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Biomimicry Design Spiral :Nature as A model

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ABSTRACT

Biomimicry is a design approach that takes nature as a source and basis thesis and ideas. It deals with nature according to the principle of learning from its balanced genius and its aesthetics, which are made by God Almighty. Then it imitates or takes inspiration from these designs, systems and configurations in order to solve human problems; the nature of systems, materials, processes and structures, which have long been the best way to inspire solutions to the needs of successive generations. The research problem emerged in "Cognitive deficiency to the importance of Biomimicry as a sustainable design approach based on natural systems and configurations as a model to solve human and design problems". The research thesis 'Biomimicry , models, working mechanism, elements, functions and ecosystems can be simulated in a way that facing challenges of designing with sustainable solutions and treatments as they require less energy and do not produce any contaminated waste'. The aim of the research 'Finding sustainable solutions to design problems by Biomimicry and benefit from its models, systems, solutions and mechanisms adapt them within their environmental context'.
Biomimicry Design Spiral: Nature as A model was addressed within two axes; the conceptual framework addressed the concept of Biomimicry within the level of Biomimicry as a model; As well as the concept of spiral design has been introduced as a practical tool for Biomimicry according to a series of spiral steps. The application framework addressed the mechanism of applying the approach of Biomimicry according to the indirect approach (biology to design) based on finding solutions to design problems through solutions and biological models of organism; As well as, 10 models of architectural projects that mimic nature's different systems and compositions have been selected as a model. The designers examined nature to extract models and simulate designs for nature's compositions to solve human and design problems, then a set of indicators and design terms were abstract to Biomimicry as a model, and then a set of conclusions.
Keywards: Biomimicry, Design Spiral, Biology to Design, Sustainable Design

1. Introduction:

The natural environment has been a fertile source since ancient times where the human and designer sought to emulate it and benefit from its systems and formations that proved its efficiency in various challenges, circumstances and variables and in harmony and integration with its surroundings. Nature is the proof of the meaning of being 'creative', one-idea gives countless solutions and forms, as it is like an art museum open at all times and places. Nature has been and continues to be an example of perfection and a treasure for life and an inexhaustible source of ideas, forms, systems and mechanisms that architects and innovators have always sought to emulate and inspire from and throughout the ages. In order to create a balance and attraction between the natural environment and the built mass, in natural harmony both in the form of the building, its

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structural elements, environmental systems and building materials, There is no doubt that naturalism is rich in what can be an important source of inspiration for the creative architect.

2. The Conceptual Framework (Biomimicry Design Spiral: Nature as A model)

2.1 The Concept of " Biomimicry"

Biomimicry is an emulation of strategies seen in the living world as the basis for human design, including the design of urban environments and materials as well as the design of social and economic systems. It is the tradition of the organism or the behavior of the organism or the entire ecosystem in terms of forms, materials, construction methods, processes or functions. (Helena, 2009) Ecosystems are flexible and sensitive, and current relationships are used to symbiotic benefit. They adapt and evolve, are flexible with changes and transformations as a result of surrounding circumstances, and most importantly, they create conditions that support the continuation of life. (Zari , 2018)

Biomicry is the science and art of simulating the best biological ideas of nature to solve human problems'(Biomimetic Guild, 2007). Ecosystems within a specific location and climate can provide a model or set of design solutions to enhance performance within the same location and climate, Emulations of organisms and ecosystems are often called 'Biomimicry '.

2.2 The concept Biomimicry in design

The focus of such an approach is on seeing the living world, not only as a resource for exploitation, but as a system, that provides models worthy of application to a human context. Investigating Biomimicry may therefore provide a means of contributing to renewable design theory and adding strategies available to designers to respond to climate change and biodiversity degradation. (Zari , 2018). Biomimicry focuses on using nature as an inspirational source of innovative solutions and principles to human problems, as the concept of Biomimicry is different levels in the mechanism of its application at the design level in terms of simulating concept, form, function, processes and systems of nature; Where it moved away from being just an emulation of the forms, patterns and structures that created nature (Aziz & El Sherif, 2016) According to Benyus[1] classification, there are three levels of biomimicry:

