Thus, for the formal inspiration of the garments, the shapes and figures of the salamander were taken into account in honor of this symbiotic relationship between the species.

For the process, the bacteria are fed with a nutrient that produces the pigment and through its metabolic process it deposits the pigment on the fabrics. In the collection, different leftover fabrics from past collections of the brand were used, so the result shows different dyeing effects. None is the same as the other and over time the dyeing result varies and change according to use and according to the passing of the seasons.

The notorious prints of the ephemeral time that represent all natural systems, and the conscious knowledge of the characteristic that these made to fade garments have, f**orce the user seek their greatest enjoyment during the short period of life of the garment.** The collections also seek to inform the user about symbiotic relationships present in nature and invites him to participate in the interaction with life and sustainability.

Naturally Occurring

- Climate and weather patterns (rain, hail, snow; wind, clouds, fog; thunder, lightning)
- Hydrology (precipitation, surface water flows and resources; flooding, drought; seasonal arroyos)
- Geology (visible fault lines and fossils; erosion, shifting dunes)
- Animal behaviors (predation, feeding, foraging, mating, habitation)
- Pollination, growth, aging and decomposition (insects, flowering, plants)
- Diurnal patterns (light color and intensity; shadow casting; plant receptivity; animal behavior; tide changes)
- Night sky (stars, constellations, the milky way) and cycles (moon stages, eclipses, planetary alignments, astronomical events)
- Seasonal patterns (freezethaw; light intensity and color; plant cycles; animal migration; ambient scents)

Simulated or Constructed

- Simulated daylighting systems that transition with diurnal cycles
- Wildlife habitats (e.g., birdhouse, honeybee apiary, hedges, flowering vegetation)
- Natural patina of materials (leather, stone, copper, bronze, wood)

"Our times require us to rethink not only what to create but also how we create," said Romain Girard, Senior Head of Innovation at PUMA. "With Design to Fade, we are working on a future, which focuses on sustainable production methods and recyclable materials."

Susana Vallejo Mesa
10642557

Natural Analogues:

Would address organic, non-living and indirect evocations of nature in clothing.

The indirect experience of nature refers to contact with the representation or image of nature, the transformation of nature from its original condition, or exposure to particular patterns and processes characteristic of the natural world. These include pictures and artwork, natural materials such as wood furnishings and woolen fabrics, ornamentation inspired by shapes and forms occurring in nature, or environmental processes that have been important in human evolution such as aging and the passage of time, information richness, natural geometries, and others.

8. Biomorphic forms and patterns.

Let's return to Biomorphism in which nature's shapes and patterns are replicated in the quest of achieving harmony and beauty. Well, Biomorphism has proven phycological effects also. Nature patterns as sunflowers or zebra stripes are recognize by the human being instinct because are already familiar to the reality we know since we are born. In other words, a pattern from nature is considered primeval and connects immediately to the innate aspects of the human brain.

According to Terrapin Bright Green, biomorphic patterns "are symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature." All in all the implementation of this pattern consists in applying symbolic references as colors, texture, patterns, contours and numerical arrangements that exist in nature to the intended design solution. The sensations that a Biomorphic design generates are fascination, attractiveness, allurement, thoughtfulness and magnetism. Some examples of resources designers might include to apply this pattern are using organic shapes, natural colors, spirals, fractals or curves. By using naturalistic shapes a design can also acquire the dynamic qualities of a living system.

Color and Behavior –

Designers have always been very interested in the color theory and how it affects human psychology. However, over the years many studies contradict each other, it has also been discovered that cultural patterns alter the different perceptions of color and that depending on the context or purpose used, new sensations are generated. Red for example is a color that for advertising generates excitement, increases mood, women feel more attractive when they use this color, and athletes are more effective and competitive. However, evidence has been found that indicates red as a color that can generate stress and pain, can be related to aggression, can decrease appetite and can increase heart rate.

A Biophilic approach to the use of color invites us to use color in a more intuitive way, and based on what sensations we feel when we experience colors in a natural context.

We can take the colors of the sea, which we directly associate with the sound of the waves and the aforementioned beneficial presence of water. We can select its hues inspired by its contrasts with its states of stillness or wildness. Thus, the reason why blue in all its hues is the favorite color of many, is its vast presence in the oceans and skies of the whole world.

Green, the second most prevalent color in nature, represents fauna and therefore renewal, growth, and well-being. Studies have found that this color generates calm and relaxation since its wavelengths of the light produced by green are more easily detected by the brain. Other studies suggest that the brain perceives that a green object is lighter than another object of the same color but of a different color (Coulthard, 2020) .

Finally, other dominant colors in natural life are those of earthy tones. Gentle browns, soft oranges, beiges and grays that relate to the earth, sand, rocks and pebbles representing a rustic, honest and raw life.

The intensity of the colors also influences our perception, more intense colors increase our feelings of excitement while more washed out ones can be more calming. Finally, anyone who has experienced a sunset or has seen a wild butterfly fly over the field knows that nature also has bright colors, however it includes them in lower doses providing a visual balance. The use of bright colors in nature is always meant to generate attention.

Shapes and Patterns –

Humans are visual creatures and we encounter patterns and shapes that are inherently enjoyable to observe. Sometimes we detect and classify things as ugly or pretty without understanding the real reason why. The forms that are generally accepted as universally aesthetical are forms resulting from nature.

The use of these shapes in design can be approached in two ways:

1. Using motifs and figures that are explicitly found in the design such as plants, shells, birds, flowers, etc.

2. More abstract figures as patterns built with curves, stripes, or dots associated with meanders, cracks, tessellations. For example, the use of spirals that are found in nature and that correspond to the golden ratio generate a positive acceptance since it is believed that the human eye makes a faster reading than it sees when they have this configuration.

