Biomimicry as an Innovation Behavior in Architecture and Interior Design

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Submit Date:2022-06-30 00:33:35 | Revise Date: 2022-09-28 23:46:53 | Accept Date: 2022-10-05 07:06:14

DOI: 10.21608/jdsaa.2022.148131.1202

KEYWORDS:
Biomimicry, Bio-inspired design, Biomimetic Architecture, Ecological Innovation.

ABSTRACT:
The term "Biomimetic Architecture" encompasses a wide range of concepts. In terms of forms, materials, building methods, processes, or functions, simulated nature inspired by an organism or the behavior of an organism or the entire ecosystem. Although this simulation has no resemblance to the organism or ecosystem that inspired it, Biomimicry fosters architectural ingenuity. It's an ecological innovation, a new way of thinking and acting in terms of the environment. The goal of the research was to see if the Biomimicry approach might be used as a tool and strategy for sustainability while looking at its applications in design and architecture. The study and analysis as one of the new approaches and patterns in the field of architecture is explored, with the goal of imitating nature and using it as a source of inspiration while also delivering novel answers to man's problems. Organic simulation is a multi-level design process that incorporates principles and concepts that are inspired by nature. The goal of this article is to introduce and pique designers' interest in the biomimicry concept, which refers to sustainability through looking to nature for solutions.

1- Introduction

Biomimicry is the imitation of the models, systems, and elements of nature for the purpose of solving complex human problems; biomimicry in architecture and manufacturing is the practice of designing buildings and products that simulate or co-opt processes that occur in nature. The term 'biomimicry' originates from the Greek word's bios, meaning life and mimesis, meaning imitate. It refers to imitating natural strategies (not forms) to devise new sustainable solutions. Although buildings guard us against natural extremes, they have a lot to learn from the natural world. Architecture has long drawn from nature as a source of inspiration. Bio-formation, or the incorporation of existing natural elements as an inspiration into design, originated with the beginning of man-made environments and still exists today. The ancient Greeks and Romans incorporated natural shapes into the design as tree-inspired columns.

The bioimmuration structure goes beyond the use of nature as an inspiration for the aesthetic components of the building, but instead seeks to use nature to solve building work problems. Imitation of nature means the imitation of life and arises from the Greek words Sir (life) and simulation (imitation). The movement is a branch of new science that Janine Pinius knew and popularized in her 1997 book "Vital Radio: Nature-Inspired Innovation" that studies nature and then imitates or draws its designs and processes to solve human problems. Instead of thinking of a building as a living machine, biomimicry requires architects to think of a building as a living thing for a living being.

2- Materials and Methods

The research used the descriptive analytical method. With the aim of studying nature as a model for imitating or inspiring natural designs and processes and applying them to humans. It uses nature as a measure intended to mimic nature and uses an environmental standard to judge the efficiency of human innovations. Nature as a guide means that biomimicry does not attempt to exploit nature by extracting physical goods from it, but the values of nature are something humans can learn from.

3- Statement of the problem

Bio-architecture is an approach like the concept of organic architecture, an approach that studies biological systems and processes in nature and attempts to simulate them in architecture and engineering through bio-design, with the aim of achieving more economical, more efficient, and less environmentally friendly constructions. Many of the ideas, theories, and techniques in this field have also been influenced by biological theories, biocomputational simulations, and biotechnology. The problem of the research becomes clear in identifying how to take advantage of natural functions and simulating them in the design process and integrating technology without compromising nature and integrating this thought into the educational process in universities of fine arts and analyzing the natural functions of living organisms and benefiting from them to enhancing students mind in the design concept and process, and to benefit from biomimicry to know how can nature be used as a constructive feature of sustainable design.

4- Biomimicry overview

Bios means life, and mimesis is to imitate. Coined by an American academic and inventor, Otto Schmitt. Bio mimicry in architecture and design is popularized by the famous biologist Janine M. Benyus.

The term 'Biomimicry' first appeared in scientific literature in 1962, and grew in usage particularly amongst material scientists in 1980s. Some scientists preferred the term 'Biomimetics' or less frequently 'bionics. There has been an enormous surge of interest during the last ten years, brought about to a large extent by individuals like biological-sciences writer Janine Benyus, professor of biology Steven Vogel and professor of Biomimetics Julian Vincent, who have all written extensively in this subject area. Julian Vincent defines it as 'the abstraction of good design from nature', while for Janine Benyus it is 'the conscious emulation of nature's geniuses." There is no difference between 'Biomimicry' and 'Biomimetics', where Biomimicry is used at developing sustainable design solutions and Biomimetics has been applied to the military technology field.

