

BIOMIMETIC DESIGN THINKING: INTEGRATING NATURE'S STRATEGIES INTO THE DESIGN PROCESS

BIOMIMETIKUS TERVEZŐI GONDOLKODÁS: TERMÉSZETI STRATÉGIÁK ALKALMAZÁSA A GÉPÉSZETI TERVEZÉS SORÁN

*Alireza Aghakhani, PhD student, University of Miskolc, Institute of Machine and Product Design
Ágnes Takács, PhD, associate professor, University of Miskolc, Institute of Machine and Product Design*

ABSTRACT. Biomimicry is a design approach that looks to nature for solutions. This paper explores how designers can use nature's strategies at every stage of their work, from identifying problems to creating and testing solutions. By learning from nature, we can develop more innovative and sustainable designs. This research aims to provide clear guidance for designers on how to integrate Biomimicry into their processes. Real-life examples show how this approach can lead to more creative and eco-friendly design solutions.

1. INTRODUCTION

The concept of drawing inspiration from nature in design is known as Biomimicry or biomimetics. It involves emulating nature's patterns, strategies, and systems to solve human design challenges. Biomimicry, a term derived from "bio" (life) and "mimicry" (imitation), is a fascinating concept that involves drawing inspiration from nature's designs, processes, and systems to solve human challenges. This innovative approach recognizes that nature, through millions of years of evolution, has already developed efficient solutions to various problems. By exploring how nature has evolved to adapt and excel, engineers can unlock novel ideas that often surpass conventional human inventions. This paper delves into the significance of Biomimicry in mechanical engineering, shedding light on how nature's blueprints can guide us toward more ingenious and harmonious engineering solutions. In today's world, we face big challenges like scarce resources and environmental problems. To find creative and eco-friendly solutions, we can turn to nature. Biomimicry, a design approach inspired by nature, has become a valuable tool for designers. It means learning from the genius of nature's designs.

Biomimetic Design Thinking is about using these nature-inspired ideas at every step of the design process, from coming up with ideas to testing them out. Applying these principles, we can create smarter and more environmentally friendly designs. This research aims to show designers how to use Biomimicry in their work. We'll look at real examples to see how this approach can lead to better, more sustainable designs. [1]

2. BACKGROUND AND LITERATURE REVIEW

Throughout history, humans have found inspiration in the wonders of the Earth. Ancient tales, like that of Daedalus and Icarus, embody our fascination with nature. Daedalus, an ingenious inventor, fashioned wings of feathers and wax, mimicking birds, to escape an island's labyrinth. His son, Icarus, ignoring his father's advice, flew too close to the sun, a cautionary tale of nature's power.

In the background history of Biomimicry, we're tracing the path from ancient wisdom to modern innovation. In the past, people have instinctively taken ideas from nature to solve problems, like using caves for shelter or carving Buddhist temples into caves and mountainsides in India, which later served as trade posts on the Silk Road. These early examples, while not exactly what we now call "Biomimicry," demonstrate our innate ability to find inspiration in nature's solutions. The formal concept of Biomimicry, where we actively learn from nature's wisdom to tackle today's issues, is a more recent development. It marks a shift from passive observation to conscious adaptation, exemplified in the deliberate design of solutions based on principles derived from the natural world. The first Chinese umbrellas, invented around 300 years ago, emerged when Lu Ban observed

children using lotus leaves to shield themselves from the rain. Inspired by the flexibility and effectiveness of the lotus leaf, Lu Ban created the first umbrellas, often made of silk.

Going further back in history, the construction of the Egyptian pyramids around 2470 years ago has puzzled many. While there are numerous theories about who or what was responsible, one plausible theory is that the pyramids were designed to mimic the grandeur of mountains, showcasing an early example of nature-inspired architecture. The sheer magnitude and symmetry of the pyramids echo the majesty found in natural formations.

Around 2000 years ago, the Chinese learned silk-making from silkworms, showcasing our early forays into Biomimicry. In the Italian Renaissance, Leonardo da Vinci, who lived from 1452 to 1519, studied bird flight, sparking his flying machine designs. In 1912, Giacomo Ciamician envisioned a world without coal by unlocking photosynthesis's secret.