Likewise, the brain has a preference for objects with curves as they present a safer option for survival since shapes with sharp points are associated with predators, with sharp and dangerous objects that activate the amygdala, the part of the brain that is associated with alertness and fear. (Coulthard, 2020). Scientists associate our interest in circular shapes with the fact that the two most important stars in the universe, the sun and the moon, are circular, being them the main sources of universal energy.

"The circle embodies all the attributes that attract us, it is a safe, gentle, pleasant , graceful, dreamy and even beautiful shape that evokes calmness peacefulness and relaxation" Manuel Lima – The book of circles

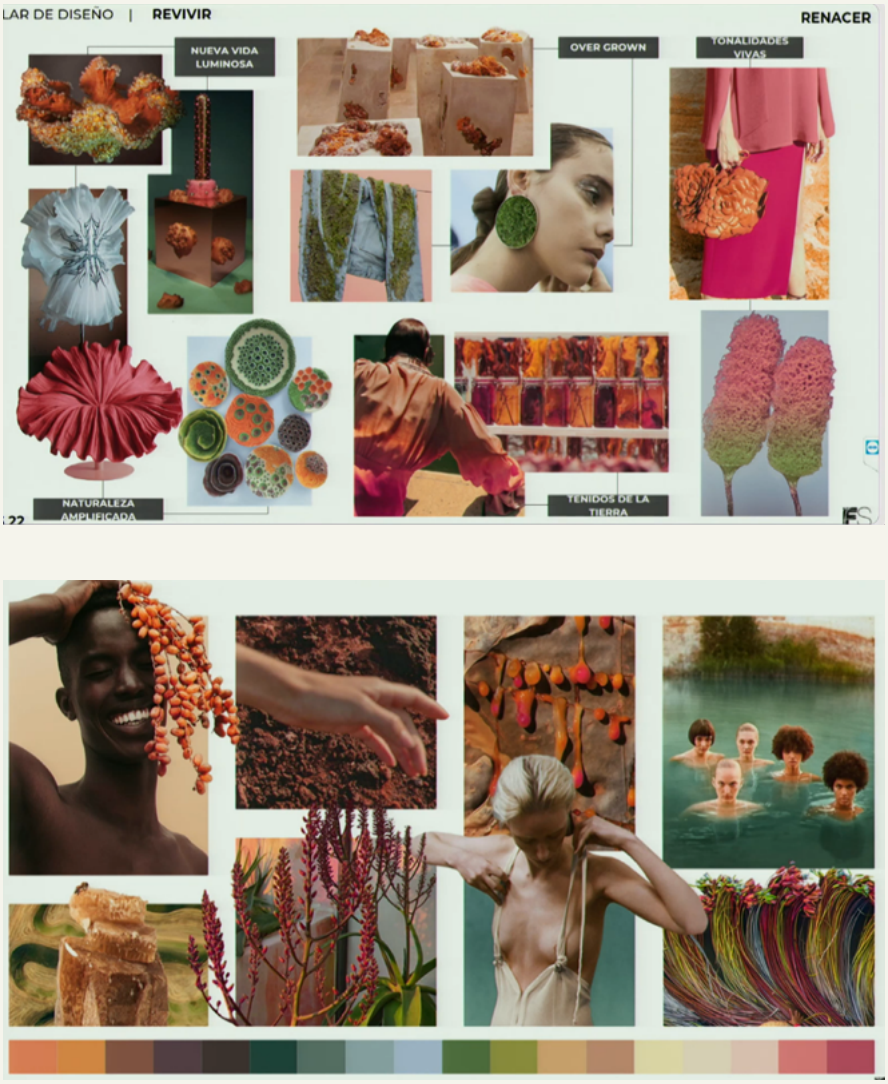
In the current context of fashion, this Biophilic design pattern is highly efficient to design collections that meet recent consumer demands. The fashion forecasting agency, Fashion Snoops states in its study "New consumers of 2022" that the new consumer is concerned about protecting the environment, connecting with the Earth, for a more conscious consumption, for more meaningful relationships, for valuing what is really essential, for being more practical and self-sufficient, for stimulating and enriching your mind, for creating an environment that allows you to be calm, for immersing yourself in new realities and finding a way to enjoy different adventures, for expressing your emotions creatively, in short, a human being interested in maintaining his own well-being, that of his fellow men and that of the planet in the midst of chaos and uncertainty.

This is reflected in the following aesthetic trends:

Re-born:

Garments that optimize natural materials, mostly with a rustic finish such as vegan leather (from fruits or nopal), and mixtures of hemp, linen and jute, represent the cultural feeling of hope and rebirth. Through all these biomorphic elements such as prints that recreate the appearance of fossils, moss, the usage of the gradients that nature offers, and the utilization of shapes based on those offered by fauna and flora, the consumer seeks mental well-being, fostered by feelings of calm and thoughts of prosperity.

Fashion Snoops talks about a reboot, a second chance, a new beginning. Far from being influenced by pessimism, this rebirth sentiment implies a slow down for humanity with the hope that a time of abundance and positivism will come; Hence, the palette is very cheerful and is inspired by a new and more relevant connection of the human being with nature, with the Earth and with other people. Citrus and refreshing tones and earthy colors stand out, but the protagonist is the honey color, sweet and warm.



Spring-Summer 2022 trends.
Cultural Sentiments
for the fashion market
- Fashion Snoops

Bio-Logical:

According to the Next Lab, Lafayette, after the pandemic the consumer seeks protection and security while wanting to continue being consciously sustainable with the environment. As synthetic and plastic fibers commonly linked to functionality generate high industrial waste; looks for raw materials that are created with chlor-resistant and antifluid properties, impermeability, breathability and bacterial filtration using textiles made with recovered and recycled fibers, 3D printed, technological and created in the laboratory. This concept called Bio-logical, uses hyper-realistic floral patterns and natural geometry, and organic designs inspired by nature, such as volumes that evoke flower petals. Also pleats and light layering.

