“Bionic; Biomimicry, Biomorphism, and Biophilia Architecture; the revolution of green building conceptual approach”

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ABSTRACT:

“When we look at what is truly sustainable, the only real model that has worked over long periods of time is the natural world.” A biologist Janine Benyus- the President of the Biomimicry Institute.

People have natural needs for contact with nature basic in fact of their physical and mental healthy life, their productivity and wellbeing. Reaching their needs from nature life originates in the existing built environment since long history is part of recalling “biologic design”. All people have improved in a natural not artificial or human constructed world. While, our senses, our emotions, and even our intellect developed in close association with nature.

How architecture can get us in touch with nature and environment?

Off course, people in modern life living and sharing each other in constructed building, spending on average 90% of our time. This atmosphere become the built environment where we. Unfortunately, lot of these new buildings and cities also have become places of comprehensive environmental damage and increasing separation if not banishment from nature life.

Biological Biomimicry is the imitation of the models, systems, and elements of nature for the purpose of solving complex human problems; biomimicry Biomorphism, and Biophilia in architecture and manufacturing is the practice of designing buildings and products that simulate or co-opt processes that occur in nature. Countless analogies can be found in the architecture of all ages. The examination and application of nature’s materials, the symbolic or structural transfer of natural form, the interrelation of the edifice with the environment, all these aspects have been considered by builders at all times.

Keywords*: *Bionic Architecture; Biomimicry Architecture, Biomorphism Architecture, Biophilia Architecture, Green Building

1. Introduction:

Steve Jobs, 2011 said: *"I think the biggest innovations of the 21st century will be at the intersection of biology and technology"*[1]. Majority of people recognize the potential for relevant lessons to be learned from nature, at the same time conceding both the limitations of such lessons and our need to be selective.

Humans have always looked to nature for design inspiration and bionic can be a powerful concept and a practical tool in the development of new. And all successful environmentalists are recognizing when lessons from nature are relevant and valuable. of course, they exhibit one or more physical (structural, mechanical, electrical, thermal and magnetic) or chemical (adhesive, reactive, catalytic and non-reactive) properties that are optimized for a particular application.

The main problem for this research is about the relationship between organic architecture way of thinking including all sub definitions belong to the Biological phenomenon and the conceptual approach for sustainable green buildings to reach the characters of highly building efficiency of maximizing comfort way of life to the users in terms of interpreting nature and applying natural principles into the design process.

The research leads us to questions, such as;

1. For how much deep could the nature effect on the conceptual approach of sustainable buildings?
2. Can Architects consider using nature as a source of inspiration? And,
3. How can they follow this approach since their studying time up to their professional life through practical production introduced or shared by them?

Naturalism principals could effect on improving highly performance green building procedures and users behavior.

This research discusses the dialogue between Biological behavior through nature life and Sustainable Architecture conceptual approach.

To gain a new sustainable architecture thinking methodology by mimicking nature from the beginning of a new Architects thought during their academic years, and guiding architects to exhibit the use of Bionic innovation.

This research focuses on the relations between Biological systems and Architecture and to classifying organic Architecture under umbrella of Green Building conceptual approach.

2. Defining the fields

From the earliest life of human being, nature plays a central role relationship with humanities specifically when it comes to imitation and metaphor. Thousand years of nature experiences,

[1] Walter I., **Steve Jobs**. (October 24th 2011) - Simon & Schuster

systems and structures motivating and inspiring architects, engineers and scientists to discover wisdom of innovations and natural technologies.(10) This inspiration of biological systems always assist humans in changing their expectation towards; "nature innovation of ORGANISM, BEHAVIOR and ECOSYSTEM". These three naturalism categories sharing each other with five biomimetic technologies categories such as; *form, material, construction, process* and *function*. Those five categories effect "ORGANISM" to be included by mimicking organisms, "BEHAVIOR" to be referred to imitating organism's behavioral aspect, and "ECOSYSTEM" to be emulated in architectural design.(15)

