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EXAMINING BIOMIMICRY AS A SUSTAINABLE APPROACH TO INDUSTRIAL DESIGN

Selin Çiko, Arkin University of Creative Arts and Design, 200302001@arucad.edu.tr

Abstract:

This research paper delves into the intersection of sustainability and biomimetic design in industrial design. The approach used is a qualitative methodology, specifically a descriptive methodology through a literature review, to explore the utilization of biomimicry in sustainable industrial design. The study analyzes the definition of sustainable design and the concepts of biomimetic design, emphasizing the potential for energy efficient products. However, there are currently limited examples of large-scale application of biomimicry in design as it is a relatively new subject. The research examines case studies to provide information and data from sources such as The Europe Sustainable Development Report 2021. The research has limitations such as a potential focus on a specific aspect of industrial design and biomimicry, lack of sufficient empirical data, and practicality and feasibility of proposed solutions. Additionally, the study may only focus on a small number of case studies, which may not be representative of the broader field. The literature review presents the concepts of sustainability and its approaches, the importance of sustainable design in industrial design, and the characteristics, approaches, levels, dimensions, and strategies of biomimetic design, as well as its application in product design. The paper also includes case studies, including the methodology, data collection, and analysis used to arrive at the results and recommendations. The conclusion summarizes the key findings, that biomimicry can reduce the need for resource-intensive materials and processes, improve the performance and functionality of products, and reduce the negative impact of human activities on the environment, and provides recommendations for future research.

1. Introduction

In today's world, there is an increasing need to find sustainable solutions to the problems caused by human industrial activity. One approach that has gained traction in recent years is biomimicry, the practice of looking to nature for inspiration in the design of human-made products and systems. Biomimicry can provide new and innovative ways to tackle issues such as energy efficiency, waste management, and material use in the field of

industrial design. The goal of this study is to explore the potential of biomimicry to provide sustainable solutions for industrial design. (Ilieva et al., 2022) This research examines the ways in which biomimicry has been applied in the past and the opportunities for future growth and development in the field. The study will also look at the potential challenges and limitations of biomimicry, and offer recommendations for how it can be implemented in industrial design to achieve maximum impact. Overall, this study aims to provide a comprehensive overview of the current state of biomimicry in industrial design, and to illustrate the potential of this approach to provide sustainable solutions for the field.

1.1. Methodology and scope of study

Qualitative methodology has been applied for this research. The study implemented a descriptive methodology through a literature review to investigate the use of biomimicry in sustainable industrial design. The definition of sustainable design will be analyzed with the concepts of biomimetic design that have been discussed after evaluating the major academic works, and as a result, the biomimetic design has been emphasized as a encouraging solution for energy efficient products. There are very few examples of biomimicry being used on a large scale in design because it is still a relatively new subject and many designers are still striving to comprehend and find methods to integrate this approach in their designs. Nevertheless case studies will be examined in this research which will provide information from articles and data from statistics such as The Europe Sustainable Development Report 2021.

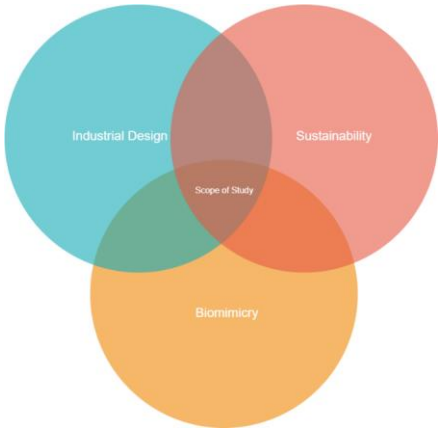

Figure 1: Scope of Study (Author, 2023).

1.2. Limitations

The research may only focus on a specific aspect of industrial design and biomimicry, and may not cover all possible applications or areas of interest. The study may rely heavily on theoretical analysis and conceptual models, and may not have enough empirical data to validate the proposed solutions. The proposed solutions may not be practical or feasible to implement in the current technological and economic context. The study may only focus on a small number of case studies, which may not be representative of the broader field of industrial design and biomimicry. Lack of understanding of bio-inspired design in specific industry or field, which could lead to oversights or lack of considerations.

2. Literature Review

2.1 Sustainability

Sustainability refers to achieving our goals without affecting the capacity of coming generations to achieve their goals. We require social and economic resources in addition to natural resources. Environmentalism is only one aspect of sustainability. Most conceptions of sustainability also include considerations for economic growth and social equality. (What is sustainability? (n.d)

The concept of sustainability has a long history, dating back to ancient civilizations, but the term itself was first introduced in the late 18th century by German mining

engineer Georg Agricola and later by Hans Carl von Carlowitz in his book Sylvicultura Oeconomica, which discussed the sustainable use of forest resources. The importance of preserving a balance between cutting down old trees and making sure there were enough new trees to replace them was emphasized. Other forestry authorities later promoted sustainable forestry and suggested actions to preserve forests, such as afforestation and the regeneration of growing timber, in order to ensure the long-term sustainability of these resources. (Du Pisani, 2006)

The 1970s energy crisis was a period of time in which there was a significant shortage of oil and gas, leading to high prices and long lines at gas stations. This crisis was caused by a number of factors, including the Arab oil embargo of 1973 and the Iranian Revolution of 1979. These events led to a decrease in the supply of oil and gas, which in turn led to higher prices and increased demand for alternative energy sources.

