BIOMIMICRY (LEARNING FROM NATURE): AN APPROACH TOWARDS SUSTAINABLE, ECO-FRIENDLY DESIGN

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ABSTRACT

Sustainable development has gotten to be a central portion of the plan within the building design callings; be that as it may, in recent years, the concept of environmentally sustainable development has picked up ground which points to adjust both financial and natural aspects of sustainability. This has required modern approaches to environmental economical plan that incorporates biological features to design. Such a design approach that draws from environment as a show in terms of architecture remains elusive. This research explores Biomimicry as a potential approach that offer assistance coordinated environmental sustainability to design by understanding the common forms to comprehend its frame and the environment within an ecosystem. This study analyzes Biomimicry hypothesis, and presents some environmental models, which is most pertinent to architecture. The aim and outcome of the framework will eventually be a design process that improves environmental sustainability by expanding the appropriateness of Biomimicry hypothesis into architectural practice.

Keywords— Energy, Global Warming, Contextual analysis, Human, Point, Building.

I. INTRODUCTION

Biomimicry invented and published by Prof. Janine Benyus in her book (Innovation Inspired by Nature) in 1997. She proposed biomimicry as a new science that studies the models of nature and imitates their designs for solving human problems (Benyus 1997). Living life forms always seem to have developed exceptionally compelling approaches to adapt to their indigenous habitat. Nowadays, Biomimicry is also defining as “Mimicking the functional basis of biological forms, processes and systems to produce sustainable solutions (Anous I. H., 2015). So, biomimicry is the suggested guiding principle to be a paradigm shift of creative and problem-based learning necessary for education toward sustainability. (Zejnilovic E., Husukic E., 2014.).

A. Definition: In 1974 the term bio-mimetics’ appeared in Webster’s Dictionary (Vincent [.19]), and defined as :The study of the formation, structure ,or function of biologically produced substances ,materials (as enzymes or silk ) , biological mechanisms and processes ( as protein synthesis or photosynthesis ) especially for the purpose of synthesis similar products by artificial mechanisms which mimic natural ones “

II. BIO INSPIRED DESIGN

Bio inspired design is examining the structure and work of organic frameworks as models and planning or building the modern materials and machines. It is broadly respected as being synonymous with biomimicry, bio mimesis, bio gnosis and comparable to biomimetics. The term biomimetics is inferred from the Greek word bios, “life” and the addition mimetic, “having a fitness for mimicry”.

DECODING
Technological challenges into functional terms

DISCOVERING
Similar functional abilities in Nature

ABSTRACTING
Natural design principles

APPLYING
design principles to generate innovation

EVALUATING
Design concepts according to sustainability and other criteria

Fig-1: Bio Inspired Design Process

It is a cutting-edge field of inquiry and practice, founded by thinkers such as Steele (bionics, 1950s), Schmitt (biomimetic, 1950s), and French (biologically inspired design, 1988) [1]. Many successful products have resulted from this approach or way of designing, drawing on form, function, and process-based inspiration from biology [2], and dating back to the 19th century, including barbed wire, Tiffany lamps, the Wright glider, the design of Central Park in Manhattan [3], and many more.

III. USAGE OF METAPHORS IN ARCHITECTURE

Aristoteles is the first person to examine and describe metaphor. According to him, metaphor is the use of a word instead of another word or meaning [4].

In design, metaphors are drawn closer in three ways.

1. Abstract
2. Concrete
3. Compound

Abstract utilize is around concept, thought, humane situation or private quality. Concrete utilize is directly around shape and is visual method. Compound utilize is the most difficult and the foremost effortful and is the strategy where the conceptual and visual one overlap.

A. Examples based on metaphors: The particular and viable character of the Gem Royal residence designed by Joseph Paxton in 1851 is the result of a design approach based on metaphors. Nearly one-meter long, the huge leaves of a water lily called as Victoria Amazonica are strong enough to carry Paxton’s seven year old daughter (Figures 2). This strength is the comes about of ribs’ of water lily structural pattern (Figure 3).