Fig.01 Prairie dog and its habitate as part of ecosystem with perfect ventilation and sustainable environment

To give a specific example regarding these type of inspirations, and as a successful experiments; USC architect Doris Kim Sung[2] wants to make buildings that automatically respond to changes in the environment. "For a long time, my work has examined why architecture is static and nonresponsive, and why it can't be more flexible like clothing," Sung said. "Why do we have to adapt to architecture rather than architecture responding to us? Why can't buildings be animated?" For this reason, Sung with lot of experiments and huge spending time, she discovered a new characteristic of some type of material that had never before been used in architecture: a metal alloy that responds automatically to changes in air temperature and heat. This material with its behaviour usually used for the coil in a thermostat, "thermo-bimetal" is made of two sheets of metal armoured together. Each metal expands at a different rate when heated, curling as the temperature rises and flattening when cooled. In other hand, the chances for any construction building are widely, especially since thermo-bimetal is not just completely zero-energy but actually reacts to changing environmental conditions.

2.1.Green Building Approach

The highest benefits gained by green buildings are to be integrated as a "whole systems" approached for the design, construction, and operation of buildings. All these systems merge all resource of water and energy efficiency, conservation of materials, and indoor air quality.

[2] https://www.archdaily.com/505016/when-biology-inspires-architecture-an-interview-with-doris-kim-sung

A green building definition focuses on the environmental impact of the building, and does not involve how the building affects, and interacts with, its surroundings and inhabitants. This definition mentioned by Kibert (2008, p.8); “healthy facilities designed and built in a resource-efficient manner, using ecologically based principles”. But this definition does not involve how the building affects, and interacts with, its surroundings and inhabitants.(1)

Fig.02 Samuel Beckett Bridge-Dublin by Santiago Calatrava’s-inspired by traditional Irish harp

Fig.03 Astralia cite de espace Toulouse imitating natural habitat

2.2.Bionic or Organic Architecture

Over the years nature has inspired many designers in the various design fields. simulate nature has been a common subject for long ago in almost every kind of art, social and science fields and now is resorted to in an abundant disciplines including architecture, sculpture, painting, interior architecture and industrial design etc. This concept of thinking is used to find answers to design problems through monitoring, analysis and modeling the characteristic behavior of materials and forms in the nature. In its diversity, nature has provided an opportunity for designers to solve design problems through new approaches. Biomimetic has increasingly been employed in architecture and engineering.(21,28)

Fig.04 Downland Gridshell Building- Sussex,UK - designed by Buro Happold and Edward Cullinan- undulating organic biophilic form

Fig.05 Council House 2-Melbourne, Australia-designed by Mick-Pearce- Biomimcing the ecological tree’s cover

2.3.Learning from NATURE

Humans have developed civilizations, sciences and technologies from trial and error since the dawn of history. As it mentioned before, it's agreed that one of the intelligent inspiration design way of thinking is to study nature, and endeavor to understand the ways in which it has developed to give the main name of environmental challenges. This way of thinking has been became "biomimetic", while the first appeared to this word in the 1950s by Otto Schmitt (Schmitt, 1969). Meanwhile, sustainable development approach is moving to a new level where buildings are making cumulative to nature, increasing supporting nature's work rather than meddlesome with life-sustaining ecosystems. Nature has been offering tremendous ideas and inspirations to designers and all branches for creating a beautiful type of architecture.(22)

2.4.Biomimicry is the future?