Spring-Summer 2022 trends. Bio-Logical, Next Lab, Lafayette

A Genius of Place looks to nature in a particular place to provide guidance on locally familiar design strategies. By asking, "How have organisms and ecosystems solved this challenge here?" we discover a suite of design strategies that are well-adapted to place.

Opening Ceremony, Message Sandals use the principles of reflexology and acupuncture. Natural stones on the sole activate pressure points that will massage the feet to relax you and lift your spirits.

9. Material connection with nature:

This pattern is about using materials and elements from nature with minimal processing. Its highly related with Ecology but also with the sense of belonging to an specific place.

In the built environment this pattern highlights how since the beginning of our existence, human beings have been relying on local raw materials that, combined with handed-down knowledge, serve to construct our shelters. This materials were chosen to satisfy particular weather, geology or seasonal needs specific from the belonging location. Instead modern buildings are little about tradition, heritage of place or local techniques due to the standardized methods send materials use. The material connection pattern invites us to re-connect with vernacular traditions to create designs that are energy and source efficient and that respect our natural surroundings.

On a Biophilic level using raw, local natural materials give us a sense of comfort and belonging linked to the idea that we are still species part of a natural surrounding which was once our real home. On a sustainable level, choosing materials with low industrial intervention, without toxic processes and low carbon footprint helps to preserve the Earth.

Materials have physical and physiological effects on people. Wood, for instance, has calming effects as it is a thermal conducting material we feel it warm. There is evidence that exposes that heart rate and pulse rate decrease when we are in interiors that use wood as an clear part of their decoration. In fashion, material fibers derived from cellulose serve as thermal regulators, absorbing humidity and wrecking out moisture.

Artisans are the real experts at celebrating nature's influence in forms and using local materials, hence they have an important role in Biophilic design. Craftsmen use the ancestral knowledge of the place and culture since the origins of the techniques and know how to use materials efficiently and elegantly creating connections between natural objects and people. Rituals and ceremonial activities will be embedded within the products' experience offer to remember our essential unity with all of life. Likewise, fashion designs will seek to connect materials with alternative medicinal practices. Handcrafted and natural dye techniques are returning to the forefront, and are shifting industrial and commercialized products into more unique and naturally intervened pieces.

Precious "Tye & Dye" motifs and stisanal accessories - Spring 2020 ready-to-wear, Christian Dior.

10. Complexity and order

Nature is recognized for its diversity. Being information-rich and despite its complexity, nature is still coherent and legible. This pattern uses the intriguing balance of nature that makes it neither boring, neither overwhelming, instead we actively engage with its information richness. Thanks to the multiple geometric references available in nature, we can encounter both variety and similarity.

Fractals are considered to be one of the most impacting structures in natures which scientists have found to have healing effects like stress reduction. Their power to reduce stress come from their feature of giving order to complexity. As mentioned in the previous chapter, since the proportion between the parts of a fractal is related with the way human sight , fractals don't strain the eyes and therefore give us an overall sense of relaxation.

Fractals together with others geometric structures as circumferences, honeycombs and Fibonacci spirals also give our reality an order which is subconsciously recognized and optimizes human wellness. Applying them to fashion will cause the same effect that they cause in architecture and interior design which is to deliver comfort and wellness to the user. Biomorphic patterns applied in prints, textures or 3D shapes will be attractive to the eye and calming to the brain maintaining at the same time balance and harmony.

Other hierarchical structures involved in this pattern are repetition, symmetry and tessellation.

"Look deeply into nature and then you will understand everything better." -Albert Einstein

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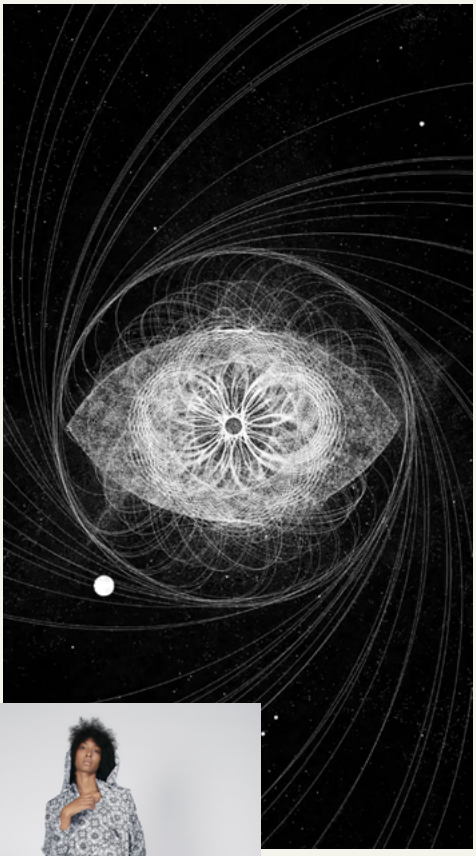
Nature is believed to contain sacred geometry that can be found in symmetrical plants, galaxies, and fractal shapes. These geometries are considered sacred because they are associated with the idea that God was a geometer of the world, the only one capable of constructing such perfect proportions, mathematics and physics. Sacred geometry can be considered the basis of all forms. Often called "sacred architecture" it weaves together the fabric of all creation. **Therefore, these geometric archetypes reveal the nature of each form and its vibrational resonance, symbolizing the inseparable relationship between everything and everyone, which ultimately constitutes the complete matrix of the universe, embodying unity.**

The ancient Egyptians believed that understanding this geometry would lead to greater consciousness and self-awareness. In addition to our physical realm, we are said to have a "Lightbody & Merkabah", which is a network of light and sacred geometry that unites your physical, emotional, mental and spiritual being. This body radiates light energy from a multidimensional self. Indian communities consider that through the contemplation of these sacred geometric shapes / codes, one can achieve states of meditation that reveal the profound wisdom of life and the creation of the Universe itself.

