

## Biomimicry – Nature Inspired Building Structures

### **Ar. Anjali Prashant Kshirsagar**

*Asst. Professor, Deccan Institute of Technology, Kolhapur  
Shivaji University, Vidyanagar, Maharashtra, India.  
Email-gp.anjali@gmail.com*

### **Ar. Seema Santosh Malani**

*Asst. Professor, Deccan Institute of Technology, Kolhapur  
Shivaji University, Vidyanagar, Maharashtra, India.  
Email-seema@maheshengg.com*

### **Er. Vikramsinh S. Tiware**

*Asst. Professor, Bharati Vidyapeeth, Kolhapur  
Shivaji University, Vidyanagar, Maharashtra, India.  
Email-tiwareamit9774@gmail.com*

### **Abstract**

From the beginning of creation, human being was surrounded by nature. Everything in nature is well organized and in harmony with the other parts of it. Through the history, nature has been always a source of inspiration for the human begin in different aspects of their life. Architecture as one of the remarkable features in every society cannot be separated from nature. Biomimicry is about solution refined and developed by nature. Biomimicry is applicable to many aspects of the architectural, engineering, and material development fields, such as building design, structure, materials and more. The uses for biomimicry have varied, however they all have had the same goal, which is to find answers and solutions through emulating nature. For any sustainable building design Biological organisms refined and developed by natural selection over a billion year research and development period can be seen as embodying technologies, functions, and systems that are solutions to the problem of surviving in nature.

**Keywords:** Biomimicry, Visual-Conceptual Inspiration, Nature Inspired structures

### **Introduction**

"Biomimicry or biomimetics is the examination of nature, its models, systems, processes, and elements to emulate or take inspiration from in order to solve human problems. The term biomimicry and biomimetics come from the Greek words bios, meaning life, and mimesis, meaning to imitate." In simpler terms, biomimicry is the conscious emulation of nature's genius

Biomimicry is an applied science that derives inspiration for solutions to human problems through the study of natural designs, systems and processes. Nature can teach us about systems, materials, processes, structures and aesthetics (just to name a few). By delving more deeply into how nature solves problems that are experienced today, timely solutions could be extracted and new directions for our built environments could be explored.

In architecture, biomimicry can be applied to improve the way

the built environment is designed, through site work, construction, and daily operations, and to reduce the impact it has upon the natural environment through numerous strategies of reducing carbon emissions, waste and more. There are vast amounts of knowledge and ideas available to inform possible solutions to architectural design that will also allow designs to be more sustainable. In addition, there are several people involved in the field of biomimicry that have provided insight on the subject and the number is growing as it is becoming more popular among designers looking to a more sustainable future.

In architectural design, there are several examples of biomimicry that can be found; although, many of these examples use it in different ways, and it is often considered not to be a total design solution but rather as a solution to a particular aspect of design. Michael Pawlyn, an architect that uses biomimicry, has identified several ways in which biomimicry can be applied to architectural design; such as, in his book, "Biomimicry in Architecture," he identifies applications for water management, climate control, structural innovations, material developments, and energy production.<sup>3</sup>

In addition, there are other forms of biomimicry; biomorphic, bio-utilization, and biophilia.<sup>3</sup> Biomorphic is the mimicking of natural forms such as designing a building to resemble the shape of a leaf.<sup>3</sup> Bio-utilization is the more direct use of nature for beneficial purposes such as using trees on a site to provide shading for windows. Finally, biophilia is the idea that there is an instinctive bond between human beings and other living organisms which inspires the use of plants to create a comforting environment. Thus, biomimicry, in the terms of architecture and use for this paper, is the emulating of biological forms, processes and systems found in nature to produce architectural solutions that could be used for sustainable solutions. It is simple to understand that the homology between natural and man-made architectural forms can be seen while considering the biological systems and structures. According to the definition of "structure", the meaning of this word can be expressed as "the arrangement or formation of the tissues, organs, or other parts of an organism" Therefore, since nature has unlimited time and

resources, due to its natural selection uses methods of infinite subtlety for its chemistry and control mechanism and therefore its progress in evolution was depending upon the development of stronger biological materials and more ingenious living system. Through history, the biological systems can be considered as a very well developed branch for architects, designers and engineers. Therefore, even a very simple and primitive kind of life can be considered as a delicately balanced.