- Nature as a model: image or inspiration, Nature can be a model where researchers and designers examine nature to extract models and copy or imitate designs for nature's compositions to solve human and design problems.
- Nature as a measure: Environmental standards, nature can be a measure where researchers and designers use nature to create a sustainable environmental balance to measure the extent to which design achieves environmental efficiency.
- Nature as a mentor: Learning from nature, nature can be a mentor where researchers and designers follow nature's approach for learning. (Benyus ،1997)

2.3 Biomimicry : Nature as model

Is a new science that studies nature’s models and then emulates these forms, process, systems, and strategies to solve human problems – sustainably. The Biomimicry Guild and its collaborators have developed a practical design tool, called the Biomimicry Design Spiral, for using nature as model

[1] (Janine M. Benyus, 1958) is an American natural science writer, innovation consultant, and author who has authored six books on mimicry of nature, including Biomimicry: Innovation Inspired by Nature. In this book, she develop the basic thesis that humans should consciously emulate the genius of nature in their designs.

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2.4 Biomimicry Design Spiral

The Biomimicry Spiral design is a step-by-step process for turning nature strategies into innovative and sustainable design solutions. The Biomimicry Design Spiral was developed in 2005 by Carl Hastrich[2]. Hastrich took a standard spiral design, added the unique steps needed for biomimicry , The spiral forms is used to emulate the design process where nature is used as a model of design and as an evaluation measure, using the following steps to apply the tool effectively and systematically to the creative process, you start with :

- identify the functions that your design needs to perform
- Once you have created a list of functions, you Translate those functions into words or terms that makes sense in the biological world
- Next, you Discover strategies that Nature uses to accomplish these functions. (This is the step most unique to biomimicry), and describe how they work in terms that make sense to your design profession. The Emulate step is where you use your professional skills to create a design solution based on emulating one or more of the strategies that you have discovered and abstracted. Then the Evaluate according to three steps
- One is to evaluate your design solution against your original design brief.
- Then evaluate your design against Nature's Unifying Patterns (or "Life's Principles"), nature's rules for sustainability.
- The third is to reflect on the many ideas and lessons that emerged in the previous steps, and strategize how you want to use the next lap or laps around the spiral.

2.5 The steps of Biomimicry Design Spiral

1. identify one or more functions that your design wants to perform, where the aim is to identify the functions that your design needs to perform
2. Translating those functions into biological terms, analyzing the basic functions and context that the design solution should address and then reformulating them in biological terms.
3. Discover strategies that nature uses to perform those functions, (This is the step most unique to biomimicry).
4. Abstract those strategies back into technical terms.
5. Emulate those strategies in your design solution.
6. Evaluate your design against your design brief and Life's Principles. Figure(1)

[2] Carl Hastrich: Born in Australia and worked as a game designer before realizing the need and desire to develop a design innovation and strategy, he created a tool in 2005 referred to it as Biomimicry Design Spiral that provides a straightforward process to follow in order to produce nature-inspired design. A single spiral lap allows the user to identify the functions that design must perform, help translate functions into biological terms, discover strategies used by nature to perform these functions, create a abstraction of strategies in technical terms, emulate strategies, and finally evaluate design.

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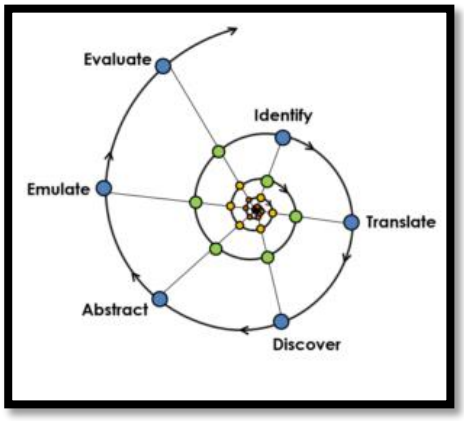

Figure (1) Shows the Biomimicry Institute- Carl Hastrich (2005)

2.6 The power of Biomimicry Design Spiral

One of the most powerful aspects of the biomimicry design spiral is the spiral process itself. You will notice that the biomimicry design spiral drives outward, just as spirals in nature grow outward. When following this spiral process, you start at the center, where each 'lap' around the spiral is small and quick. Taking numerous quick laps at the beginning of a design process allows you to rapidly explore many potential options and opportunities, reveal hidden assumptions, generate and sift through many wildly creative ideas very quickly, and see what begins to emerge before committing to a particular solution pathway. This approach minimizes time needed to achieve radical sustainable innovation.