![Water Lily Leaves](image1)

**Fig 2:** i) The picture depicting the strength of water lily leaves carrying Paxton’s 7-year old daughter, ii) Structural pattern of water lily’s leaf


Joseph Paxton clearly depicted his metaphoric motivation in his lecture at the Royal Society of Arts amid development of Crystal Palace as takes after: “The underside of the leaf presents a beautiful example of natural engineering in the cantilevers which radiate the center, where they are nearly two inches deep, with large bottom flanges and very middle ribs from buckling; their depth gradually decreases towards the circumference of the leaf, where they also ramify” (Paxton, 1850-1: p. 6).
Similarly, the strong identity of the Eiffel Tower rises from its metaphorical genes. Latticework in Eiffel tower comparable to the curvilinear design on the top of the femur guarantees the transmission of loads coming from the upper portion to the ground. In spite of the fact that its work is similar, the pattern on the femur is reversed here.

IV. DESIGN INSPIRED FROM NATURE

Design inspired from nature could be a strategy for making solutions to human challenges by imitating plans and concepts found in nature. It's utilized all over: buildings, vehicles, and indeed materials.

The building in Zimbabwe (Eastgate Middle in Zimbabwe) (Fig. 5) was outlined from a motivation of a termite slope. With the usage of the self-cooling feature of the hill built by white ants, a sustainable arrangement way has been created for the cooling and heating strategy that caused energy consumption within the building. When compared to the same estimate buildings, Eastgate Shopping and Office Complex makes 10% vitality saving. In this context, the building may be a fruitful bio architecture sample both since it takes the nature and the intellect of nature as a solution procedure and since it is as an architectural design which understands the vitality area by getting motivated by the nature.

Fig5. Biomimicry's cool alternative: Eastgate Centre in Zimbabwe Termites and the Ventilation Principles of the Building
A conveyor framework moved forward from the nature motivation is the balloon method utilized in 1970 Fuji Pavilion (Fig. 6). This framework was planned for a presentation in Osaka in 1970. The building comprises of 16 sections, each piece has 4-meter width and has 25-meter average height and the width of the building is 50 meters. In this building air was utilized as structural conveyor, the framework was progressed with the inspiration from balloon frog.

Another conveyor framework progressed from nature inspiration is Munich Olympic Stadium that was built with a spider web model (Fig. 8). Spiders look like a cover put onto the bushes, spreading web is carried with staples hung to the edge of the bushes. This conveyor framework empowers spider to form his web in a wide range without relinquishing durableness.

Sponge-like Pearl River Tower (Fig. 8) which has 71 floors and 309-meter height, designed by Skidmore, Owings & Merrill’s and completed in 2011, is an award-winning building. Designers, who say that they were influenced with the ocean sponge within the building’s design, took the structure of the sponge that is almost taking gallons of water and living beings into itself in a day and they utilized this thought to devour less vitality in their plans
V. METHODS AND MATERIALS

Before approaching Biomimicry as a design concept, it is indispensable to basically comprehend the form, procedure, and biological system levels of the common creature. Therefore, starting with form, shape, habitats, and more details to value its ground-breaking endurance and versatile systems.

This project-based research was conducted in 3 phases. In the first phase, we explored different formulations and the invention of project, site and the concept we are looking forward to achieving of mechanical and structural properties, toughness, and maybe sometimes the form. In phase 2, after collecting data we analyze and input the result on design consideration. We also may digitally fabricate a structure if need. Different examples
VI. DESIGN PROCESS

A. Design Concept: The concept of this biomimicry hypothetical research is a series of sketches, ideas, and explorations with the caterpillar. It is chosen for the research regarding the facts: Caterpillars Move in a Wavelike Motion, From Back to Front, Caterpillars with a full complement of prolegs move in a fairly predictable motion. Usually, the caterpillar will first anchor itself using the terminal pair of prolegs and then reach forward with one pair of legs at a time, starting from the hind end [5] and Caterpillars Get Creative When It Comes to Self-Défense. With this to features of caterpillar the concept is arranged and. By going into considerable depth, including structure outlines, demonstrative plans, segments and elevations, and 3D models of a productive methodology so that we can achieve the goal.