The biomimicry term appeared in 1982 and it was invented and published by the famous scientist Janine Benyus in her most significant 1997 book (Biomimicry Innovation Inspired by Nature). Biomimicry was manifested in her book as "the new science that studies nature's models and imitating these designs to solve human problems". She also claimed looking to nature as a "Model, Measure, and Mentor" and she also suggested that the main aim of biomimicry is sustainability. Biomimicry is the most brilliant and genius way to look for sustainable solutions to human's problem by mimicking and emulating nature in its analogies, phenomenon and patterns. Biomimicry's main aim is making a great design by mimicking the different living organisms which have been evolving through 3.8 billion years[1]. The important distinction to be made between 'biomimicry' and 'bio morphism' is the former uses nature as a source for original/unconventional forms; the latter engages with the way nature functions. (Figure 1).

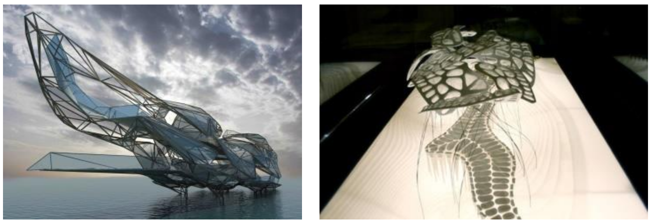

Figure 1: Typical examples of Biomorphic, fluid form with flowing complexity, organic shapes, all beautiful objects in their own right.

Figure 2. Projects that embody the principles of Biomimicry. They use function (systems, structural form, process) to define their state

We should look to nature for inspiration- like a data base of tried and tested ideas. Nature does not have all the answers but it does have some very interesting ones that we could definitely learn from.

"The way biological systems solve problems is pretty different from the way engineered systems solve problems," says Peter Nowakowski, biologist at the University of Akron and its Biomimicry Research and Innovation Center. Human-designed solutions, he says, are crude and additive. They rely on using more materials or energy to accelerate reactions—both costly expenditures. Natural processes rely on unique geometry and material properties. (Figure 2).

The first ever nature inspired functional forms to answer a structural problem can be seen in the Sagrada Familia Church designed in 1882 by Antoni Gaudi. He used columns that modelled the branching canopies of trees to solve statics problems in supporting the vault. Later, organic architecture of the modern era can be said as the advent of biomimicry in architecture, though not literally. Architect Frank Lloyd Wright's buildings like Falling Waters (integrated with nature), Guggenheim Museum (nautilus shell) and Johnson Wax building (supportive lily - pad columns) are the famous prototypes of organic architecture. (Figure 3).

Until the end of 20th century, the idea of organic architecture sought to incorporate architecture into nature in contrast with the concept of biomimetics, that seeks to incorporate nature into architecture. Biomimetics has aged backwards. Born as an ordinary design technology, biomimicry is evolving with introduction of brand-new innovations and an unambiguous necessity of existence of human kind. This is the curious case of biomimicry

Figure 3. Sagrada Familia Church, Barcelona, Spain (left), The Solomon R. Guggenheim Museum, Manhattan, New York City (top). Johnson Wax Headquarters, Racine, Wisconsin (bottom).

4-1 Gaudi a biomimicry pioneer

Antoni Gaudi is one of the most celebrated architects of all time. Gaudi drew inspiration for the design from natural forms. He believed that the best way to honor God was through design derived from nature. In addition to the use of naturalistic aesthetic design, he also delved into biomimetics with structural forms inspired by nature. He analyzed the function of natural forms and applied those elements to his architecture. The Sagrada Familia serves as a precursor to the modern field of biomimetics. For Gaudi, form and function were one in the same. Inspiration from nature helped solve various problems of structural engineering and even helped improve the lighting of the interior. Gaudi was using Biomimicry before others had even coined the term.