Due to nature's systems constantly learn, adapt and develop their environments and processes, designers can take advantage of this way of thinking. These designs will enable the development of repeated observation and development steps. Detecting and/or seeing new lessons, constantly applied during design exploration by applying this process it is possible to create buildings and/or products and/or processes that are more sustainable in nature, perform better, use less energy, dispose of or reduce waste, reduce material costs, and open up opportunities to create new products. The sequence of steps in the spiral includes divergent and convergent thinking followed by reflection and redirection. This sequencing, repeated with each lap, allows you to continually drive towards more innovative and effective design outcomes. This process helps creators respond to design challenges by thinking about biological nature, exploring the natural world, and then evaluating the results to make sure that the original design mimesis nature at all levels: form, process, ecosystem.

3 Applied framework of Biomimicry Design Spiral : nature as a model

The applied framework of Biomimicry Design Spiral includes: nature as a model, follow the indirect approach that is called (Biology to Design or Biology Influencing Design) (Biomimicry, 2007). It is a design approach that uses abstract ideas and concepts as principles of that phenomenon in nature, which refers to the biological tradition where a particular composition, behaviour or function is analysed in an organism or ecosystem and translated into a human design context.)Panchuk(2006 ، This approach is based on the solution, searching for solutions to engineering problems inspired by the solutions of natural systems by monitoring nature, which leads to technological design, (Helms, Vattam, & Goel , 2009) Solution -based approach used when the biological principle is the source of design ideas, the design process originally depends on scientific knowledge of biologists and scientists instead of human design problems. The designer identifies a useful feature of nature and then stripped and translated into a technological context before defining the design goal. (Biomimicry, 2007) . The indirect approach is based on the principles of normal system performance, the design uses abstract ideas and concepts as principles of that phenomenon in the natural domain , i.e. from down to up. It takes biological phenomena as a starting point, and identifies the

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principles and then applies the solution that suits human needs by analyzing the characteristics of the natural structures, Then reflect these characteristics on the obstacles that may arise in the future (Faludi, 2005)

3.1 Applied Architectural Projects

Ten architectural projects have been selected that take nature as a model to Biomimicry and take advantage of the formal system of natural beings and their ecosystems and their harmony within their surroundings.

1. Cactus Skyscraper Design Project

Cactus Skyscraper located in Doha, Qatar designed by Aesthetics Architects in Bangkok. The design Idea mimesis nature as a model By emulating the cactus plant's formal system and its outward leaf distribution system to provide shadows for windows in hot weather conditions in Qatar, When the temperature reaches more than 55°C, it opens and closes automatically according to the amount of sunlight simulating the mechanism of pores in the cactus plant .

Figure (2) Shows Cactus Skyscraper Design Project

2. Lotus Temple Project in India

It was designed by the Iranian architect Fariborz in 1986. The design idea mimesis nature as a model by emulating the formal system of the lotus flower and the mechanism of distributing its papers and consistency within its surroundings, as it consists of 27 petals on 9 sides covered by marble and surrounded by Dead pools and green spaces pass through the corridors of movement. .

Figure (3) Shows Lotus Temple Project in India

3. United Nations Memorial Project

It was designed by ACME in South Korea / 2009. The design idea mimesis nature as a model by emulating the hexagonal formal and structural system of the beehive. The project is a memorial design that is the central point in the UN (United Nations) peace park. The structure is comprised of hexagonal shaped cells, sometimes forming a mass and sometimes open spaces between floors and a high roof with a lot of windows and areas which allows natural sunlight to poor through the interior, and this reflects the idea that the United Nations is made up of several countries with different cultures that together create one entity.