"Biomimicry from bios which means life, while mimesis meaning is to imitate", "Biomimicry implies conscious forethought, an active seeking of nature's advice before something is designed". The conclusion of combining between those two meaning gave us a new word with lot of studies about "nature's best ideas". So, the beginning of the story is how to imitate these nature designs? Scientist tried hard to find out through all type of since by preparing a close studies to these nature and made lot of researches in different environments on our earth at day and night through difficult conditions, these processes lead us to solve human massive problems since his born up to the last minute of his/her life. For example; studying a leaf to invent a better solar cell is a unique example which is called "innovation inspired by nature." The main meaning for this sentence is that nature, imaginative by necessity, has already solved many of the problems tussling with. All type of life such as; animals, plants, and microbes are the perfect engineers. Biomimicry is a new way of viewing and valuing nature which has lot of real opportunities to change way of life in near future for all mankind and all generations. It introduces an era based not on what we can extract from the natural world, but what we can learn from it.(9,10)

Fig.06 Energy Park and Energy storage building- Heidelberg, Germany- redesigned by LAVA- inspired by geometries in nature like leaves, spider webs, and reptile skins.

Fig.07 Moscow Circus School- a competition won by Maryam Fazel and Belinda Ercan- Inspired by the forewings of insects—called elytra.

2.5.Sustainability and Biomimicry

Inspiration from wonderful and intriguing systems of nature is nowadays becoming a subject of research and development and technologies driving force in architecture, resulting in majestic works of architecture. Biomimicry or "nature technology" has broad range, biomimicry contributes, both practically and philosophically, to many of the eco-design paradigms devised in the last 30 years, including the Natural Step, Natural Capitalism, Cradle to Cradle, Ecological Design, and Living Building Challenge. It is about solution refined and developed by nature. Biomimicry uses nature's models and then emulates these forms, process, systems, and strategies to solve human problems – sustainably to give solutions more sustainable. Today, the search for biomimietic applications has developed into a scientific discipline, and biomimicry are now the subject of systematic study uses an ecological standard to judge the sustainability of our innovations. For any sustainable building design, need to consider structural efficiency, water efficiency, zero-waste systems, thermal environment, and energy supply. Janine Benyus (Benyus, 1997) founder and president of the Biomimicry Institute and author of the book "Biomimicry: Innovation Inspired by Nature" talks about the experiences which human beings had gained by observing the natural world as a source for ideas. Living organisms showcase flexibility in their form and positions. Living processes are interesting to interpret for they are non-linear phenomena.(5)

Fig.08 Birmingham New Street Station- transport hub UK- designed by AZPML- inspired by geometries of motion and the distortion of perception

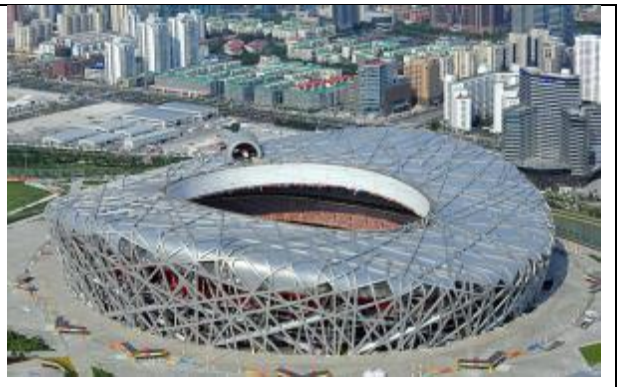

Fig.09 The Olympic stadium- Beijing,China- designed by Herzog and De Meuron, imitating the example the structure of a bird's nest

2.6.Biomimicry in Architecture

Biomimicry promises to be game-changing in fields from materials science to building construction to all branches in all entire life. Majority of architectural process have lot of great difficulties of the 21st century, such as: substantial amelioration in the efficacious use of resources, shifting from a fossil-fuel to a solar industry, and changing from linear to closed-loop systems for managing the flows of energy and materials. Through several bionic examples from life, some of this innovation can be biomimetics in architecture,(28) such as;

2.6.1. The Eastgate development[3], designed by Mick Pearce's vision for the Eastgate centre in Harare, Zimbabwe, lot of scientists concern with one of important issue

[3] http://www.bbc.com/earth/story/20150913-nine-incredible-buildings-inspired-by-nature

for all internal buildings such as; passive-cooling systems which is inspired by termite mounds. This type of unique natural technology has lot of secrets bio-thermal innovation we can learn from and also show us clearly how such biologic thinking can be applied to buildings and settlements.