Gaudi was the first to use hyperbolic paraboloid vaults in the history of architecture. This design was innovative not only because it was aesthetically pleasing but because it was incredibly strong and enabled Gaudi to eliminate flying buttresses and incorporate unusual design elements into his buildings. Wikipedia describes the Sagrada Familia as a building Gaudi conceived "as if it were the structure of a forest, with a set of tree-like columns divided into various branches to support a structure of intertwined hyperboloid vaults. He inclined the columns so they could better resist the perpendicular pressures on their section. He also gave them a double turn helicoid shape (right turn and left turn), as in the branches and trunks of trees. This created a structure that is now known as fractal."[2] (Figure 4).

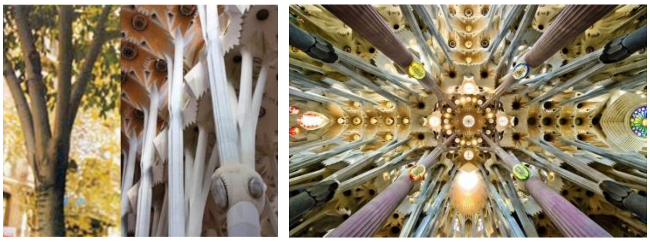

Figure 4. Sagrada Familia Church, Barcelona, Spain: columns that mimic branching canopies, it is a well-known example of using nature's functional forms to answer a structural problem.

4-2 Metabolism Architecture

Metabolism is a movement found in Japan after World War stressed the idea of endless change in the biological world. The metabolism promoted a flexible architecture and dynamic cities that could meet the needs of a changing urban environment. The city resembles a human body where its individual components are created and become old, but the entity as a whole continues to evolve. Like the individual cells of the human body that grows and dies although the human body still lives, the city, too, is in a continuous cycle of growth and change. Metabolists see nature as a metaphor for human beings. The Kisho Kurokawa model Helix City (Figure 5) was modelled after DNA, but uses it as a structural metaphor instead of its basic characteristics for the purpose of its genetic coding.

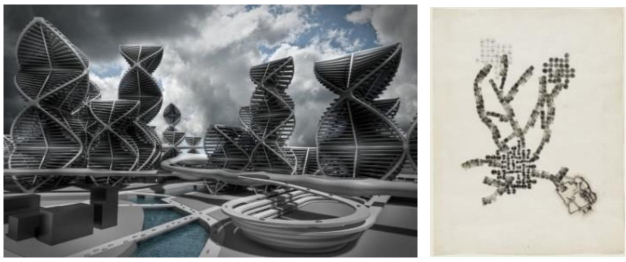

Figure 5. Kisho Kurokawa, Helix City Project, Tokyo, Japan (Plan) 1961, This structure is in the form of a three-dimensional cluster system acts as a space frame for data transmission.

4-3 Approaches to biomimicry

Approaches to biomimicry as a design process typically fall into two categories:

1. Defining a human need or design problem and looking to the ways other organisms or ecosystems solve this, termed

here design looking to biology

2. Identifying a particular characteristic, behavior or function in an organism or ecosystem and translating that into human designs, referred to as biology influencing design .[3]

4-4 Design looking to biology

Nature simulations can work on three levels: the organism, its behaviors, and the ecosystem. Buildings at the level of an organism mimic a specific object. Working at this level alone may not be without simulating the way an object participates in a larger context is insufficient to produce a building that integrates well with its environment because the organism always works and responds to a larger context. On the behavioral level, buildings mimic how an organism behaves or relates to its larger context. At the ecosystem level, the building mimics the natural process and the largest environmental cycle. The principles of ecosystem follow that ecosystem:

(1) depend on contemporary sunlight.
(2) improving the system rather than its components.
(3) are compatible with and dependent on local conditions.
(4) diverse in components, relationships, and information.
(5) creating conditions for sustainable life.

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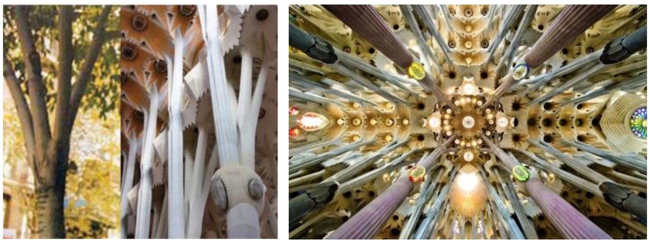