B. Conceptual development: Conceptual development seeks solutions, systems, requirements, and to define the aesthetic concepts. It helps to achieve sustainability in nature by understanding the rules overseeing those forms. The form is set to a geometry that folds by itself when projection from the surrounding is needed and again unfold in typical environment.

Fig-9: Movement study of caterpillar

Source: https://www.nature.com/articles/37253/figures/1

(In a the insect is walking from left to right; in b and c it is retreating from right to left. Stippling indicates when leg-bearing segments (6-9, 13) are off the ground. The black arrow in b and c signifies the rapid recoil stage of locomotion. Speed, stride frequency and stride length during normal forward walking were 1.0±0.2 cm s⁻¹, 1.7±0.2 Hz and 0.6 cm, respectively. Measurements were made from video images (Panasonic, 50 frames per second, shutter speed 0.001 s, and NAC200, 200 frames per second with strobe synchronization)
VII. DESIGN PHASES

**Fig-10:** Elevation view (conceptual drawing)

**Fig-11:** Variation in Design according convenient time and environment (conceptual drawing)

Source: Authors

The form is set to a geometry that folds by itself when projection from the surrounding is needed and again unfold in typical environment. As caterpillar uses his body foldable and inflatable, design structures also turn of events and organization of a full-scale transformable engineering using a scope of plan and manufacture methods. Design also responsive towards time, temperature and climate. As fall or rise or critical weather it will able to fold itself and cover the area to project inner situation.

**Fig-11:** Structure in water (conceptual drawing)

Source: Authors
Another feature as mentioned earlier it Get Creative When It Comes to Self Defense. Keeping on mind that the structure well float on water and fully cover in ground if there occurs a critical natural disaster.

VIII. DESIGN

Fig-12: View_01(conceptual model)
Source: Authors

Fig-13: View_02(conceptual model)
Source: Authors
IX. BIOMIMICRY AS ECOFRIENDLY SUSTAINABLE FUTURE

Sustainability is tied in with a design that won't risk the ability to address those issues in future. The main aim of biomimicry Architecture is sustainability. Biomimicry fills in as a focal point that extends the arrangement space by guiding us to the practical arrangements effectively accessible in nature. Nature has her own biological process of being constant in the environment. Biomimicry as the concept is the generous functioning of ecosystem services in the built environment. Built environment is held responsible for environmental and social problems like excessive waste production, energy, and material use, and greenhouse gas emission attributed to
the habitat’s humans have created for themselves (Zari 2007). Design may focus on both architectural and urban scale. How much procedures can be comprehended and applied relies upon the condition, basically can be found by trial and error. By research and case study, it is possible for mankind to find out—it is the only way to keep the relation between building and nature. Biomimicry has enormous potential to fill the hollowness between natural and build environments. Biomimicry gives incalculable chances to improve our reality. Biomimicry manufacturers the microscopic structures create innovative, environmentally-friendly. Applying the natural structures so that they will bond to hold in every situation. It's taking motivation from nature to make an item that is friendly to the earth. Biomimicry is the science of studying nature's models and taking inspiration from it to solve human problem — for instance, a solar cell inspired by the function of a leaf.[6]

Fig-15: Bio mimicry Approach

Source: http://mikequah-imagineplace.blogspot.com/2015/10/the-thinking-principles-behind.html