The global economy and people's daily lives were significantly impacted by the energy crisis of the 1970s. It prompted an emphasis on energy efficiency and the creation of alternative energy sources, such solar and wind energy. This crisis also led to a shift in thinking about the use of natural resources and the need for sustainable solutions. As a result, the energy crisis of the 1970s played a major role in the emergence of the modern environmental movement and the concept of sustainability.

The need for sustainable energy solutions was highlighted during the energy crisis, which also emphasized the importance of reducing dependence on fossil fuels, improving energy efficiency and developing renewable energy sources. The crisis also made people aware of the need to conserve resources and to think about the long-term impacts of energy consumption. The lessons of the 1970s energy crisis continue to shape the way we think about and approach energy today, and it continues to be a touchstone for discussions about sustainability and the transition to a more sustainable energy future. (The 1973 Energy Crisis Sparked the Idea for the IEA. What Have We Learned Since Then?, 2023).

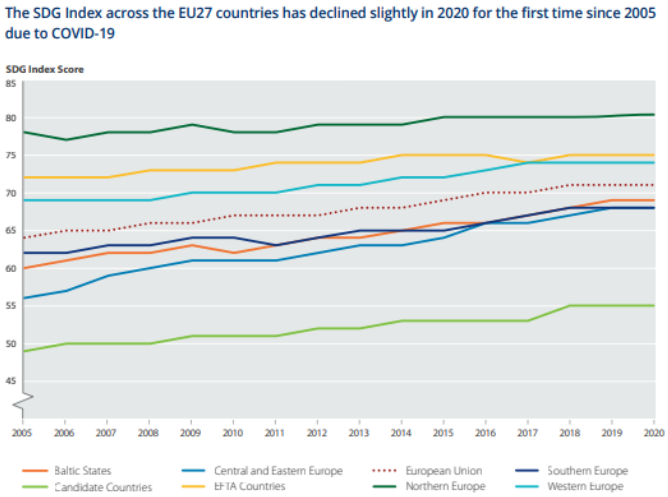

Figure 2: Sustainable Development Goals Index (Europe Sustainable Development Report, 2021)

The Sustainable Development Goals (SDGs) Index is a tool used to measure the progress of countries in achieving the United Nations' 17 sustainable development goals. The SDGs are a universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity by 2030. The SDGs Index assesses countries on a variety of indicators related to the SDGs, such as poverty, hunger, health, education, gender equality, clean water and sanitation, and sustainable cities and communities. The index provides a comprehensive overview of a country's performance in achieving the SDGs, and can be used to identify areas where more progress is needed. It is a composite index that considers multiple dimensions of sustainable development and is based on the data from multiple sources including the World Bank, UNESCO, and UNDP. It provides a benchmark for countries to track their progress and identify areas where they need to improve in order to achieve the SDGs. (THE 17 GOALS | Sustainable Development, n.d.

2.1.1 Sustainability approaches

There are numerous approaches to becoming more sustainable. Such as building more durable and functional items that will need to be replaced less frequently will result in less effect from making replacements, as will using manufacturing techniques and end products that are more energy efficient than traditional processes

and end products. (LibGuides: Sustainable Product Design: Sustainable Design Principles, n.d.) Although the term "biomimicry" was originally used in 1962, it has only recently become more well-known. The term "biomimicry" derives from the Greek words "bios" (life) and "mimesis" (to resemble). In 1997, Janine Benyus provided one of the earliest published descriptions of biomimicry. She calls it "The conscious emulation of nature's genius," while Pawlyn defines it as "Mimicking the functional basis of biological forms, processes, and systems to produce sustainable solutions." Many people think that a biomimicry strategy can significantly cut CO2 emissions while also saving money. According to Michael Pawlyn, it is possible to reduce carbon emissions while saving money. Innovation is the solution.

It is our responsibility as designers to ensure that the structures we design are consistent with their users and the surroundings they are in. There are characteristics of how buildings are built, manufactured, and viewed. We must be a part of the neighborhood where we are creating. (Nkandu and Alibaba, 2018)

2.1.1 Importance of sustainable design in industrial design

Today's world places a lot of emphasis on the idea of sustainability in design. It means addressing immediate demands while preserving resources for use in the future. Contrary to common opinion, sustainability in industrial design is strongly tied to the product life cycle, human health, etc., as well as waste and energy reduction. To create designs that can be categorized as sustainable, it is crucial to make sustainable decisions at every stage of the design and production process. As designers, we have a variety of responsibilities in this process, including conceptualizing sustainability, selecting eco-friendly materials, lowering energy use and waste, guaranteeing a good life cycle, and ensuring the product and its components are recyclable. (Gupta et al., 2015)

2.2 Biomimetic Design

Through biomimicry, we may get a compassionate, connected knowledge of how life works and, ultimately, how humans fit in. It is a strategy that borrows ideas from and

copies the strategies used by organisms that are still extant today. Over billions of years of exploration and development, failures are fossilized, and what is left is the secret to human life. The goal is to create brand-new ways of living, procedures, and systems that tackle our biggest design issues sustainably and in cooperation with all living things. By using biomimicry, we may learn from nature's mistakes and successes while also helping to heal the environment and ourselves.