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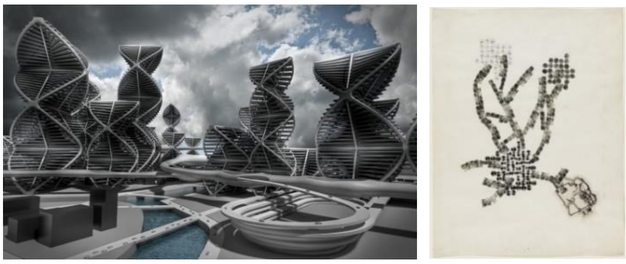

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walls also contain venting flaps to allow hot air to travel up and out of the building.
The design of this tower presents some advantages that make it very effective. Firstly, the building has minimal windblast of pedestrians at street level, due to the cylindrical shape of the tower, which allows wind to pass smoothly around it. Another advantage of the is the efficacious implementation of passive cooling, heating, ventilating and lighting techniques through the use of double skin façade. In addition, the use of rotated floor slabs produces lightwells, which provide each floor with natural day lighting and ventilation.

However, this design does pose some disadvantages and threats. A massive building such as the Gherkin Tower made of glass gives rise to a few problems that presents a danger to its users, as was the case when one of the numerous glass panels fell off in 2005 when a window fell from the 28th floor to the plaza below. Another drawback in the design of glass skyscrapers is the sun glare from the glass. This creates discomfort for the pedestrians and drivers below and can result in accidents as the strong glare may disrupt your vision. Despite this, the gherkin tower does prove more efficient than most buildings its size, credit can be given to the biomimicry design methods used by the designers. [5]

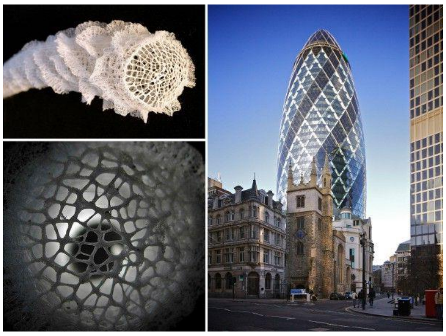

Figure 7. Venus Basket sponge (left) Gherkin tower (right)

4-5-2 Behavior Level.

On a behavioral level, the building simulates how an organism interacts with its environment to build a structure that can also be placed without resistance in the surrounding environment. Behavior level mimicry requires ethical decisions to be made about the suitability of what is being mimicked for the human context. Not all organisms exhibit behaviors that are suitable for humans to mimic. The danger exists that models of consumption or exploitation could be justified on the basis of how another species behaves. For example, mimicking the building behavior (and outcome of that) of termites might be appropriate for the creation of passively regulated thermally comfortable buildings. But, mimicking the social structure of termite colonies would not be suitable however if universal human rights are valued.

Example1; Qatar's giant cactus the designers from Bangkok-based Aesthetics Architects GO Group decided to model the MMAA's new office upon the cactus, taking inspiration from the way these plants deal with the scorching desert climate. The modern office and adjacent botanical dome are going to biomimicry the cacti and the way that they successfully survive in hot, dry environments.
Depending on the intensity of the sun during the day, the sun shades can open or close to keep out the heat when it is too much. This is similar to how a cactus chooses to perform transpiration at night rather during the day in order to retain water. [6](Figure 8)

The functional processes silently at work are inspired by the way cacti sustain themselves in a dry, scorching climate, and management system follows processes that conserve water and has minimum waste outputs.

Figure 8. Qatar's giant cactus the building is covered from its top to its bottom with shades that resemble the spines in the cactus plant.

Example 2: Eastgate Centre Large office and shopping-complex in Harare, Zimbabwe. There is no doubt that termites are among the worst enemies of buildings, but it can be a source of inspiration for rethinking heating, cooling, and air conditioning, and this is what we see in the East Gate Building in Zimbabwe, where architect Michael Pierce has adopted in his design for termite muffles, as the Eastgate building is completely ventilated, cooled, and heated using natural means.
Table 2. Behavior LEVEL

Behavior Level (Mimicry of how an organism behaves or relates to its larger context)	Form	The building looks like it was made by termite.
	Material	The building is made from the Same material that termite builds with, using digested fine soil as the primary material
	Construction	The building is made in the same way as a termite would build in, piling earth in certain places at certain times.
	Process	The building works in the same way as an individual termite mound would by careful orientation, shape, materials selection and natural ventilation
	Function	The building function like the same way internal conditions are regulated to be optimal and thermally stable.