However, for the development of the natural forms the selection of the nature can be considered as an accepted model for the latest designers and this explanation called according to the Darwin as “natural selection”. (Gordon, 1978) At least three kinds of inspiration can be renowned in architecture and design, and each kind plays different role. All these three provide a spectrum whose understanding is critical for the progress in design. These three levels of inspiration are named as visual and conceptual.

### Visual Inspiration

Visual inspiration is relatively well understood and widely used. In this case, picture of various living organisms, or their system, are used to create similarly looking engineering systems. Visual inspiration can produce useful result especially in architectural design from the aesthetic points of architecture.

### Visual Inspiration Architectural Example

For example a picture of sea turtle shell can be used to shape a reinforced concrete for a large span roof structure in an exhibition building. Unfortunately, it requires the involvement of a human designer who knows structural engineering and the theory of elastic shells, and who is able, most importantly, to avoid using inspiration in a wrong context. In such a case, a visual can be incorrectly to produce a dangerous design. For example, the use of the same sea turtle shell shape (Figure 6.1) to design a shear wall in a tall building may result in a structure excessively sensitive to large vertical forces and may be ultimately dangerously unstable.



Figure 1: turtle shell in nature



Figure 2: Exhibition hall inspired from turtle shell

Denver International Airport is another example of this kind of architecture. Denver The tensile fabric roof of this building is designed by inspiration from the naturally occurring beauty of the Rocky Mountains. As the largest airport in the United States, it reflects a mixture of historic and modern architecture.

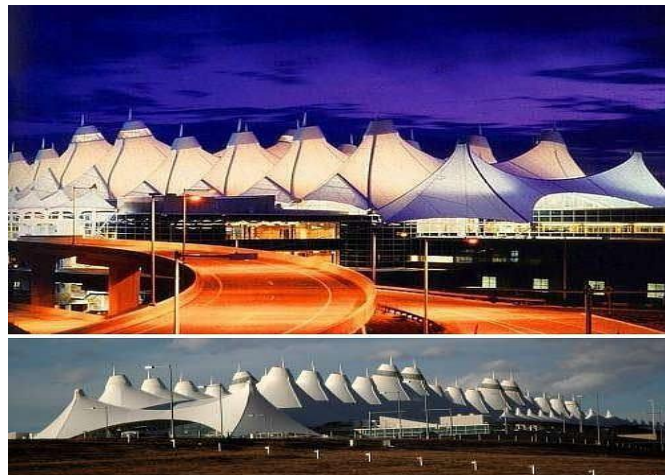


Figure 3: Denver international airport in USA



Figure 4: Natural rocky mountain

Selfridges Building in Birmingham, by architect Jan Kaplicky, founder of Future Systems, features a curvy space-age design that epitomizes what the aesthetic goal of bionic architecture is all about. His idea was to combine the organic and natural forms with high technology to achieve the optimization. Completed in 2003, it remains one of the leading forward-thinking buildings out there.



Figure 5: Bullring in Birmingham done by Jan Kaplicky



Figure 6: Wasp nest structure

Floating House in created by Robert Oshatz Inspired by Nature, Taking inspiration from ocean, the end result sits in harmony with its surroundings. Oshatz is known for his curvaceous, swooping architecture and unique approach to design. Since active construction is prohibited on the Willamette, Oshatz had to construct the home off-site on the connected Columbia River and pull it by barge to its mooring. This unique home is kept afloat by locally sourced 80-foot Douglas fir logs, and the exterior design takes its cue from ocean waves.



Figure 7: floating House and its natural concept

### Conceptual Inspiration

Conceptual inspiration occurs when a structural engineer uses a principle found in nature in design, for example, the biological principle of homeostasis. This principle states that any living organism reacts correspondingly to recover its vital functions when attacked by an external agent. A designer can apply this principle, for example, to determine the optimal shape of shell roofs subjected to thermal and mechanical loads. Unfortunately, using conceptual inspiration requires a solid understanding of both nature and structural engineering and cannot be used in a mechanistic way by an automated designing system.

Visual inspiration is skin-deep. Conceptual inspiration is abstract and difficult to use. In fact, both require the involvement of a sophisticated human designer. Fortunately, the third kind of inspiration, called here computational inspiration, is the most promising from the perspective of automated conceptual design. It is the most intriguing, still poorly understood and difficult, but has the greatest potential to revolutionize design. In this case inspiration occurs, on the level of computational mechanisms, which are inspired by the mechanism occurring in nature. Such mechanism will not be discussed in this study.