We have the natural ability to build a world that sustains the wellbeing of all life, is harmonious, and is regenerative. We are privileged enough to have direction as a developing society to enable us meet this task. The amazing network of plants, animals, and bacteria that makes up our planet has undergone billions of years of study and development. Sustainable innovation can be transformed by incorporating biological strategies into design. (Biomimicry Institute, What is Biomimicry, n.d)

2.2.1 Biomimetic design characteristics

Studies like Zari's 2007 biomimetic architecture helped to explore the principles of the biomimetic technique at different scales. These investigations help us comprehend the workings of the natural world better. Only with explicit understanding of the natural world are solutions for architectural design conceivable. (Hafizi and Karimnezhad, 2021)

Emulate, Ethos, and (Re)Connect are the three key components that the science of the practice uses to translate natural tactics into design. These three elements, which permeate every facet of biomimicry, epitomize these fundamental principles.

1. Emulate

Using natural ecosystems, processes, and forms as models to create more regenerative designs through a deliberate, scientific approach

2. Ethos

The belief that through comprehending how life functions, we can build environments that sustain and improve life.

1. (Re)Connect

The concept that it is crucial for us to have a feeling of location on Earth since we are connected to all of nature. The approach of (Re)Connect urges us to observe and spend time in nature in order to gain a better understanding of how life works and to build a better ethos for simulating biological mechanisms in our creations. (Biomimicry Institute, What is Biomimicry, n.d)

2.2.2 Biomimetic design approaches

Approaches to using biomimicry in design often fall into one of two categories: defining a need or design issue for humans and investigating how other creatures or ecosystems address it, as described here Design influenced by biology (Top-Down method) is the process of analyzing a property, behavior, or function of an organism or ecosystem and applying it to human-made creations (Bottom-Up approach) (Aziz and El Sherif, 2016)

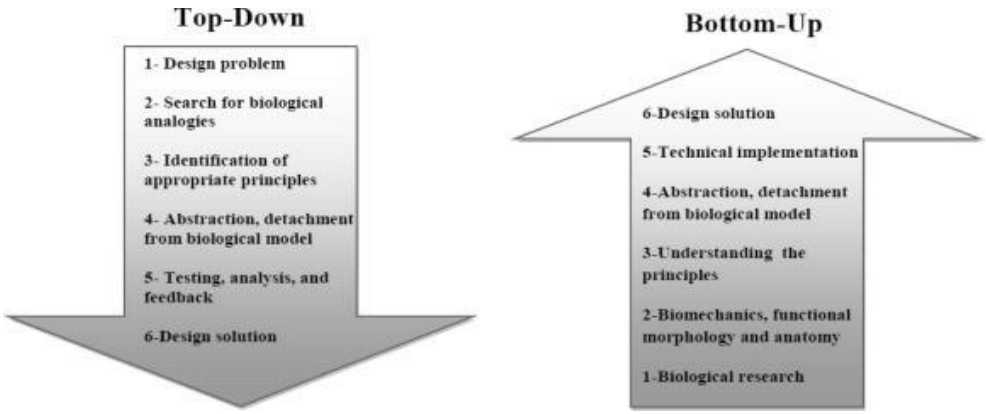

Figure 3: Top-Down method, Bottom-up approach (Aziz and El Sherif, 2016)

2.2.3 Biomimetic levels and dimensions

Behavioral adaptation describes how an organism reacts to its environment in order to live. Biomimetic methods Two main strategies have been put out in the literature to use the knowledge of nature to architectural design. A top-down or problem-based approach starts the design process by determining the issue at hand. In this method, the planner or designer recognizes the issue and looks to nature for a solution. As they come across an organism that has found a workaround for a comparable issue, they abstract the finding and apply it to their design issue. (Hafizi and Karimnezhad, 2021)

1. Organism

The basic unit of a biomimetic structure is an organism or structure. Nature paints a whole image of intricate and varied shapes. These organisms can adapt to shifting environmental conditions.

2. Behavior

At the behavior level, structures are created to reproduce a single entity. The individual's behavior, not the organism itself, is imitated at the level of behavior. Similar replications of relationships between species or organisms may be feasible.

3. Ecosystem

One crucial component of biomimicry is ecosystem mimicry, often known as eco-mimicry. Combining the other two layers of biomimicry is an advantage of ecosystem-level design. These three levels—from, material, construction, process, and function—can be applied to many aspects (sub-levels) of design. (Hafizi and Karimnezhad, 2021)

2.2.4 Biomimetic strategies

1. Dynamic

The dynamic adaptation typically shows a motion on a large scale.

2. Static

The static adaption approach operates at the micro-scale properties of materials. (Hafizi and Karimnezhad, 2021)

2.2.5 Biomimetic design and product design

Biomimicry is the practice of designing and creating products, systems, and processes that are inspired by and modeled after natural phenomena and ecosystems. It involves studying the structure, function, and behavior of living organisms and their environments, and applying that knowledge to the design of sustainable solutions for human needs. (Biomimicry Institute, What is Biomimicry, n.d)

There are several ways to apply biomimicry in industrial design:

1. Identify a problem or need that can be addressed through biomimicry. This could be a problem related to energy efficiency, resource use, waste management, or any other area where nature has evolved successful solutions.