Biomimicry is viewed as an innovation move from nature to humankind since nature has the ideal mechanical structure vital for the most elevated usefulness. Nature contains those classes of living things and frameworks that appear autonomously of human goal. The benefit of sustainable construction to the natural ecosystem and human health is indisputable. It has been shown that increasing about 2% in the initial investment cost (to support sustainable design) leads to nearly 20% savings in overall building cost (Lotfabadi et al. 2016). In sustainable design, the structure interfaces with the earth and adjusts to the atmosphere conditions. We all know nature uses its own composition to perform and to restore or reform energy. Biomimicry allows following the procedure of nature. Biomimicry also helps to solve global warming and the limited amount of energy supplies.
X. THE BASIC PRINCIPLES OF SUSTAINABLE ARCHITECTURE

![Diagram of sustainability principles]

Fig-16: The different principles of sustainability in architecture

Source: Dr. Dina Ahmed Elmeligy, 2019

Biomimicry provides a wide range of solutions for structural efficiency, water efficiency, zero-waste systems, thermal environment, and energy supply, which are essential for any sustainable building design (Singh and Nayyar 2015). Useful, and basic arrangements should be chosen in solidarity with the neighbourhood conditions. Ecological building considerate a proper waste management system. Installing framework to sustainable power source assets, for example, sunlight-based vitality, wind, biomass. Location basic design for instance, north-south position, opening of the building, east-west façade treatment.

XI. RESEARCH CONTRIBUTION

This research contributes to gathering knowledge by theoretical study of the process of biomimicry. Understanding from the definition to design approaches. Second, a framework of methodology that shows how to apply the biomimicry process on a design. This step is very important to accomplish the goal. At long last, this paper about biomimicry isn’t just a fundamental assessment of science. It likewise incorporates development and configuration research with a reasonable structure on a small scale.
XII. CONCLUSION

Biomimicry promotes imaginative methodologies which may contribute flexible arrangements. Practicing biomimicry allows to inherent sustainability. Design became efficient and adaptable. Taking example from nature leads our design for living in harmony. Biomimicry works as a tool of creation. Biomimicry is about valuing nature for what we can learn, not what we can extract, harvest, or domesticate. In the process, we learn about ourselves, our purpose, and our connection to each other and our home on earth. [7] If we analyse the biomimicry levels, it could be seen that the living being level is usually connected to the commitment of biomimicry. However, there is still a large research gap when it comes to using biomimicry to tackle management situations. As aforementioned, biomimicry can be defined “as an approach to innovation that seeks sustainable solutions to human challenges by emulating nature’s time-tested patterns and strategies” (Biomimicry Institute, 2018). Installing some green on the veranda of putting solar panels on the roof on every building is not sustainable creation. As humans, we need to be more involved with nature for inspiration for the design, however, biomimicry brings the solution for living and to achieve ecologically sustainable design by creating unity between nature and the built environment.

FUTURE WORK

The Biomimicry design approach not only focuses on aesthetics but also responsive to the structural solution. Building facades, material all are relatively detailed fields of study. The arena of biomimicry is still a relatively new felid of research. This research holds only introduction information about biomimicry with the benefits of balancing a sustainable environment with an example of the design and design process. If the further scope of this research is given probably can follow on detailing and implementation of the process. Engaging possible modelling and 3D printing techniques to manufacture architectural elements equipped with different performative characteristics. In addition, there is a genuine absence of practical testing and real usage of biomimetic ideas to help structure a case for biomimicry concerning the executives. As Richard Rogers said, the buildings are similar to the birds that they dress their feathers in winter to adapt to the new condition and to regulate their metabolism (Mahdavinejad et al. 2013). With the writing survey this paper expounded on the significance of development and the capability of biomimicry in adding to this issue. Because of the pattern around biomimicry right now, it was additionally very hard to recognize unadulterated logical writing, books and the executive’s scholars. This creates a lot of unsettling influence in writing, which made looking for ideas very troublesome and might diminish the unwavering quality of this research.

XIII. REFERENCES


[5] https://www.thoughtco.com/fascinating-facts-about-caterpillars-1968169) and