### Conceptual Inspiration Architectural Example

Ark of the World, Costa Rica is the example of inspired design. The buildings created by Greg Lynn are based on a type of architecture for which he coined the term 'blobitecture'. This type of building relies on the 'blob-like' shapes of amoebas and other naturally occurring forms to create the basic bulbous (rounded) design of the buildings. One of the best examples of this is his plans for the Ark of the World, a building located in the Costa Rican rainforest which is planned to serve as an eco-center and location of eco-education.



Figure 8: Costa Rica done by Greg Lynn

A tensile fabric roof serves as a platform for people interested in looking out over the rainforest and a column-based water garden keeps the place cool. The design of the building itself appears floral in nature, which is pretty damn cool. Urban Cactus in Rotterdam is a 19-storey residential building, shaped in a way that is inspired by an irregular pattern of outdoor spaces. Natural sunlight and a unique design on the

harbor give it the semblance of bionic architecture and of course it's interesting and curvy aesthetics make it an appealing building. However, it's not 100% green or sustainable; therefore it only gets an honorable mention on most bionic architecture lists.



Figure 9: Urban Cactus in Rotterdam



Figure 10: irregular pattern of outdoor spaces

Beijing Olympic Stadium, by Swiss architects Herzog and de Meuron houses a 91,000-seat arena under its 12-metre-deep steel exoskeleton, Inspired by Bird Nest because of its tightly woven lattice structure.

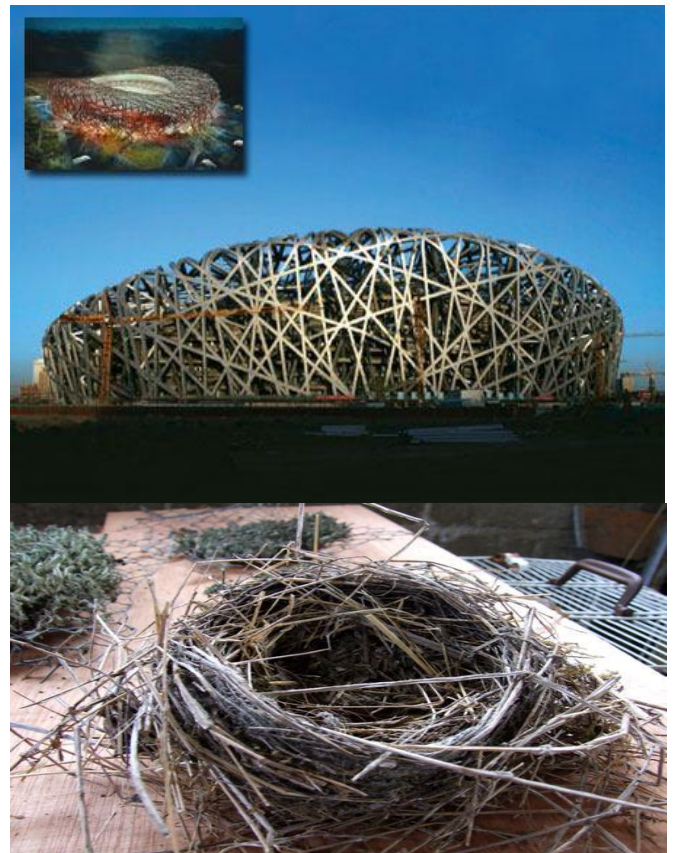


Figure 11: Beijing Olympic Stadium and natural nest

### Conclusion

All through the history, from the time that human were line with the nature up to the time that human hurts the nature right after the industrialization. Accordingly nature has been a part of architecture from the time that human directly used it by living in the caves and using building material according to the nature of its surrounding up to the time after industrialization which the perspective has been changed by the new materials, tools and technologies and inspiration of nature took place in architecture. But it is not all what architecture took from nature, by short look to the development of architecture, form, function and space quality and some of the main factors which has been taken to the consideration, all through the history of classic architecture, and has been extend up to today's architecture. However the best way of facing with it by inspiring from natural structure base on this study, but there are facts beyond this which take inspiration from nature to have most optimized architecture as optimization in nature, to face with new restraint, and limitation of resources, beside being in harmony with nature as medium we are living in. The study has intended to show new approaches to have new era of architecture, by taking inspiration from nature in different perspectives.

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