2. Research natural models or systems that address similar problems. Look for examples in nature of how living organisms have solved similar problems, and consider how those solutions might be adapted for human use.

3. Analyze the structure and function of the natural model. Understand how it works and what makes it effective, and consider how those principles could be applied in the design of a new product or system.

4. Develop a prototype or concept based on the natural model. Use the insights and principles learned from the natural model to create a design that addresses the problem or need identified in step 1.

5. Test and refine the prototype. Evaluate the effectiveness and sustainability of the prototype, and make any necessary adjustments to improve its performance.

By following these steps, industrial designers can use biomimicry to develop innovative and sustainable solutions for a wide range of problems and needs. (McConnell, 2021)

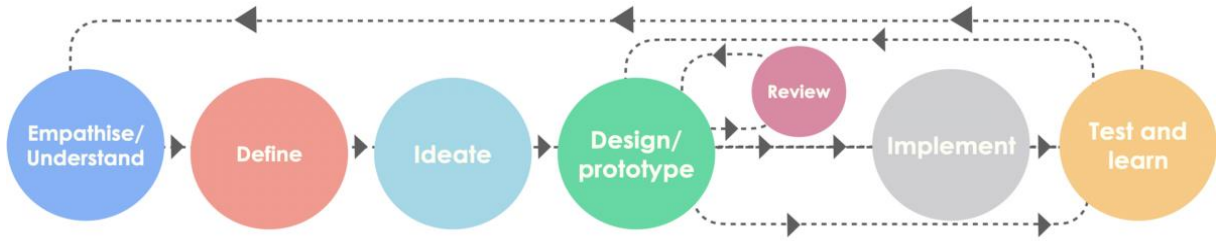

Figure 4: The product design process (McConnell, 2021)

3. Case Studies

3.1. Methodology

The research methodology used for the biomimetic design case studies was content analysis. In order to find patterns and themes relating to the usage of biomimicry in design, this process involves systematically examining written or visual materials, such as research papers, publications, product design requirements, and other related papers. The case studies were able to use content analysis to identify key trends and innovations in the field, as well as to obtain a deeper knowledge of how nature-inspired design ideas are being used in practice. This approach made it possible to examine the data in great detail, giving a thorough and in-depth analysis of the subject of biomimetic design.

3.2 Data collection: existing cases

I. Mimicking Spider Silk: Spintex Engineering

Spintex Engineering is a company that is working on developing technologies to produce spider silk for use in a variety of applications. They use a process called electrospinning which creates fibers that have similar properties as spider silk, including high tensile strength and flexibility. The process is more scalable and sustainable than traditional methods of harvesting silk from spiders and has many potential applications, including medical products and sustainable fashion textiles. The company is currently focusing on developing its spider silk-like fibers for use in medical applications. (Spintex | Silk Reimagined, n.d.)

Figure 5: High-performance Fibers(Spintex | Technology, n.d.)

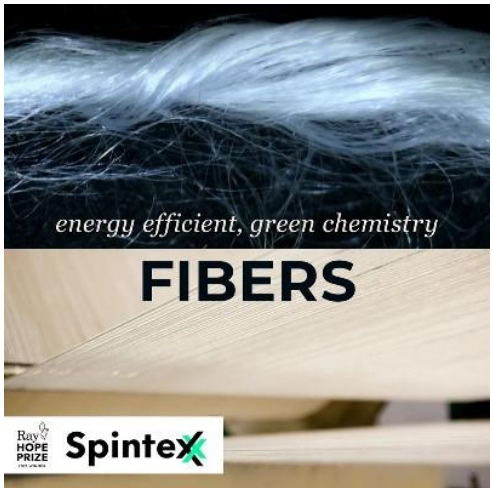

Figure 6: Fibers by Spintex Engineering (The Top 10 Biomimicry Examples and Innovations of 2021, n.d.)

II. Diatoms (or Algae) Inspired Water Purification: Aquammodate

Aquammodate is a company that is using biomimicry to develop a more sustainable and effective method for purifying water by replicating the filtration process of diatoms, a type of algae, by using synthetic materials. The company's water purification system consists of a series of filters that mimic the structure of diatom cell walls and has potential applications in water treatment plants, industrial processes, and in developing countries. Aquammodate is using aquaporins to replicate the diatoms silica-based cell walls for a energy-efficient and selective technology that generates high purity grade water in a single filter pass, performs desalination at any scale and eliminates impurities and industrial pollutants like arsenic, microplastics, and pharmaceutical residues. (Aquammodate Water Purification – Aquammodate Water Purification, n.d.)

Figure 7: Water Purification by Aquammodate(The Top 10 Biomimicry Examples and Innovations of 2021, n.d.)