Thus, with sacred geometry, high frequencies of energy and light are reached that can activate, heal, awaken and transform. Symbols are like codes that can be used more consciously for deep soul awakening and connection with our true divine essence. Sacred geometry produces certain harmonizing and rebalancing effects at all levels. It connects the inner and the outer, bringing everything together.

The SS21 collection of the Threeasfour fashion brand was inspired by the sacred geometry, Vesica Piscis. The almond shape formed by the intersection of two circles is also called the matrix of all creation and the eye of Horus, and symbolizes protection, power, and good health. This geometry was rendered in 2D Opt Art digital prints



derived from the sacred form, and in 3D forms with more experimental looks. If these sacred geometries present in fashion clothing had the same healing properties, wearing them will help us to resonate higher with the universe. These are probably questions that will never be answered, however they are trending topics related to alternative ways to stimulate mental and spiritual well-being.

Will this sacred geometry present in fashion clothing have the same healing properties? Will wearing them help us to resonate higher with the universe? These are likely questions that will never be answered, however, they are a interrogation of trending topics related to alternative ways to stimulate mental and spiritual wellness.

Following the Biomorphism approach through Fashion Tech, Nervous System, the aforementioned generative design company, worked with New Balance to create a 3D printed inner part of the heel of the shoes to provide cushioning. The principles of this design are customizable Voronoi structures, built on the Turing's patterns of nature, to create foams of variable density that adapt to the biomechanics of different runners. In this way, it is noted how the creators of the design use the complex patterns of nature to achieve functional characteristics in these fashion accessories.

Additionally, they created a generative tool that functions as a midsole customizer that exposes how consumers will one day design their own shoes by leveraging 3D printing, computing, and combining their own biometric data and performance preferences. The platform allows the consumer to have direct manipulation of the design that the creators believe will one day replace mass production with custom, on-demand manufacturing.

Another complexity and order found in nature that has been inspiring the ultimate design fields are Self-Assembly & Self-Organization. These are features of natural systems in which chaotic parts organize to a final stage or configuration.

The disordered parts locally interact to build a ordered final structure in a process called Self-Assembly, Whereas ins self-organizing systems the parts never come to rest in a final configurations as the continuously move and oscillate between multiple states due to the interaction with the environment.

The Self-Assembly Lab from MIT, Stratasys and Autodesk are working with a single multi-material 4D printing to create products or mechanisms that can transform from any 1D strand into 3D shape, from 2D surface into 3D shape or morph from one 3D shape into another. This technique offers adaptability and dynamic response for structures and systems of all sizes using only natural elements as water, heat, light or other simple energy input.

One of his projects is to create reversible transformations in textiles that are at the service of the well-being of the person who uses them. Through these transformations, the shape or the porosity of the garments can be worked on to achieve breathable and waterproof clothing that responds to body temperature and humidity. The research is still in process and the objective is to create active textiles belonging to the category of programmable materials that provide performance to the fabrics usually used in sportswear.

In one of its experiments, the laboratory found a way to create permanent transformations that would help to customize the fitting of the garments. This discovery has an excellent future in the retail experiences that a brand can offer through the use of technology. In addition to the added comfort of wearing a custom-made garment, it is believed that the experience of seeing the garment magically take on the shape of the wearer could also generate psychological benefits.

It is believed that not only seeing how the garment visually adjusts to your biometric data will generate a close link between the garment and the user, but also that the user will have more confidence in the effectiveness of the benefits offered.

"You want to see that it's actually active, that it's alive and transforming with you and around you," Tibbits, thez founder and co-director of the Self-Assembly Lab. Says. "Most products in our world don't adapt unless they're robotic. This is more lifelike, where it has a natural transformation you expect in natural things".

Nature of the Space // Nature of Fashion: Analogous experiences

In the built environment context this category of patterns relates to spatial configurations and the positive and healing sensations we experience with space and place. Behind these natural positive impacts there may logically be biological reasons because although the human being has adapted to the urban way of life, the brain knows that it is not its natural environment, and it still longs for primitive stimuli more connected with Mother Earth. Let us not forget that for millennia the human species developed, in nature itself, the most successful adaptation strategies for its survival, and that is where it should return to restore values lost or simply misplaced by current times.

we have experienced since Paleolithic times how nature reveals hidden feelings and embedded adaptational patterns in the way we relate with it. Nature offers several patterns of interrelationships that provoke a direct stimulus in our neurons and hence in emotions and suppose an experience that generates immediate well-being. For thousands of years, human beings have found themselves in the world experiencing pleasant sensations produced by the spatial configurations of nature and what they mean for us. The sensation of finding natural structures that provide protection and shelter or the natural structures and configurations that generate curiosity and invite exploration causes positive feelings in the human being, and these are easily stored in memory, to which we can resort when we need to feel good. This is how the value of what we have experienced endures in our memory, and in time.