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Figure (4) Shows United Nations Memorial Project

4. The Shinkansen train project

The Shinkansen train was designed by Japanese railway engineer "Eiji Nakatsu", which has a speed of more than 300 km/h. The design idea mimesis nature as a model by mimicking the formal system and the mechanism of action of the kingfisher bird, It features a long beak that increases the speed of its swoop on fish inside the water and increases the smoothness of its movement in the air as well as benefiting from the solution of the problem of the high sound of the train inside the tunnels due to air pressure, the shape of the front of the train was designed long similar to the beak, which helped engineers get rid of the sound and also helped to increase the speed of the train by 10% and decreased its energy consumption by 15%.

Figure (5) shows The Shinkansen train

5. Milwaukee Art Museum Project

It designed by Santiago Calatrava: Milwaukee, Wisconsin/2001. The design idea mimesis nature as a model by emulating the structural and formal system of the bird's wings and the movement of the flutter when flying, as well as emulating the formal structures of the fish's fins in some parts of the project, as well as emuating the formal structures of the fish's fins in some parts of the project. It consists of a collection of wings similar to the bird's wings, which numbered (271) that opens and close in a movement similar to the flutter of the bird wing throughout the day to provide shade inside the museum. As well as the structural structure contains 72 fin-like compositions, ranging in length (8-32 meters) and it weighs a whopping 90 tons. It takes three and a half minutes for these censor-clad fins to open or close. It contains sensors that monitor wind speed and direction.

Figure (6) Shows Milwaukee Art Museum Project

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6. Fennell Residence Project

It designed by architect Robert Harvey, Portland, Oregon (2001-2005). The design idea mimesis nature as a model by emulating the shell system inspired by the shape of a snail or a shell, as it is featured by a wooden curved roof similar to the shell surrounding the inner mass , as well as allowing the house to be illuminated with natural lighting. The house is designed to be floating over water.

Figure (7) Shows Fennell Residence Project

7. National Olympic Stadium, Beijing project

It designed by architect Herzog & de Meuron (2003-2008). The design idea mimesis nature as a model by by the structural system inspired by a bird's nest to achieve the principle of containment and force the distribution evenly and in line with the function in terms of streamline shape. The structure was decoration and consisted of giant steel arches assembled in a dynamic way that resembled a bird's nest. The structure looks chaotic while at the same time very strong. It consists of approximately four identical parts and together forms a huge steel ring weighing 27,000 tons of steel.

Figure (8) Shows National Olympic Stadium, Beijing project

8. Esplanade Theatres Project

Esplanade is a building on the shore of Marina Bay in Singapore, which designed by DP Architects and Michael Wilford in 2002. The design idea mimesis nature as a model through the design of an elaborate structure that has influenced the appearance and function of interiors are two glass domes and covered with pointed aluminum pieces through emulating the outer shell of the Dorian fruit covered with pyramidal spikes and multi –layer. The Dorian plant uses its spikes to protect its seeds Just like on the outside of the building, an advanced shading system is adjusted throughout the day to let in sunlight but at the same time protect the interior from overheating.

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Figure (9) Shows Esplanade Theatres

9. Heliotrope house Project

The Heliotrope designed by the architect Rolf Disch located in Germany/2010. The design idea mimesis nature as a model through emulating the formal and movment system of sunflower, its movement and rotation with the sun's movement to take advantage of the natural light as a natural lighting system efficient for home spaces, heating water and achieving energy efficiency.