In the 1950s, the term "biomimetics" was coined by American biophysicist and inventor Otto Schmitt, signifying nature's influence. In 1997, Janine Benyus made a groundbreaking contribution to the field with her book, "Biomimicry: Innovation Inspired by Nature." She not only coined the term "Biomimicry" but also ignited widespread interest in the subject among engineers and designers worldwide.

In 1955, Swiss engineer George de Mestral invented Velcro, inspired by tiny hooks on bur surfaces. Japan's late 1990s application of Biomimicry redesigned noisy bullet trains using kingfisher beak-inspired fronts. [2]

The 2010s brought advancements. Engineers improved wind turbines, using fish school behaviour as a model, increasing efficiency. In 2012, gecko feet inspired adhesive substances for attaching objects to surfaces with ease. In 2014, sharkskin-inspired materials repelled bacteria, offering healthier environments. These examples illustrate how Biomimicry continues to connect us with nature, fostering innovation and sustainable solutions.

3. CASE STUDIES: THE CACTUS-INSPIRED BUILDING FACADE

Here in this section to understand better the idea of this research paper we provide specific examples of nature-inspired which can be integrated into each stage of the design process, from problem identification and ideation to prototyping and testing. [6]

In a world where energy efficiency and sustainable design are becoming increasingly crucial, innovative solutions that draw inspiration from nature have captured the imagination of architects and engineers alike. One such solution takes its cue from an unlikely source – the resilient and water-storing cactus. [3]

Problem Identification: imagine a scenario where a common problem faced is the overheating of buildings, leading to excessive air conditioning use, and a notable spike in energy consumption. This issue is particularly pertinent in areas with scorching climates, where the relentless sun beats down on structures, turning them into veritable ovens.

Idea Generation: the natural world is a treasure trove of ideas. Biomimicry enthusiasts, tasked with addressing this challenge, turned their attention to the cactus. These hardy desert dwellers have evolved over time to effectively manage temperature and conserve water. They store water and regulate their internal temperature through tiny openings on their skin.

Concept Development: this cactus-inspired approach was translated into a concept for a building facade. The idea was to create a facade that mimicked the cactus's water storage and cooling mechanisms to naturally cool the building, without relying heavily on energy-consuming air conditioning systems.

Design: in the design phase, the team specified materials and technologies to mimic the cactus's attributes. They chose superhydrophobic coatings to imitate the water-resistant quality of the cactus's skin. The facade was designed with modular panels that could capture and store rainwater, providing both an efficient cooling mechanism and shade to reduce heat gain.

Prototyping: with the design in hand, the team built a prototype of the cactus-inspired facade. This prototype incorporated superhydrophobic coating and a rainwater collection system.

Testing and Iteration: the next step was to test the facade's ability to cool the building. Data was collected on its effectiveness in reducing energy consumption compared to a traditional building facade. The design was tweaked based on the results of these tests.

Scaling and Production: once the prototype proved successful in cooling the building, it was time to scale up production. The cactus-inspired facade became a practical solution for buildings dealing with excessive heat gain.

Continuous Learning: the journey didn't end with production. Ongoing observation of the facade in real-world conditions allowed for further

adjustments and improvements, ensuring optimal performance and environmental benefits.

Documentation and Sharing: the findings and successes of this biomimetic design approach were shared with the architectural and construction community. The concept's potential to significantly reduce energy consumption and environmental impact was highlighted, encouraging others to adopt similar designs.

By emulating the cactus's natural cooling mechanism, this biomimetic approach not only addressed the initial problem of overheating but also harnessed nature's wisdom to create a more efficient and eco-friendly solution. This example illustrates how looking to the natural world for inspiration can lead to innovative, sustainable, and energy-saving designs in our built environment.

4. PRACTICAL GUIDELINES FOR DESIGNERS

Design Thinking and Biomimicry are two influential ideas that have become increasingly popular in the developing field of design. While biomimicry finds creative solutions by studying nature, Design Thinking takes a human-centred approach to problem-solving. By combining Design Thinking with Biomimicry, a new path for creativity, sustainability, and problem-solving can be explored. For designers wishing to include Biomimicry into their design processes work they can use a Biomimicry Design Lens (Figure 1) which is a specialized perspective that designers adopt when seeking inspiration from nature to solve human problems and create sustainable and efficient solutions. This lens emphasizes emulating and adapting natural forms, processes, and systems into human-made designs. According to the book "A Practical Guide to Bio-inspired Design" [4] the following practical guide can be offered for designer and readers.