III. Mycelium Inspired Building Materials: Biohm

Biohm is a company that is using biomimicry to develop sustainable and environmentally friendly building materials, inspired by the way mycelium, the vegetative part of fungi, grows and forms networks in nature. The company produces insulation and sheet material from mycelium and organic waste materials, which are strong, lightweight, and able to withstand extreme temperatures and conditions. The materials are also able to absorb and filter toxins from the air, making them potentially useful for use in areas with air pollution. The company aims to drive innovation in the building sector to produce a more sustainable built environment. (BIOHM | the Future of Home | London, n.d.)

Figure 9: Building Materials by Biohm (The Top 10 Biomimicry Examples and Innovations of 2021, n.d.)

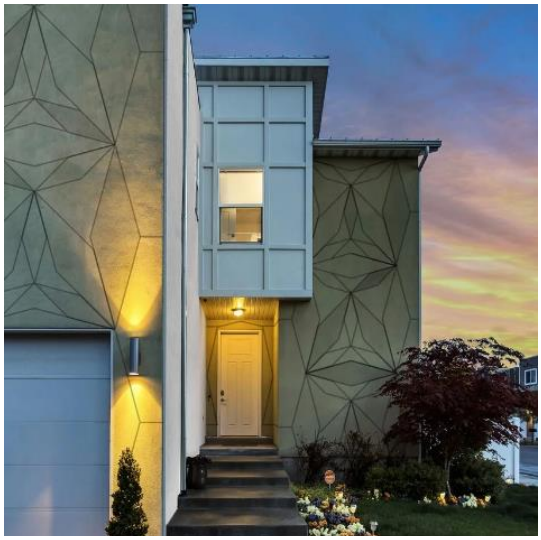

Figure 8: Construction Systems (BIOHM | the Future of Home | London, n.d.)

IV. Oysters Inspired Ecosystem Restoration: GROW Oyster Reefs

GROW Oyster Reefs is a company that uses biomimicry to restore oyster reefs in a sustainable and effective way. The company's method mimics the natural growth and formation of oyster reefs by using a combination of natural and artificial materials to create a self-sustaining structure that can adapt to changing environmental conditions. The restoration process not only provides ecosystem benefits but also creates job opportunities and can boost local economies. The company's patented concrete mixtures and micro- and macro-designs are chemically comparable to oyster shells and help revive oyster populations. GROW's products help to restore habitat for the long term by collaborating with nature to rebuild coastal ecosystems. (Grow Oyster Reefs, 2022)

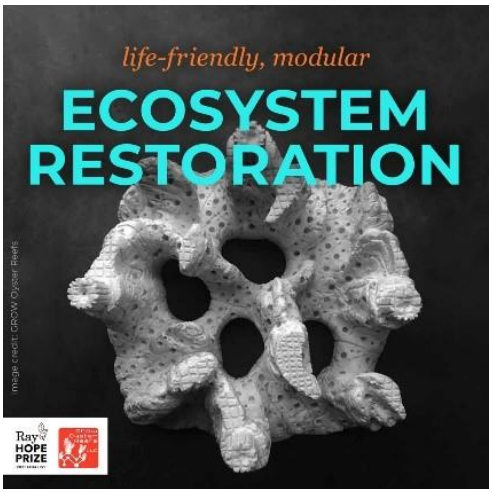

Figure 10: Ecosystem Restoration by GROW Oyster Reefs (The Top 10 Biomimicry Examples and Innovations of 2021, n.d.)

Figure 10: GROW_ REEF DISK© for living shoreline enhancement, natural oyster larvae (spat) collection, oyster gardening and research. (Grow Oyster Reefs, 2022)

V. Beetle Inspired White Pigments: Impossible Materials

Impossible Materials is a company that is using biomimicry to develop a new type of white pigment for use in paints and coatings. The company's technology is inspired by the way some beetles are able to produce highly reflective white pigments, called biogenic microstructures, which are made up of small, highly reflective crystals. Impossible Materials has developed a process for replicating these microstructures using synthetic materials to produce a white pigment that is more reflective, sustainable, and environmentally friendly than traditional white pigments. The pigment is being developed for use in a variety of applications, including in paints and coatings for buildings, vehicles, and other structures to reduce the energy needed for lighting in buildings. (Impossible Materials, n.d.)

Figure 11: cellulose-based white pigment to replace the controversial, but most widely used white pigment, titanium dioxide (TiO2) (Cellulose White Pigments From Impossible Materials | | AWRD (Ja), n.d.)

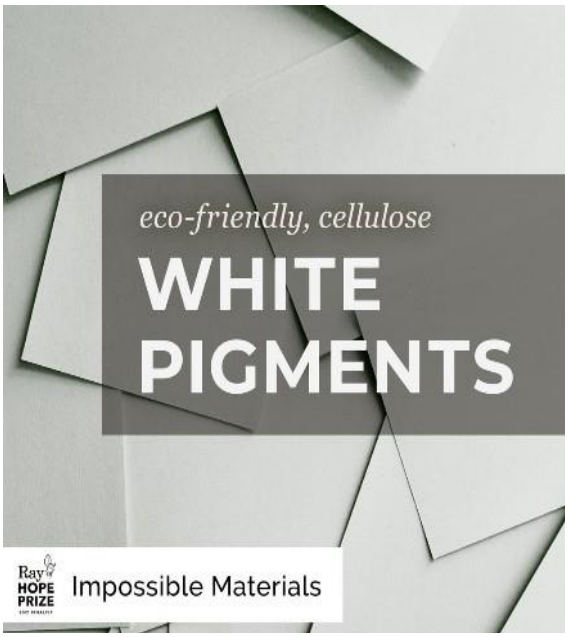

Figure 12: White Pigments by Impossible Materials (The Top 10 Biomimicry Examples and Innovations of 2021, n.d.)