Hence, in the fashion industry application, this category would address induced sentiments of nature in clothing that could be powerful in generating cultural and ecological attachment to the garments. The biophilic design applied to fashion seeks to satisfy these inherent adaptations and relational patterns with nature to enhance people's physical and mental health and fitness. Therefore, **this patterns applied in fashion intend to give people and experience of fashion that mirrors our experience of being in contact with nature.**

11. Prospect

In the built environment theory, **this pattern describes a cleared view over a distance for surveillance and planning which imparts a sense of safety and control of the actual situation** and feeling of freedom. Prospect is a way of saying that **people like to see what's coming for their future to feel safe and mentally secure.** The main idea is to allow the user to contemplate the whole view so the individual is able to perceive approaching opportunities & hazards.

The pattern considers the use of several spatial Attributes that would be hardly possible to integrate in fashion such as delivering views from physical high perspectives, elevated planes, using transparent materials to see through, open floors and balconies.

However, a deeply analysis can be done and t**his pattern could be implemented in the fashion system as an analogic concept that will offer the user the same ability to control, predict what will happen with the products he chooses.** Also giving him freedom of decision-making by offering the complete overview of the entire life cycle to which the product belongs.

Offering traceability and transparency in the fashion systems are a clear example of prospect in the industry. As well as some of the 2023 sustainability strategies presented by WGSN like tracking the ecological print of a fashion garment by labelling it: **"The experiment found that climate labels have a psychological effect on people and that they can trigger more sustainable choices even for the most reluctant consumers".** (Rocca, 2021)

Likewise, the sustainable strategy of investing in regenerative designs brings positive symbiosis between nature and users as the customers trust the already given overview of the life cycle of the product he is buying. Hence not feeling any sense of guilt that will interfere with his emotional wellness.

On the other hand, It is possible to relate this pattern with bio methods of viewing and controlling our wellness.

Bio feedback is a mind-body technique or therapy, introduced in the 70s, that uses biometric sensors to allow a person to visualize body processes such as breathing, heart rate by means of real time visual and auditory feedback. The purpose is to achieve positive effects on physical and mental functions by the idea that if we consciously observe what is happening in our body, we will be able to control and induce improvements in our responding reactions. In other words, if we can have the whole panoramic view of our body processes we can be in the advantageous point we have always enjoyed being, and at since we have evolved.

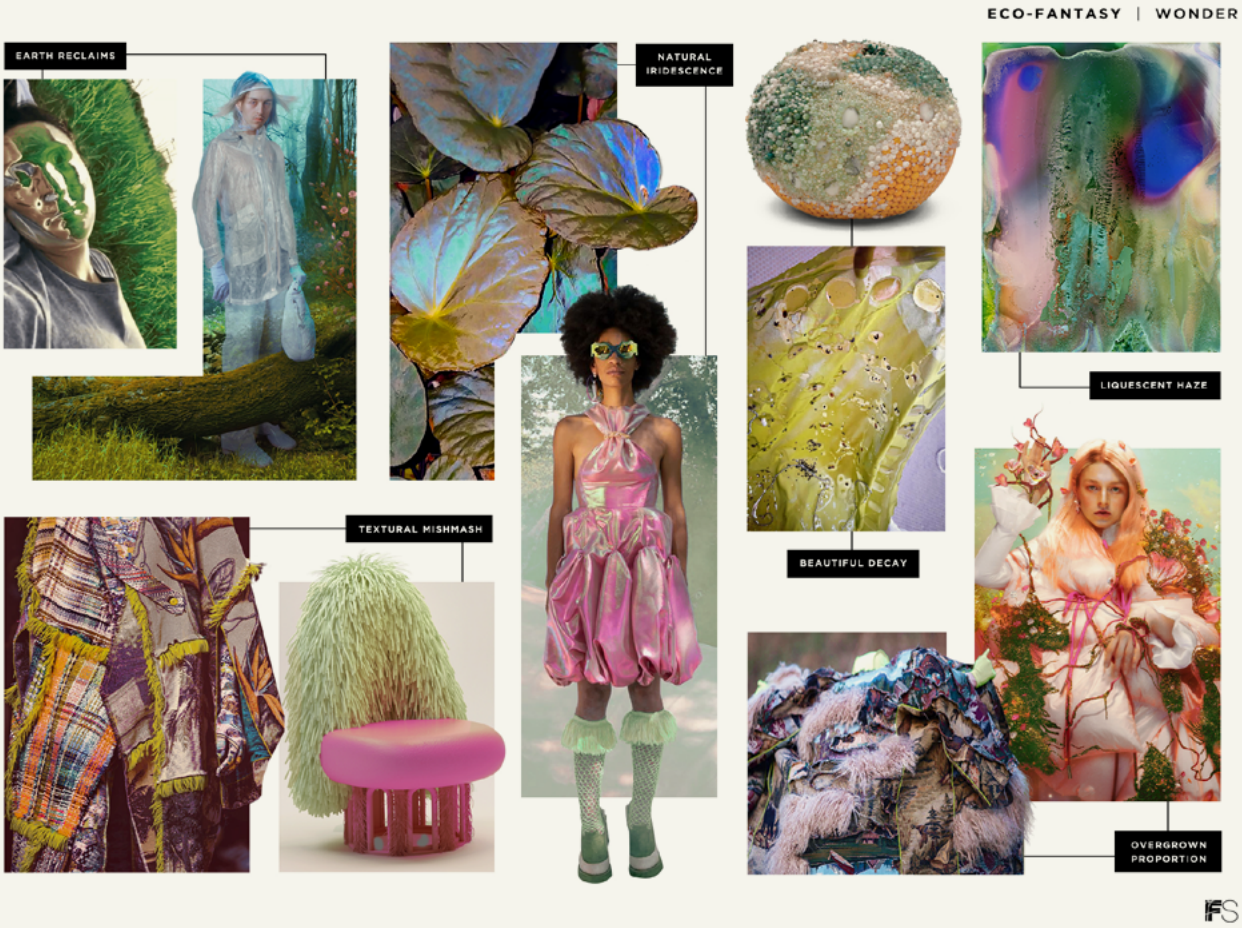
The increased awareness of involuntary body functions, gives us the chance to spot coming dangers facilitating us to control them and thus to reduce stress, anxiety or negative feelings. It is believed that this practice of Biofeedback therapies will deliver answers to the rising consumer requirement of achieving mental and physical wellbeing.