Fig.10 The Eastgate development Tunnelling- Harare, Zimbabwe - designed by Mick Pearce- inspired by Ant termites are masters at creating air exchange systems to ventilate their mounds

2.6.2. The sea sponge features[4] seems like a lattice-like exoskeleton of hexatinellid and it made up of siliceous spicules that look like tiny six-blade propellers. These pile together to build a strong, cylindrical, lattice-like exoskeleton that, because the spicules are made of silicon, appears glassy, traps natural ambient light, and glows. in 2004 lord Foster completed a fascinating example of biomimetic architecture using the main idea of sea sponge, located in 30 St. Mary Axe in London's financial district, fondly nicknamed The Gherkin and The Swiss Re Tower, with 180 meters tall, holds 40 floors, and its steel exoskeleton dons stripes of navy colored, diamond-shaped pre-fabricated glass panels. They call the exoskeleton an organic scaffold. Flexible Silica (silicon) form on the intersecting points of the lattice to "laminate," or reinforce the overall structure, allowing it to flex under stress, without damaging the core lattice. Two offset lattices allow the outermost structure to flex under stress without compromising structural integrity. The diagonal lattice absorbs bending and torque stress on the exoskeleton. Also, Venus Flower Baskets gather nutrients from water by filtering water through spaces in the lattice. Flagella found on the inside walls of the Venus Flower Basket swirl the water upwards. In other creatures, the tail-like structures of flagella propel animal sperm during mating. The steel exoskeleton of the building allows opening windows to inter natural light and fresh air to penetrate the structure. The building's curves allow wind to easily whip around its shape. (Rectangular buildings deflect wind down, blasting anyone at street level on a windy day.) Also, vents at street level harvest wind by sucking it in and swirling air upwards. Beams radiate from the center of the structure to support each floor. A hole in each floor called an atrium exposes the beams. This cuts the air conditioning bill by 50%.

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[4] http://www.bbc.com/earth/story/20150913-nine-incredible-buildings-inspired-by-nature

Fig.11 The Gherkin and The Swiss Re Tower- London,UK- designed by Norman Foster, inspired by Sea Sponge air ventilation system

2.7.Biomorphic Architecture

Biomorphism is type of thinking understanding the deep meaning, the mechanism and the form of nature. After that, going forward to extract organic forms, the outline shape and structures and combining them in a bionic design concept. Biomorphic is one of the subjects in the architectural approach that has a mean concern for the environment natural issues, in which this approach was born from the idea of the importance of nature and enhancing the environment, including climate. One of the main important regarding how we can mimicking is through the shape, material, structure, location and mechanisms in the universe. All these items can be used as the basic idea formed in the design of architecture through a process of collaboration between humans and nature itself. The history of Biomorphism is started during the Art Nouveau and Surrealism period which suggests that it is not only shape that matters, but also patterns and mechanisms that are derived from biological models that are of interest (Hugh, 2003). Therefore, accurate language becomes an opportunity in shaping understanding and better enables the environment to come forward into experience (Mugerauer, 2000). It was suggested that designers use the word “biomorphic” (Feurstein, 2000) when describing environmental designs that merely mimic the appearance of natural forms. Architecture biomorphic design presenting visual biomorphic shapes, structure, and systems which are not straight, radical and special, but still on the composition, installation and the correspondence of what has been followed from the nature living systems. The main target to minimize the problems of sustainability in architecture global, Biomorphic issue-based ecology and metaphor, which is both have a common approach to the design process forms the basis of analysis of other associated forms and making an architecture to takes into account ecological solutions as well as "green architecture" themed nature. Solving the relationship between the form of organic and sustainable architecture which is exist, but it is not a mutual relationship. On the other hand, both of these tow architectures concept are part of sustainability survival system. For example, designer can raise the benefits of energy efficiency as part of responsible towards the environment by using Architecture biomorphic. This type of high energy quality will benefit the building itself and the environment for the expected future. From this point of view, Biomorphic architecture is not only presented in terms of shape, but also presented the sustainability of such nature.(20)