VI. Fog Harvester Beetle Inspired Water Capturing: Infinite Cooling

Infinite Cooling is a company that is using biomimicry to develop a new way to capture and harvest water from fog. They got inspiration from certain species of beetles that are able to survive in dry, desert environments by collecting water from fog that forms on their bodies. The company has developed a system that uses a similar mechanism to capture and harvest water from fog. The system is made of a series of vertical tubes or panels with a porous surface that is able to capture water droplets from fog. The water droplets are then channeled towards the bottom of the tubes or panels, where they can be collected and stored for use. The fog harvesting system has a number of potential applications, including in areas where water is scarce or in disaster relief situations where access to clean water is limited. It could also be used to supplement traditional water sources in more developed areas. It also helps in saving millions of dollars and hundreds of millions of gallons of water each year by partially closing the water cycle loop at industrial operations. (Infinite Cooling | Cooling Tower Water Capturing | United States, n.d.)

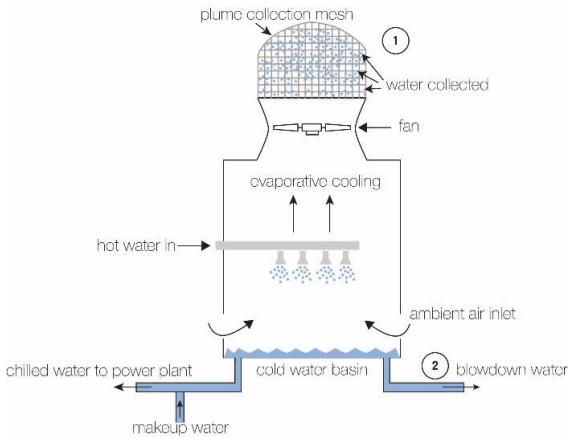

Figure 14: Schematic of product on cooling tower, showing water usage and water recovery (Infinite Cooling | James Dyson Award, n.d.)

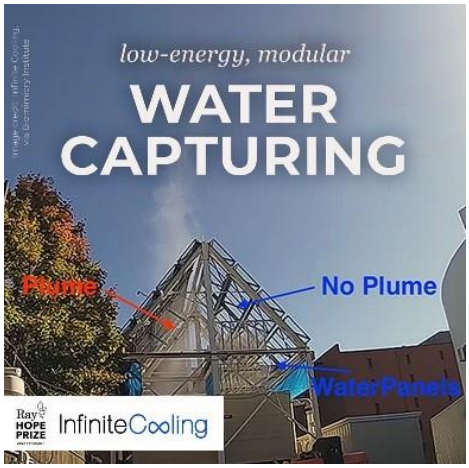

Figure 13: Water Capturing by Infinite Cooling (The Top 10 Biomimicry Examples and Innovations of 2021, n.d.)

VII. Mussels Inspired Underwater Adhesive: Mussel Polymers Inc

Mussel Polymers Inc is a company that uses biomimicry to develop a new type of underwater adhesive, inspired by the way mussels attach themselves to rocks and other underwater surfaces. They have created a non-toxic adhesive called Poly (catechol) styrene (PCS) which is 300% stronger than other underwater adhesives, and is being introduced first for coral restoration. The adhesive is made from synthesized mussel adhesive protein (MAP) which is extremely strong and resistant to degradation, making it ideal for use in aquatic environments. The company's adhesive is being developed for various applications including construction, marine engineering, and aquaculture, and has the potential to be more effective and sustainable than traditional underwater adhesives. (Mussel Polymers, n.d.)

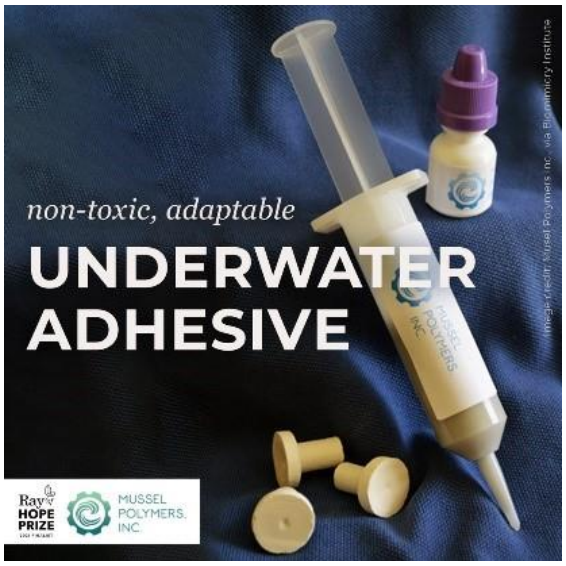

Figure 16: Underwater Adhesive by Mussel Polymers Inc (The Top 10 Biomimicry Examples and Innovations of 2021, n.d.)