Biofeedback has been used in the medical practice to treat chronical pains conditions, and is now been explored in the emotional field through healthcare devices. **In the Fashion Tech field, garments could be used to display emotional states by translating them into light, colors vibration outputs that could alert the user of the coming stress conditions allowing him to take measurements or initiate a calming ritual.**

Garments, footwear and accessories embedded with bodysensing technology offer a new dimension of self-awareness and wellness-tracking. Clothes can e.g. help people to recognise personal stress triggers, so they can learn strategies to better manage them.

Emotion and stress tracking Accessories.Hussein Chalayan in collaboration with Intel, is rethinking how biometric tech can improve our wellbeing, 2016

12. Refuge



This pattern relates with the need of finding a place for withdrawal, where the individual feels safe and protected from environmental conditions, actual risking situations, or overwhelming social contexts. This state of safety sense reduce irritation , cognitive fatigue, improve concentration and increases emotional healthy as the individual will no longer feel vulnerable (Brownig, Ryan, & Clancy, 2014). The safe conditions delivers protection, rest and healing.

Applying this pattern to the fashion industry designs could be thought to deliver some functions of refuge conditions to situations like:

- ***Weather/climate protection:*** waterproof, windproof properties, insulation, moisture wicking, fast drying

- ***Protection from physical danger:*** antibacterial, sun-shielding, chemical resistant, Abrasion resistant, odor control.

Besides the physical protection of the external conditions, the refuge pattern represents a evolutive need of having a short break from our daytime pace living, a moment to apart ourselves from noise and society to dedicate time for ourselves seeking privacy, quietness, to relax, think, or be creative.

The notion of escapism represents an absolutely colossal opportunity for fashion brands in these times, when the consumer feels strongly battered by two pandemics: that of the coronavirus and that of the economy. At times like the current ones, the consumer wants to escape from reality, not to be constantly reminded of it (to add an extra anxiety). The human being finds this way of escapism by connecting with nature.

In a digital age, fashion is offering virtual spaces where the user can create their own alternate reality, their twin identity that will make them forget reality and allow them to experience comforting surreal moments. In an attempt at hyper-real escapism, the Eco-Fantasy trend arises which integrates natural landscapes with a futuristic and fantastic aesthetic. It partners with virtual and augmented reality platforms that offer borderless digital universes with enchanted botany, bright and iridescent colors, hypnotic details, and smooth, rounded shapes. At a more functional level, biomimetic forms are offered with synthesized injections of fluorescent or metallic shades. **This aesthetic presents an escapism towards a multi-dimensional portal in which the human mind finds refuge in its immeasurable creativity.**

Configurational Attributes
- Modular refuge
- Partial refuge
- Extensive refuge

12. Mystery

This pattern relies in the individual's desire of acquiring more information about something that has stimulated his curiosity. In design it is applied by introducing a surprise element because as humans, we are programmed to relish feelings of expectancy and exploration. **The objective is to reward people curiosity through designed elements so the users gets enthusiastic about exploring an interacting with it further,** "the key is to provide the odd quirk or fluctuation in an otherwise predictable space (design)" (Coulthard, 2020).

To recreate this sense of mystery we can go back to color theory. Dark colors can create mystery and atmospheric designs. Moreover, through Biodesign biosensors could be integrated to fashion to express different colors, scents triggered by environmentas shifts such as tempertaure or lighting.

Living microorganisms with bioluminescent proporties could also be grown in different design applications to generate surprise in fashion. The gen that codes for the light reaction can also be inserted in living organisims.

It has been aforementioned that when designing with nature and living things, designers give up a bit of the control the usually have over the final results. Shapes, colors, structures are handed over to the real innate creator. Bacteria for example, are able to carry out performative communicational behaviors that render grown images and patterns of sculptural forms.

The fashion patterns and prints, in the future will be mysterious features of the design that will be revealed jus after the wearer interacts, with it or after sometime of usage. Living patterns that grow, change color and eventually die.

This revealed features will enhance the user's amazement for fashion and therefore the bond between him and his garments. Beneficials effects will be perceived as every time the user interacts with a changing element he will experience enthusiasm, enjoyment and amusement.

Common Features
- Light and shadow
- Sound or vibration
- Scent
- Activity or movement
- Artwork or installation
- Form and flow
- Translucent materials

Objectivity, Nurit Bar - Shai exhibits bacteria sophisticated social behaviour forming unexpected foraging swarms to obtain food

"Mystery engenders a strong pleasure response within the brain that may be a similar mechanism to that of anticipation, which is hypothesized to be an explanation for why listening to music is so pleasurable – in that we are guessing what may be around the corner. zThe benefits of mystery conditions are suggested to include improved preference for a space; heightened curiosity; increased interest in gaining more information and greater likelihood of encountering other biophilic conditions" (Brownig, Ryan, & Clancy, 2014)

14. Risk/peril

Described as "An identifiable threat coupled with a reliable safeguard" t**his pattern delivers feeling of excitement caused by a low-risky situation that can be explored.**

When experiencing nature, this is the feeling that you get when looking over the edge of a cliff but coupled with a sense that everything will be right and you will remain safe. **Exploring risky landscapes could be stressful but also exciting. Adrenaline junkie people consider short term stress beneficial for health. Adrenaline boosts our brain power and stimulates the release of dopamine in our nervous system.** In other words, it contributes to the feeling of wellbeing experienced with the sensation of pleasure and peace once everything has happened and the risk has been eliminated. Risk makes us feel alive and testes our courage.