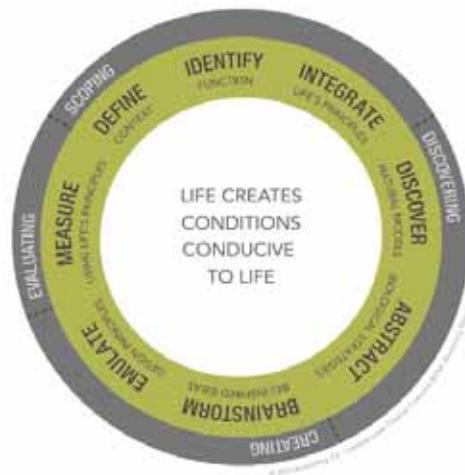


Figure 1. Biomimicry Design Lens

Retrieved from <https://biomimicry.net/the-buzz/resources/designlens-download-2/>.

1. step: Recognize the Basics of Biomimicry

Make sure you understand the fundamentals of Biomimicry well before attempting to incorporate them into Design Thinking. This entails valuing tried-and-true, long-lasting solutions from the natural world, viewing ecosystems as role models, and acknowledging nature as a mentor.

2. step: Start with Empathy and Observation

In the spirit of Design Thinking, begin with empathy. Observe and immerse yourself in the problem context, much like anthropologists' study cultures. However, extend this to nature itself – study ecosystems, organisms, and their

interactions. What can they teach you about the problem you're trying to solve?

3. step: Define the Problem

Clearly define your design problem such that it can be connected to a system or phenomenon found in nature. When building a transportation system, for instance, start by defining the problem by taking into account how ants effectively move around and communicate in a network.

4. step: Use Nature as Your Inspiration for Ideas

Allow the genius of nature to inspire you throughout the ideation stage. Consider how

your design issue might be approached by natural systems or organisms. Consider these sources of inspiration's structural, functional, and behavioural elements.

5. step: Models and Prototypes Inspired by Nature

When developing models or prototypes, actively include biomimetic components. Make use of natural materials, structures, and forms. When creating a sustainable packaging solution, for example, consider using biomimetic materials, which can biodegrade effectively in a manner similar to that of leaves in forests.

6. step: Test and Learn from Nature

Thoroughly test your design solution and contrast it with traditional solutions. Get information about user satisfaction, sustainability, and efficiency. Additionally, keep studying and taking notes from nature as you look for ways to improve and enhance your design.

It's important to remember that Biomimicry encourages collaboration between different fields, sustainability, and ethical design. Share your ideas to help connect Biomimicry with Design Thinking, creating new, eco-friendly solutions. Embrace these principles to support a design approach that values and learns from nature.

5. CHALLENGES AND ETHICAL CONSIDERATIONS

One of the core principles of Biomimicry is sustainability. We should ensure our design aligns with ethical and ecological considerations and avoid harmful practices and materials and strive for a harmonious relationship between our design and the environment. [5]

Biomimicry, which means learning from nature to design ideas, has its advantages, but it also comes with some difficulties:

Complexity: Nature can be very intricate, making it hard to figure out how to copy it in a design.

Limitations: Not all natural solutions can work for human problems, so there are limits to what we can use in our designs.

Intellectual Property: When we copy nature, there can be legal issues related to using these ideas in our designs.

6. CONCLUSION

Biomimicry is a fascinating way of designing things by taking cues from nature. It's better than traditional methods because it leads to more eco-friendly, efficient, and cost-effective solutions. Although there are challenges, the benefits are clear. Biomimicry has already inspired many cool designs and could help us find more sustainable solutions to environmental problems.

It's not just about products; Biomimicry can be used in architecture, transportation, and city planning too. For example, architects learn from termite mounds to make energy-efficient buildings, and transportation designers copy how birds fly to improve air traffic.

As Biomimicry becomes more popular, it could change how we create and innovate. Nature is a great teacher, and we can all learn from it. Following nature's lead can make the world more sustainable and beautiful for us and the future.

7. REFERENCES

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