Figure (10) Shows Heliotrope house Project

10. Eastgate center Project

The Eastgate Centre is a shopping center and office building located in Harare, Zimbabwe, designed by architect Mick Pearce in collaboration with Arup engineers. The design idea mimesis nature as a model through emulating the house of termite by constantly opening and closing a series of heating and cooling vents throughout the mound over the course of the day. With a system of carefully adjusted convection currents, air is sucked in at the lower part of the mound, down into enclosures with muddy walls, and up through a channel to the peak of the termite mound. The industrious termites constantly dig new vents and plug up old ones in order to regulate the temperature. This is reflected in climate treatments in the design by storing heat during the day and disposing of it at night. During the night, large fans draw cool outside air through spaces built between floors and during the day, smaller fans push the outside hot air through the

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same spaces, through 48 round brick funnels to the roof of the building. The complex consists of two buildings separated by an open central court-like courtyard covered by glass and open to air currents. It consists of two large buildings, separated by an open middle space similar to the Court covered by glass and open to air currents.

Figure (11) Shows Eastgate center Project

Table 1 shows steps, indicators and terms of biomimicry design spiral: nature as model

<table>
<tr><td>The steps of biomimicry design spiral</td><td>define</td><td>translate</td><td>discover</td><td>abstract</td><td>emulate</td><td>evaluate</td></tr>
<tr><td>Indicators of biomimicry design spiral</td><td>Emulate formal system</td><td>Emulate structural system</td><td>Emulate shell system</td><td>Emulate work mechanism (processes)</td><td>Emulate ecosystems system</td><td></td></tr>
<tr><td rowspan="4">Terms of biomimicry design spiral : nature as model</td><td colspan="3" rowspan="3">Biomimicry of Forms , Structures, and Ecosystems of Model of Nature</td><td colspan="3">containment and forces distribution</td></tr>
<tr><td colspan="3">streamline shape</td></tr>
<tr><td colspan="3">The mechanism of distributing its elements and structures</td></tr>
<tr><td colspan="3" rowspan="2">Its harmony, adaptation, and work mechanism within the context of its surroundings</td><td colspan="3">Integration and harmony between the built and natural environment</td></tr>
<tr><td colspan="3">benefit of renewable nature energy</td></tr>
</table>

4. Conclusions

1. Biomimicry is the science that studies the models of nature and then imitates or takes inspiration from these designs and operations in order to solve human problems, it is a new way to view and evaluate, nature,it is not based on extracting what we can from the natural world, but on what we can to learn from it.
2. Natural systems: flexible and sensitive, they adapt, evolve and flexible with changes and transformations as a result of surrounding conditions. More importantly, it creates conditions that support the continuation of life.

3. The Biomimicry approach is based on finding solutions to design problems by emulating the natural world, through imitation processes of the forms found in nature, and their functions and ecosystems in a manner challenged of sustainable design.
4. The Biomimicry approach focuses on using nature as an inspiring source for innovative solutions and principles to human problems
5. The Biomimicry approach has different levels in its application mechanism at the design level in terms of simulating the concept, form, function, processes and nature systems
6. The Biomimicry: Nature as a model is a science that study models of nature and then emulates these forms, processes, systems and strategies to solve human problems in a sustainable manner.
7. The Biomimicry approach, nature as a model depends on emulating natural forms, concepts and principles and benefit from the formations in them and using the natural materials , that constitute it and the structural systems in it to reach sustainable solutions and designs.
8. Biomimicry Design Spiral: is a step-by-step process of transforming nature strategies into innovative and sustainable design solutions.
9. The spiral form is used to emulate the design process, where nature is used as a model and a measure of several steps: define, translate, discover, abstract, emulate, evaluate.
10. The power of Biomimicry Design Spiral is create buildings and/or products and/or more sustainable operations in nature, better performance, lower energy use, waste or reduce waste, reduce material costs, and open opportunities to create new products, through frequent steps for monitoring and development.
11. When following this spiral process, you start at the center, where each 'lap' around the spiral is small and quick. These help explore many potential options and opportunities, and reach more innovative and effective design results.
12. The indirect approach called (Biology to Design), a design approach that uses ideas and concepts as principles wherever a specific composition, behavior or function in an object or ecosystem is analyzed and translated in the context of human design.
13. It is an approach based on the solution, searching for solutions to engineering problems inspired from the solutions of nature's systems by observing nature.
14. Living organisms and the surrounding environment are a model that reflects an accurate representation of integration with and interact with the ocean by displaying energy and material flow methods.

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