Fig.12 Curved shell house-designed by Javier Senosiain - inspired by sea shell

Fig.13 Lotus Temple- Delhi, India- designed by Fariborz Sahba - inspired by lotus flower shape

2.7.1. National Taichung Theatre[5] designed by Toyo Ito in collaboration with Cecil Balmond which became a new landmark of Taiwan. The Architects drew inspiration from the formation of rocks, caves and the transience of water. Toyo devised an ideal construction technique taking in account its complexity. And used prefabricated steel cage and was filled with concrete to achieve curved walls. To promote energy efficiency, the building has employed unique air control and heat dispersion technology during daylight hours adjusts its settings as per the number of persons in the theatre. At night, we use a natural ventilation system to maintain the appropriate climate conditions. This aesthetic building promotes a symbiotic relationship between humans and the natural world by using simple horizontal and perpendicular variations to create a changed space. On the building's exterior, you can see many light blue circles. Like air holes allowing the theater to breathe during the day, the rays of light allow natural warmth and light to pour in. At night, yellow light permeates the environment of the theater inside and out. To protect the curved wall surfaces from fire, there is a special water screen system, which can immediately douse flames and smoke, scatter crowds and assist in firefighting measures. All safety precautions have been taken for both the building and the crowds who attend our theatre.

Fig.14 National Taichung Theatre- Taiwan- designed by Toyo- inspired by the formation of rocks, caves and the transience of water.

[5] http://en.npac-ntt.org/

2.7.2. Kunsthaus Graz[6] is an exhibition center for contemporary art, the building exhibits Austrian and international art from 1960 onwards. It becomes an instrument of art communication, and a contemporary piece of Austrian art itself. Also the new Kunsthaus Graz acts as an interface between past and future, creating a productive tension between tradition and avant-garde. Despite it's out of place appearance amongst the surrounding baroque landscape, the building itself was well received and has found its place within the city as being a gift for the future, the Kunsthaus functions as a bridgehead at a point where the past and the future meet. Kunsthaus Graz is shown as the trademark of a city struggled to achieve a productive dialogue between tradition and the avant-garde. The interplay between the new biomorphic structure on the bank of the Mur and the old Clock Tower on the Schlossberg creating a unique purpose to urban planning. While the building's interior is meant to inspire its curators as a black box of hidden tricks, its outer skin is a media façade which can be changed electronically. Its BIX media façade was designed by realities: united and constitutes a unique fusion of architecture and media technology that transforms the plexi-glass building into a large screen in the middle of the city.

Fig.15 Kunsthaus Graz museum- Graz, Austria - designed by Peter Cook and Colin Fournier- The building's innovative complex double-curved geometric façade- an enormous biomorphic shell defined as "friends alien".

2.8.Biophilic Architecture

Environmental damage one of the main issues like waste and pollution, or excessive use of resources like energy and water has lot of concern to be deducted by sustainable design. The massive effective damages is part of reconnecting human being with nature in the modern built environment essential to their needs for health and productivity through life time, no matter the environment site location or climate changes. For this point of view, Architects looking for connecting their way of thinking and natural eco systems by using part of a new concept in architecture called "Architecture biophilic".(26,33) The socio-biologist, Wilson in his book "Biophilia" popularized in 1984 the concept of the biophilic human being by utilizing the term "biophilia" to describe his deep feelings of connection to nature during a period of exploration and immersion in the natural world. Wilson defined biophilia as "the innate tendency to focus on life and lifelike processes". Architecture biophilic is fighting for increasing; human health,

