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Biomimicry - Architectural Implementation of Natures Designs

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ABSTRACT

In the pursuit of sustainable building design and technology, Biomimicry emerges as an alternative solution. The impetus drawn from nature acts as a driving factor in architecture, giving rise to magnificent architectural creations. Biomimicry embodies refined solutions developed by nature itself. When aiming for any sustainable building design, it becomes imperative to account for factors such as structural efficiency, water conservation, waste elimination systems, thermal harmony, and energy provision. Biomimicry is essentially a repository of solutions. It encompasses biological entities that have undergone meticulous refinement through the crucible of natural selection, spanning billions of years of research and development. These organisms encapsulate technologies, functionalities, and systems that serve as resolutions to the challenges of survival in the natural realm. Often, these challenges mirror the ones confronted by humanity as we strive to devise novel approaches to sustainable design and living. Remarkably, these natural entities have tackled similar issues with a remarkable economy of means. The objective of this document is to unveil the potential for achieving a radical enhancement in resource efficiency by seeking inspiration from nature. It delves into the application of Biomimicry within the current landscape of architectural design, yielding an array of design methodologies, tiers, and principles. Furthermore, this paper delves into the endeavors of architects who have been profoundly influenced by the natural world.

Key Words: Architecture, Biomimicry, Sustainable Building, Zero Waste System.

1, INTRODUCTION

Biomimicry, derived from the Greek words "bios" meaning life, and "mimesis" meaning to imitate, represents a novel field that examines nature's finest concepts and subsequently replicates these intricate designs and processes to address human challenges. For instance, scrutinizing the structure of a leaf to enhance the development of superior solar cells exemplifies this approach, often termed as "innovation inspired by nature." The fundamental premise is that nature, driven by its inherent creativity, has already surmounted numerous obstacles that humanity grapples with. Animals, plants, and microorganisms serve as consummate engineers, having discerned effective solutions, appropriate adaptations, and above all, enduring strategies right here on our planet. This constitutes the remarkable revelation of Biomimicry: a repository of failures has transformed into fossils over 3.8 billion years of evolution, while the thriving ecosystem around us holds the key to survival.

Biomimicry represents an emerging scientific discipline that delves into nature's prototypes, subsequently emulating these intricate forms, processes, systems, and approaches to holistically address human predicaments in a sustainable manner. It employs an ecological benchmark to assess the sustainability of our innovations. After countless epochs of evolution, nature has assimilated invaluable lessons on what functions effectively and what endures. Consequently, Biomimicry introduces a fresh paradigm through which we perceive and appreciate nature—a paradigm centered not on extracting from the natural world, but rather on imbibing knowledge from it.

2. INSPIRATION FROM NATURE

One of the initial instances of Biomimicry can be traced back to the examination of birds, which subsequently facilitated humans in acquiring the technology of flight. Nevertheless, one could posit that our forebears imitated the strategies of the creatures in their vicinity to enhance their prowess as hunters or gatherers, or even to construct more advanced shelters. Sustainable progress is ascending to a fresh echelon, where structures coalesce with nature, harmoniously bolstering nature's processes instead of disrupting life-nurturing ecosystems. Nature has consistently provided a wealth of ideas and inspirations to designers, catalyzing the creation of innovative architectural marvels.

The Venus flower basket sponge (depicted in Figure 1) resides within an underwater habitat characterized by robust water currents. Its lattice-like outer structure and circular form play a pivotal role in dissipating the strains experienced by the organism. Drawing inspiration from this very Venus flower basket, architect Norman Foster conceived the design for the Gherkin tower (shown in Figure 2), featuring a skin adorned with hexagonal patterns.