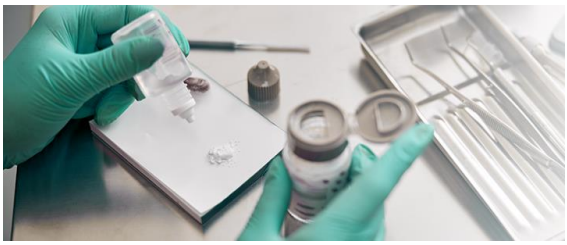

Figure 15: Mussel Polymers - Dental and Biomedical Applications (Dental, n.d.)

VIII. Photosynthesis Inspired Chemical Energy: New Iridium

New Iridium is a company using biomimicry to develop a chemical energy storage system inspired by photosynthesis. Their system uses specialized cells to capture sunlight and convert it into chemical energy, which is stored in a chemical compound that can be used to power various applications such as transportation and electricity generation. This system has the potential to be more sustainable and environmentally friendly than traditional energy storage methods, and reduce reliance on fossil fuels. The company's technology also utilizes organic compounds to enable photocatalysis, which reduces the time and energy required for chemical reactions, lowering costs and promoting green chemistry in the industry. The company has already been using their products in the pharmaceutical and chemical industry. (New Iridium, 2022)

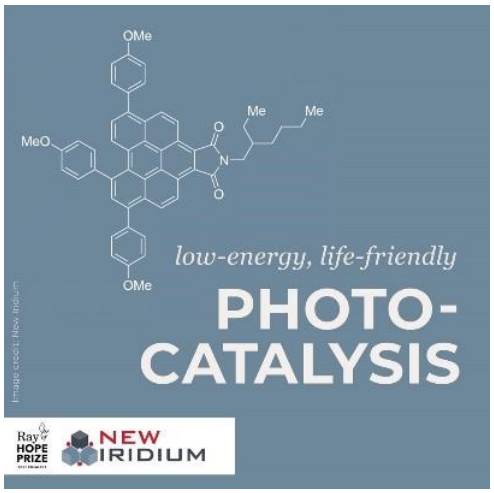

Figure 17: Chemical Energy by New Iridium (The Top 10 Biomimicry Examples and Innovations of 2021, n.d.)

IX. Fungi Inspired Industrial Land Restoration: Novobiom

Novobiom is a company using biomimicry to develop a more sustainable and effective method for restoring industrial lands by using fungi to break down and decompose organic matter. They execute mycoremediation on-site, using naturally occurring fungi that target certain toxins like oil or heavy metals. Novobiom's technology involves introducing specific types of fungi to the contaminated site, which then break down and remove the contaminants, restoring the land to a more natural state. This method has potential benefits of being more sustainable and environmentally friendly than traditional methods and reducing the impact of human activities on the environment. (Novobiom | Bioremediation, n.d.)

Figure 19: Fungi (Impulse, n.d.)

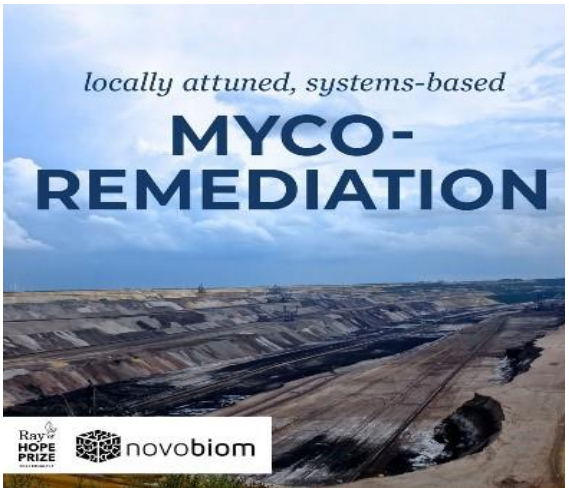

Figure 18: Land Restoration by Novobiom (The Top 10 Biomimicry Examples and Innovations of 2021, n.d.)

X. Tidal Streams Inspired Hemp Fiber Processing: Renaissance Fiber

Renaissance Fiber is a company that uses biomimicry to develop a more sustainable and efficient way to process hemp fibers. The company's technology is inspired by the way tidal streams transport and sort particles in the ocean. Renaissance Fiber has developed a machine that uses a series of tubes and chambers to transport and sort hemp fibers based on their size and density, allowing them to produce high-quality fibers more efficiently and sustainably than traditional methods. The company's hemp fiber processing technology has potential benefits such as being more environmentally friendly and reducing energy and resources needed for production, making it more cost-effective. Additionally, the technique developed by Renaissance Fiber sequesters carbon which may then be recycled. (Renaissance Fiber, n.d.)

Figure 21: Products (Products & Services | Renaissance Fiber, n.d.)