Table 2. Behavior LEVEL

The building consists of four external stone walls and an internal lobby of seven floors. The outside air is drawn into the interior through many ventilation holes, and then it is either cooled or heated through the building's mass according to which is hotter, the building's concrete or the air, and not only that, this system costs one-tenth the costs of the usual air conditioners for the buildings, and it consumes 35% less energy than six traditional buildings. (Figure 9)

The structure, however, does not have to look like a termite mound to function like one and instead aesthetically draws from indigenous Zimbabwean masonry.

After a detailed simulation, the engineering company (Arup engineers) gave Pearce a set of rules to follow in his design:

1. The external walls on the North façade must not have any direct sunlight falling on them.
2. The window to wall ratio are must does not exceed 25%.
3. Windows must be light filter, controlling glare, noise and security.
4. Because of noise pollution and unpredictable wind pressures and temperatures, windows must be sealed with ventilation relying solely on the duct system.[7]

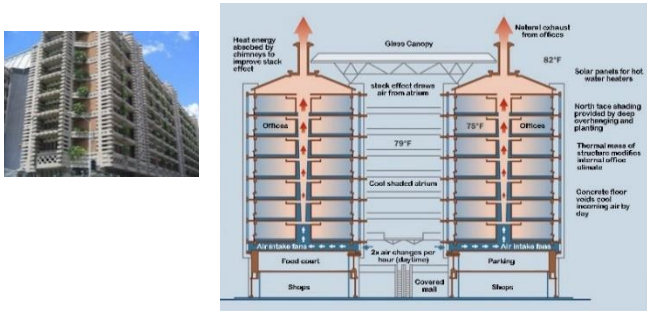

Figure 9. Eastgate Centre As in the termite mounds, the air enters the building into the lower floors and offices before escaping through the chimneys at the top.

4-5-3 Ecosystem Level:

Benyus (1997) and Vincent (2007) describe the mimicking of ecosystems as an integral part of biomimicry. An advantage of mimicking at this level of biomimicry is that it can be used in conjunction with other levels of biomimicry (organism and behavior). The most important advantage of such an approach to biomimetic design however may be the potential positive effects on overall environmental performance.

Ecosystem building involves simulating how many components work together, and tends to be on a urban scale or a larger project that contains multiple components rather than an individual structure.

Example1 The Eden Project (2001) in Cornwall, England.

Grimshaw architects designed this project, it is a series of artificial biomes with domes designed in the style of soap bubbles and pollen. The air-generated hexagonal geodesic bubbles are built with Ethylene Tetrafluoroethylene (ETFE), a light and strong material. And the final superstructure weighs less than the air it contains. The advantage of the geodesic dome shape is that it adapts easily to most ground surfaces. The use of inflated Ethylene Tetrafluoroethylene (ETFE), a material that is both light and strong, (1% of the weight of double glazing) provides other benefits such as a lighter steel frame, letting in more sunlight and adding solar gain also and it costs 1/3 less than the traditional glass solution. [8]

Each of the biomes consists of several geodesic domes joined together. These domes are made of hexagonal pillows, made from three layers of a material called Ethylene Tetrafluoroethylene (ETFE) welded together along the sides and on top of one another. These layers have air pumped into them this increases the level of insulation without affecting the amount of sunlight shining through the material. The amount of air in between the layers is adjustable, during the winter, the pillows are pumped with more air to increase the amount of insulation and they are partially deflated during the summer to allow more cooling in the space. The pillows are built to detach easily from the steel frame, so they can be replaced should a more efficient material come along. One advantage of the geodesic dome shape is that it adapts easily to most ground surfaces.

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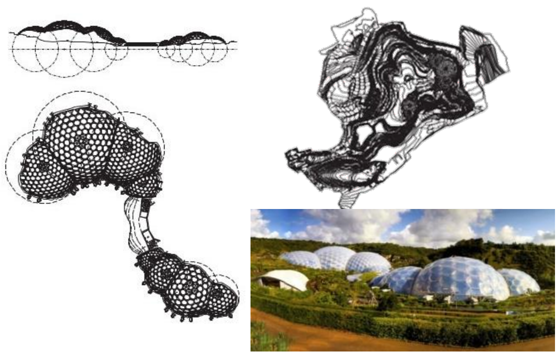

Figure 10. The Eden Project (2001) in Cornwall, England. The two large biomes house close to 3,000 species of plants from all over the world.