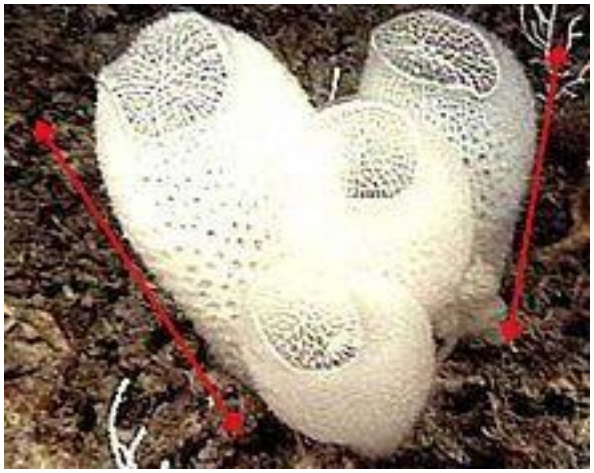

Figure 1: Venus Flower Basket

Figure 2: Gherkin Tower

From an architectural perspective, witnessing the construction of remarkable new stadiums like the Bird's Nest (depicted in Figure 4) and the Water Cube is truly captivating. These edifices not only prioritize energy efficiency and ecological sustainability but are also deeply rooted in nature-inspired design principles. The architectural blueprint of the Water Cube (shown in Figure 3) draws from the captivating pattern of water bubbles found in foam, creating a structure that is inherently influenced by the principles of geometry and crystalline systems. The building's framework is constructed using steel, while the bubbles themselves consist of Ethylene tetrafluoroethylene pillows. This innovative membrane allows more light and warmth to permeate compared to conventional glass, thus maintaining a warmer environment for all five pools and reducing energy consumption by 30%. The rooftop collects rainwater, which is then efficiently filtered and recycled through an advanced backwash system.

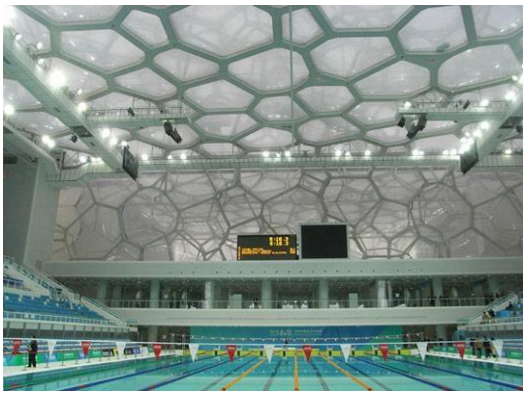

Figure .3 Water Bubble

Figure 4: Bird’s Nest stadium

3. INFLUENCE OF BIOMIMICRY IN ARCHITECTURAL DESIGN:

Biomimicry design involves more than just replicating nature's designs; it encompasses integrating nature's efficient functionalities, including heating and cooling systems, as well as optimizing natural light and ventilation strategies.

Figure 3: Habitat 2020, china

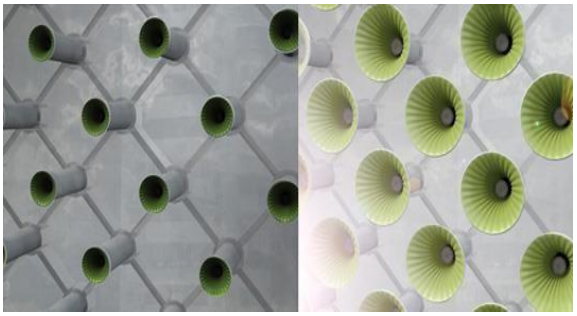

Figure 4: Living skin of Habitat 2020

Embracing the principles of biomimicry represents one of the most impactful strategies for reducing the ecological footprint of buildings. The Habitat 2020 building, conceived for China (depicted in Figure 3), stands as a forward-looking exemplar of biomimetic architecture. This visionary project harmonizes cutting-edge concepts with fundamental cellular functions, resulting in "living" structures that emulate the workings of natural organisms. This approach, inspired by nature, envisages urban existence as a dynamic and constantly evolving ecosystem. Within this urban tapestry, edifices unfurl, retract, inhale, and adapt in response to their surroundings. The Habitat 2020 building revolutionizes our perception of architectural surfaces. Rather than being mere constructions or protective layers made from inert materials, the exterior is conceived as a living skin. This skin (illustrated in Figure 4) functions as a permeable membrane that bridges the gap between the habitat's exterior and interior. An alternative analogy likens this skin to the surface of a leaf, adorned with multiple stomata-like cellular apertures that facilitate gaseous exchange and transpiration in plants.

The exterior would facilitate the ingress of light, air, and water into the living space. It would dynamically orient itself in response to sunlight to allow illumination. Airflow and breezes would be directed into the structure and undergo filtration, ensuring the provision of fresh, naturally conditioned air. This dynamic façade would possess rainwater harvesting capabilities, involving the purification, filtration, utilization, and subsequent recycling of water. Moreover, this adaptable surface might even have the ability to absorb moisture from the atmosphere. The resultant waste would undergo conversion into biogas energy, a versatile resource that could be harnessed for various purposes within the habitat.

Fig.5 Tree pod

A captivating illustration of advantageous biomimicry is found in the Treepods devised by Influx Studio. These innovative Treepods (depicted in Figure 5) ingeniously adopt the operational principles of trees and ingeniously incorporate these attributes into the structural blueprint. The fundamental objective behind this endeavor is to establish a mechanism for air purification by devising a system adept at capturing CO2. The specific tree variety that Influx Studio looked to emulate is the Dragon tree, primarily due to its expansive canopy that offers extensive shading. This canopy design also lends itself to accommodating solar panels,

which serve to power the air purification mechanism. This approach to implementing biomimicry achieves success on multiple fronts, effectively considering both the visual aesthetics and the operational functionality inherent to the Dragon tree.