Applying it in the fashion system and strangely ahead of her time; Anouk combines the latest in science and technology to make fashion an experience that transcends mere appearances. Sensors embedded in the design monitor the space around the wearer, and body-sensors check in on stress levels as comfort or anxiety. She made a co-work with Intel-Edison to create the 'Spider Dress' which is an perfect example of this aesthetic. The dress is made by sensors and moveable arms to create and defined the boundary of personal space while employing a fierce style. "This robotic dress attacks when you come to close" she mentions. **This is a customized way to interact with ourselves and our surroundings. in other words, Wipprecht researches a new way of interface in with the world around us through our clothes.**

Thee idea is to introduce the sense of a "controlled risk" in design could also appear by taking advantage of organisms that once we were afraid of. This antagonistic but beneficial sensation of safety and danger, in a speculative future, will be achieved through parasitic prostheses synthesized from parasites grown at home that will help us to adapt easily to the adversities of our environment.

Lindsay Ann Hanson from Central Saint Martins university developed a product that combines biosynthetic materials for her pursuit of achieving well-being. She presented her conceptual collection of clothes and footwear designed to protect travelers from the growing threat of antibiotic-resistant bacteria. Her prototype sneaker called the "Resistance Runner project" is a sports shoes that protect wearers from potential contamination through the use bacteriocins to protect. Bacteriocins are substances produced by some bacteria that are able to combat the growth of similar bacteria. They are used as alternatives to traditional antibiotics in to avoid contamination due to the emrging antibiotic-resistant bacteria that threat public health.

"The Resistance Runner is a bioengineered shoe that incorporates a cloned bacteriocin and micrococcus matrix in its manufacturing technology, which allows for the blocking and capturing of resistant bacteria. The matrix is based on a protective biofilm and needs to be recharged in a nutritional broth every seven days to remain activated and create an effective bacterial culture. The shoes, therefore, come with a ziplock bag that contains the "nutritional broth" and serves as a charging unit" (Resistance runner)

DISCUSSION

Since we have evolved our mission in the planet has been to control natural forces around us in the hunt of multiple new ways to improve our permanence on Earth. This controlling attitude continues to exalt the capabilities of human mind an our apparent superiority towards other living species. **But, is the control and conquest of nature the best manners of achieving the ultimate wellness?**

The future of planet earth depends on in the genuinely of our wills. In a more figurative example, Scientific studies has shown that Nature is affected not only by our actions but also by our thoughts. **A water particle can take a different shape when crystallizing according to resonations of the type of thoughts we can transfer it.** As we are composed almost entirely of water, as all those particles are forming, they group together to take the shape of what we are thinking about. **Surrounding our bodies with nature, direct or indirect, we are forced to think more cautiously, to choose better actions and even to be positive in our thoughts because from the same way that positive thoughts and actions are amplified, negative ones are extended and grasped**. Water is purified with positive ideas, it is polluted with negative ones. **Hacking Biology will open for us new ethical dilemmas.** Apparently Bio design is a new peaceful opportunity of the human attempt to control the natural in our pursuit of hacking life into new machines.

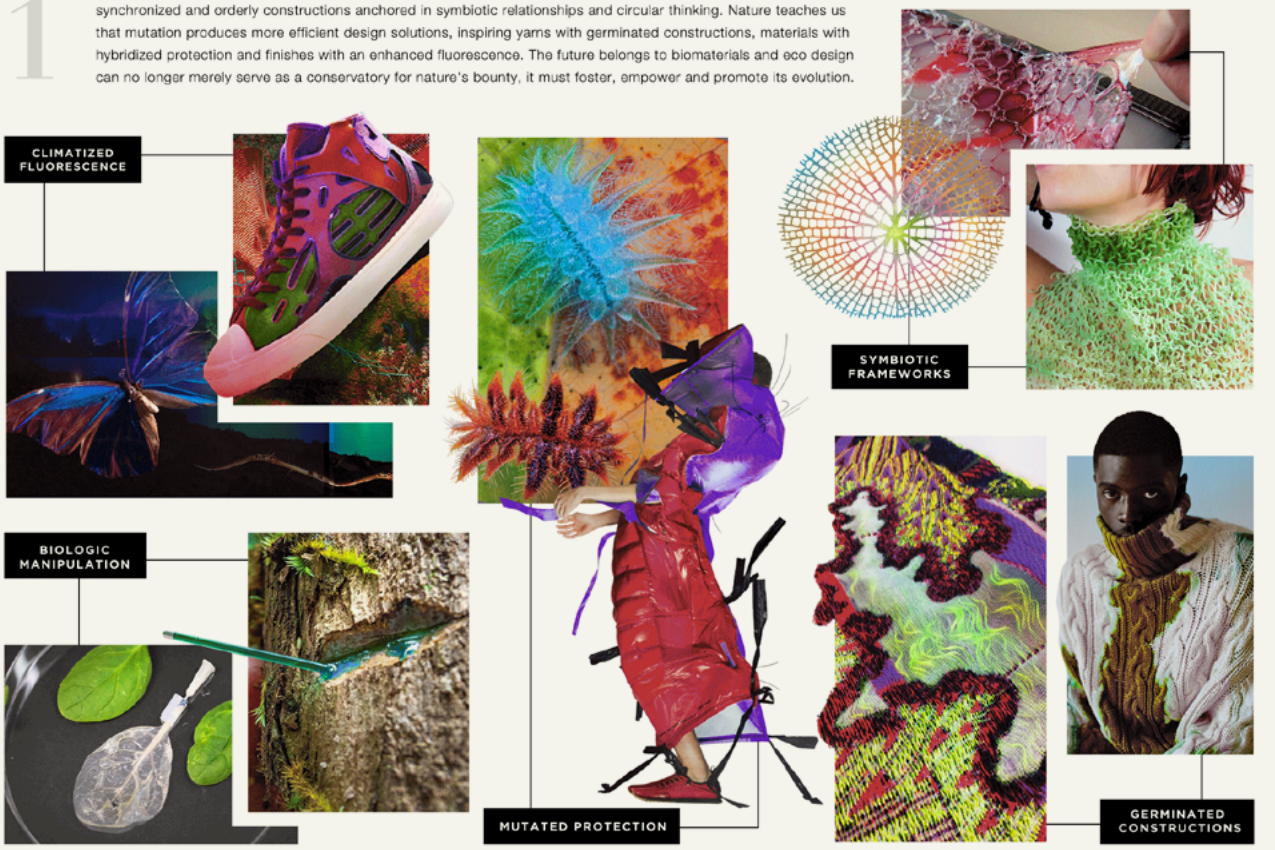
However, the control over it will only be initial. We are approaching such a point of convergence and connectivity with nature that when we include Biodesign within our biop**hilic design process, control is reduced to only the initial phase, then it is given up... and handed over to the mother and master of all universal designs to flow into her ever destined creation.** By consciously incorporating nature in fashion we will surround ourselves with even more particles composed of water and carbon that will continue to be part of the supportive group that will amplify our most desired and thoughtful aspirations. Biology is still unpredictable and the mystery beneath it boosts or delight.