[6] https://www.museum-joanneum.at/en/kunsthaus-graz/architecture

ecology and sustainability precepts, such a integrate part of architectural formation which must be in optimal proportion with other buildings material. However, biophilic architecture must have a regional dimension with regard to environment and culture inspired by designs found in nature. It offers an exciting opportunity to achieve environmental, moral, social and economic benefits. According to this understanding, Biophilic design concept looking for creates a good habitat for human being in the modern built environment which satisfies their ingrained need for advantageous contact with nature.(31) Biophilic design has eccentric answers for providing essential needs humanities, such as;

- Increasing productive and satisfaction when people move to facilities with natural light, restored landscapes, and other biophilic features.
- Contacting with nature increasing the meaning of faster recovering for People from major illnesses and medical problems.
- Even children in their education life to reach higher test scores, being less absent, and showing better attention, the designer should be care with greater natural lighting, access to the outdoors, and fewer artificial materials.

Fig.16pixel façade building- designed by oliver thomas and keyan rahimzadeh- the façade system is based on our instinctive desire for nature

Fig.17 Central park building-Broadway,Sydney- with green walls on the exterior of a high-rise

2.8.1. Parkroyal on Pickering[7] exemplifies Singapore's stated goal of becoming a "City in a Garden"designed by WOHA's design team. They takes architecture and landscape integration to a whole new level of inspiration to create "hotel-as-garden" by incorporating the same greenery within and around the Parkroyal Hotel. WOHA designed a unique integration of the local tropical ecosystem and the city fabric to increase the concept of biophilic approach by elevated area of green space consists of a large platform bridges the towers and provides a private park space, featuring tall palm trees, shrubs, a flowering understory, a waterfall, and hanging vines every four-stories, curvilinear "sky-gardens" wrap the front of the hotel in local tropical plants. This design creates over 49,000 ft2 of green space, doubling the growing potential of the site. The visual connection with nature is reinforced through the

[7] www.terrapinbg.com

extensive use of indoor living plants. Hanging gardens adorn this back facade, providing the public at large with a view to elements of nature, living systems, and natural processes.

Fig.18 Parkroyal on Pickering- Singapore City, Singapore - designed by WOHA- inspired by the landscape of the adjacent Hong Lim Park

2.8.2. BIQ House in Hamburg-Germany[8] the world's first algae zero-carbon apartment complex building built for the International Building Exhibition (IBA) designed by joint venture between Splitterwerk Architects, ARUP, Colt International and Strategic Science Consult. The concept of the design is to create a green facade-cum-algae farm by using a radical new theory on how we will live in the near future. This theory depends on bacteria, microalgae which can produce more biofuel per hectare than alternative crops. By marking the first time algae-reactors have been fully integrated into the fabric of a building. On the south-east and south-west facades, there is a second skin of hollow glass panels containing micro-algae farms. Here, the algae floats around basking in the sunlight which hits the structure, while being fed on a diet of carbon dioxide and nutrients by a network of pipes. Photosynthesizing and growing, the algae-pulp can then be periodically harvested and fermented in an external biogas plant to generate energy. Aside from producing energy and performing the usual job of heat and sound insulation, the facade is characterized by other valuable traits. Heat from excess sunlight, not needed by the algae, is collected and can be stored in brine-filled boreholes, to be used for space and water heating. In addition, the algae provides adaptive shading throughout the year; the more intense the sunlight gets, the more algae grows inside the facade and the more shade is provided.

[8] https://www.iba-hamburg.de/projekte/bauausstellung-in-der-bauausstellung/smart-material-houses/biq/projekt/biq.html

Fig.19BIQ House -Hamburg,Germany- designed by joint venture between Splitterwerk Architects, ARUP, Colt International and Strategic Science Consult -the world's first algae powered building

The Conclusion

Although many scientist consider that Biomimicry is an alternative solution, while all researches directing us to an amazing conclusion that; by Biomimicry humanity will live in harmony with nature and in the future we will be able to decrease disease by increasing the comfort zone for people and step by step it will be some kind of "life style" very soon.

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