The intent behind these Treepods is not to supplant natural trees, but rather to function as compact air purification systems, significantly amplifying their CO2 absorption capacity. What makes this intriguing is that these structures not only replicate tree attributes but also elevate them by optimizing the functional attributes of the Treepods. Embracing this form of biomimicry proves to be more advantageous for the environment compared to a purely sculptural or visual approach to biomimicry.

Fig.6 : Tent tower

Another instance of Biomimicry manifests in the form of the All-Seasons Tent Tower (depicted in Figure 6), designed by OFIS Architecture. Resembling an unconventional human-made volcano, this cylindrical tower embodies a versatile design, powered by solar energy and enveloped in a mesh facade that modulates sunlight for effective temperature control. Given the seismic vulnerability of the Yerevan region, where the city is located, the paramount concern in selecting an appropriate structural system for the building was ensuring earthquake resistance.

The vertical framework, responsible for countering gravitational loads and the impact of seismic forces, was strategically enhanced by fortifying the tower's concrete cores and composite columns. Meticulous attention has been dedicated to fine-tuning environmental conditions and curbing the tower's energy requirements. The external surfaces will boast a high-performance facade, accompanied by an adaptable external shading mechanism that curtails solar heat gain during the warmer months. Through a system of pipes embedded within the concrete slab, cooling is efficiently achieved without causing unwanted drafts, while ensuring comfortable heating during the winter. In summer, the cooling of interior spaces primarily relies on the utilization of this slab system. When winter arrives, the incoming fresh air will be warmed within the units and subsequently circulated into rooms utilizing the principles of displacement ventilation.

Fig. 7: Lily pad, a floating city

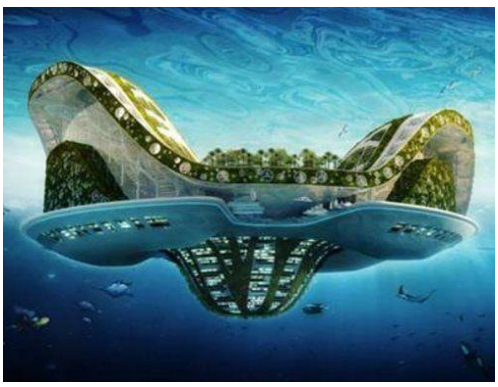

Fig. 8 Lily pod

Only a handful of urban planning strategies tackle the challenge of accommodating the potential surge of displaced populations due to rising sea levels caused by global warming. None, however, boast the level of grandeur exhibited by this particular solution. The Lilypad (depicted in Figures 8 and 9), envisioned by Vincent Callebaut, represents a visionary concept for a self-contained floating metropolis, designed to offer refuge amidst the repercussions of impending climate shifts.

The implementation of the Biomimicry concept in the architectural design of the Lilypad, crafted to resemble a water lily, envisions an emissions-free city that will float in the depths. Through the integration of various cutting-edge technologies, the blueprint anticipates not only producing its own energy but also effectively addressing CO2 levels in its vicinity. This fully self-sustaining aquatic city is strategically conceived to provide sanctuary for future populations displaced by shifting climate conditions.

Figure 9: Mangal city

Previously, the notion of cities originating from nature was common, but the perception has evolved to recognize that nature is now becoming an integral part of urban centers. The urban landscape is akin to a living organism. 'Mangal City' (depicted in Figure 9) stands as an 'urban ecosystem' that mirrors the characteristics of the Mangrove plant, incorporating spiraling plant growth patterns and emulating the dynamics of natural ecosystems. Designed by the Chimera design team, this series of futuristic spiraling skyscrapers envisioned for London beautifully embodies the principles of Biomimicry. The project constitutes an 'urban ecological system,' comprising modular pod capsules that dynamically adjust to align with the surrounding environmental and contextual factors.

CONCLUSION

Projects of this nature, which draw inspiration from the natural world, empower architects and designers to formulate eco-performance principles. These principles can serve as a valuable resource for professionals across the industry, offering them the means to integrate Biomimicry solutions into their own creations on a global scale. In this new era of sustainability, structures such as buildings, outdoor artworks, and other human-made constructions would mirror the functionality of trees, meadows, plants, and animals. They would possess the capacity to capture, cleanse, and store rainwater, transform sunlight into energy, convert carbon dioxide into oxygen, safeguard soil against erosion, propagate plant life, and minimize waste. It becomes imperative for emerging architects and designers to forge bio-inspired design adaptations that mirror nature's most ingenious concepts, thereby ensuring that all forthcoming buildings embody sustainability at their core.

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