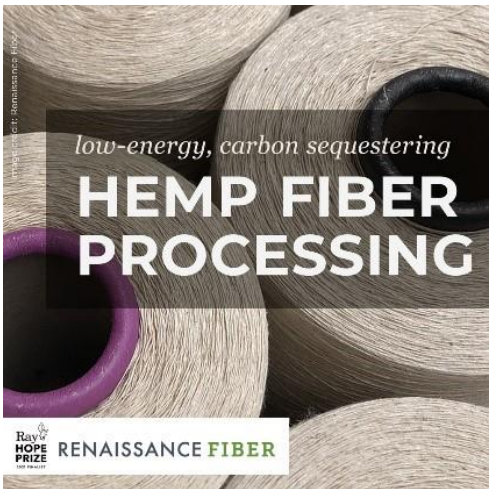

Figure 20: Hemp Fiber Processing by Renaissance Fiber (The Top 10 Biomimicry Examples and Innovations of 2021, n.d.)

3..3 Data analysis and findings

#	Case Study	Biomimetic Characteristics			Biomimetic Level			Biomimetic Strategy		Biomimetic Design Approaches	
		Emulate	Ethos	(Re)Connect	Organism	Behavior	Ecosystem	Dynamic	Static	Top-Down	Bottom-Up
I	Spintex Engineering	X			X			X			X
II	Aquammodate	X			X			X			X
III	Biohm	X			X			X			X
IV	GROW Oyster Reefs	X		X	X			X			X
V	Impossible Materials	X			X				X		X
VI	Infinite Cooling	X			X			X			X
VII	Mussel Polymers Inc	X			X				X		X
VIII	New Iridium	X			X			X			X
IX	Novobiom	X	X	X	X			X			X
X	Renaissance Fiber	X			X			X			X

The table provides an overview of several case studies of biomimetic design, highlighting key characteristics, levels, strategies, and design approaches used in each case.

One of the main trends that can be observed from the table is that most of the case studies employ a bottom-up approach, which involves mimicking specific aspects of nature, such as the structure or function of a particular organism. This approach is consistent with the general principle of biomimicry, which emphasizes the importance of studying nature's solutions to problems and adapting them for human use.

Another trend that can be observed is that most of the case studies are focused on emulating specific organisms or behaviors, as opposed to broader ecological systems. This is consistent with the fact that most of the case studies are focused on specific product or technology development rather than more holistic solutions.

The majority of the case studies are focused on dynamic biomimetic strategies, which involve mimicking the adaptive or responsive behavior of living systems. This is in contrast to static biomimetic strategies, which involve mimicking the structural or functional characteristics of living systems without regard for their adaptive or responsive behavior.

Overall, the table shows that biomimetic design is a diverse field that encompasses a wide range of approaches and techniques. The case studies demonstrate that biomimicry can be used to develop a wide range of products and technologies, including fibers, water purification systems, building materials, ecosystem restoration, pigments, water capturing, underwater adhesive, chemical energy, industrial land restoration and hemp fiber processing.

Currently, biomimicry is being used in various industries, including construction, engineering, materials science, energy, water, food and agriculture and many more. Many companies are now investing in the development of biomimicry-inspired products and technologies, and the field is expected to continue to grow in the coming years.

4. Results and recommendations

There is growing evidence that biomimicry can be a valuable tool for providing sustainable solutions in the field of industrial design. By studying and mimicking the strategies and mechanisms used by nature to solve problems, designers can develop more innovative and effective products and processes that are less resource-intensive and have a smaller environmental impact. (Biomimicry Institute, What is Biomimicry, n.d)

One key benefit of biomimicry is that it can help to reduce the need for resource-intensive materials and processes. For example, using bio-inspired materials like mycelium and spider silk can help to reduce the environmental impact of traditional building materials, such as concrete and steel. Similarly, using biomimicry to develop more efficient manufacturing processes can help to reduce energy consumption and waste. (Infinite Cooling | Cooling Tower Water Capturing | United States, n.d.)

Another advantage of biomimicry is that it can help to improve the performance and functionality of products. For example, using biomimicry to develop new types of adhesives and coatings can improve their strength and durability, while using bio-inspired designs can help to make products more energy efficient and user-friendly. (BIOHM | the Future of Home | London, n.d.)

In light of the numerous benefits of biomimicry, it is imperative for both designers and decision-makers to support and promote its usage as a means of providing sustainable solutions for the future.

5. Conclusion

In conclusion, biomimicry is becoming a crucial element in providing sustainable solutions for industrial design. By examining and replicating the problem-solving techniques of nature, designers are able to create products and processes that are more efficient, effective, and environmentally friendly. (Biomimicry Institute, What is Biomimicry, n.d) One of the primary advantages of biomimicry is its ability to reduce resource consumption. Using bio-inspired materials such as mycelium (BIOHM | the Future of

Home | London, n.d.) and spider silk can greatly minimize the environmental footprint of conventional building materials like concrete and steel. (Spintex | Silk Reimagined, n.d.) Similarly, incorporating biomimicry into manufacturing processes can lead to decreased energy use and waste generation. Additionally, biomimicry can enhance the performance and functionality of products. Adopting biomimicry to create innovative adhesives and coatings, for instance, can improve their strength and durability. (Mussel Polymers, n.d.) Similarly, incorporating bio-inspired designs into products can increase their energy efficiency and user-friendliness. Overall, the use of biomimicry in industrial design has the potential to significantly improve the sustainability of products and processes. It is important for designers and policymakers to continue to invest in and promote the use of biomimicry as a means of providing more sustainable solutions for the future.

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