By leading our action with love instead of fear of the forthcoming, Biophilic designs create a future scenario in which humanity lives in healthy relationship with the whole of our biosphere. **The Biophilia Design concept in fashion will generate bilateral benefits; for nature itself and for the human being. It represents a solidary sustainability project in which, as human beings, we learn from our creator, Mother Earth, who nurtures and recharges us despite being mistreated. Only when all humans beings could be fully aware of this, we will respectfully take care of nature, who will shine in all its splendor and will reveal the true universal reality.**

SHIFTS + INNOVATIONS

1

Biology and technology forges a new path for material innovation, where earthly wonders align to produce more synchronized and orderly constructions anchored in symbiotic relationships and circular thinking. Nature teaches us that mutation produces more efficient design solutions, inspiring yarns with germinated constructions, materials with hybridized protection and finishes with an enhanced fluorescence. The future belongs to biomaterials and eco design can no longer merely serve as a conservatory for nature's bounty, it must foster, empower and promote its evolution.



IFS

CONCLUSIONS

The task is to learn from nature that is collective, cyclical, responsible, and patient, thus the design of fashion using bio-inspired approaches can be the key to achieving a more meaningful, beneficial and contributing fashion future. Our responsibility is to restore the bio-balance that has been lost over the years of our 'progress'. For instance, Biomimicry recognizes the innovation potential of life's tested-and-true "technologies" and delivers inspiration to the system's design with optimal usage of our resources without wastage.

Through our journey of becoming better global citizens we will carry Mother Nature wrapping her arms around our skins. Clothing more than a second skin will become an integrated extension. **Therefore, integrating fashion with the principles and laws of nature would be an opportunity to charge ourselves mentally and emotionally in an infinite way with an eternal source of energy that improves our well-being.** Moreover, by consciously incorporating nature analogues in fashion we will be emotionally stable and comfortable.

However it's Biophilia, the innate love of life, that will promote positive interactions between people and nature to encourage an expand the sense of interconnection and responsibility for the human and natural survival. By recognizing the health benefits of mankind's biological connectedness with nature, **Biophilic design encourages an emotional attachment and a sense of gratitude towards nature, fuels more awareness of our negative environmental impact, and hence enhances people's need for investment to planetary care**.

Garments and fashion solutions within the system resulting from a biophilic design methodology, will represent greater solutions for individuals that want to consciously consume fashion, to figh the overproduction and overconsumption fashion issues while adquiring wellbeing features. **Consumers will perceive these "sustainability choices" not a sacrifice, but beneficial ones driven by an emotional attachment resulting from a deep connection and understanding of mutual and therefore symbiotic relationships with nature.** Through Biophilic fashion, customers will understand that nature represents a source of beauty and well-being.

In a not too distant future, innovation will rely upon the wisdom of nature and the knowledge of ancient and universal natural practices. At the same time, biological processes such as ageing will be re-evaluated and embraced as we focus on accepting and revering the natural encoded performance. **The power of nature will control and affect every consumer area, from tech and beauty to manufacturing and experience.**

Fashion will be also used to engage material researchers and speculative designers to build out visions of post-nature futures, imagining futuristic natural materials of tomorrow in an attempet of creating awareness about not caring our planet. **The power to tailor organisms into fashion is countribuiting to virtual and digital fashion to imagine limitless designs that predict breathless optimistic scenarios but also frightening and dystopian ones.**

Finally, with the 14 Biophilic patterns used as a toolkit guide to design fashion garments for wellbeing, possibilities are infinite. The understanding of these patterns and their implementation in the fashion system is a raw new proposal exposed in this article that needs be refined and strengthened as new evidence is gathered. However, there is an increasing and potential interest in biophilia research in psychology, neuroscience and endocrinology. Then, just pick a pattern and start brainstorming multiple ways to combine Fashion Tech and nature to achieve bilateral wellness that merges environmental sustainability and well-being!

The prospect is clear, and we will feel ultimate wellness by understanding that nature nurtures us as far as we always give back, and this is the science behind ecology and the codified performance of the Natural.

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