Example2: Sahara Forest Project Qatar, Tunisia and Jordan. A greenhouse project that took inspiration from the Namibian fog-basking beetle, which has found its own way to evolve its own fresh water in a desert and to regulate its body temperature by accumulating heat by day and collecting the water droplets formed on its wings by the fog. The greenhouse design emulates this beetle to combat climate change in an arid climate. (Figure 11)

Ecosystem Level (Mimicry of an ecosystem)	Form	The building looks like an ecosystem (a termite would live in) .
	Material	The building is made from the Same kind of materials that (a termite) ecosystem is made of, it uses naturally occurring common compounds, and water as the primary chemical medium).
	Construction	The building is assembled in the same way as (a termite) ecosystem principles of succession and increasing complexity over time are used.
	Process	The building works in the same way as a termite ecosystem it captures and coverts energy from the sun and stores water.
	Function	The building is able to function in the same way that a termite ecosystem would and forms part of a complex system by utilizing the relationships between process, it is able to participate in the hydrological, carbon, nitrogen cycles etc. in a similar way to an ecosystem.

Table 3. Ecosystem LEVEL

The Exploration Architecture design team strived to design an eco-system that was not only sustainable but also regenerative. Three core components drove the design of the greenhouse; the major one being a creating a saltwater cooled greenhouse, concentrated solar power (CSP) and technologies for desert vegetation.

Saltwater cooled greenhouses present suitable conditions for year-round cultivation. To create a saltwater cooled greenhouse Charlie Paton created system to provide evaporative cooling and humidification in the greenhouse structure using saltwater. The evaporated air condenses to fresh water allowing the greenhouse to remain heated at night. This system produces more water than the interior plants need so the excess is spewed out for the surrounding plants to grow.The salt extracted from the evaporation process are crystallized at different stages to extract various elements. The first things to crystallize out the evaporated saltwater is calcium carbonate followed by sodium chlorite; these elements can both be compressed into building blocks. Many

other elements present in seawater are reused in other ways to minimize the waste. Concentrated solar power involves concentrating the heat from the sun with solar tracking mirrors to create steam that drives conventional turbines; this produces zero carbon electricity, which is twice as effective as photovoltaics.
This project offers a solution to restoring forests and creating a solution for vegetation of deserts as a source of food, water and energy in an otherwise resource – constrained area of the world. [10]
"…the Sahara Forest project is a model for how we can create zero carbon food, abundant renewable energy in some of the most water stressed parts of the of the planet as well as reversing desertification in certain areas" [11]

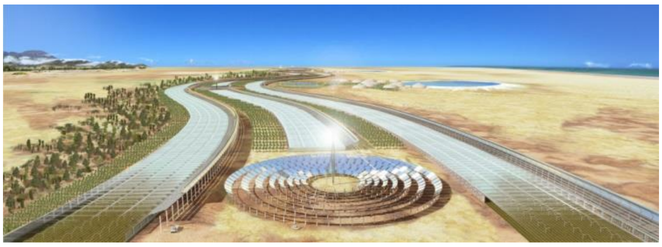

Figure 11. The Sahara Forest Project is a new environmental solution designed to utilize what we have enough of to produce what we need more of, using deserts, saltwater, sunlight and CO2 to produce food, water and clean energy.

5- The concept of simulating nature as a system

Nature is the proof of the meaning of being "creative." One idea gives countless numbers of solutions and shapes, the designer can extract from an idea that is endless designs, and more than one approach has emerged to deal with the forms of nature that differ in form, thought and style as nature She became a source of perfection for inspiring human thought for creativity and simulation. A person is not created in his product, but re-shows what is created in nature in various forms, whether at the level of the apparent form or at the level of the internal system and the mechanism of the work of this system and the adaptation of the shape with the surrounding environment, so the person is in permanent interaction with his surroundings. An inexhaustible version of the ideas, shapes, systems, and mechanisms that architects and innovators always strive to emulate and to draw from them throughout the ages in order to create a balance, attraction, and natural harmony between the natural environment and the mass.

6- Simulating ecological systems in Architecture

It is a process of imitating nature or simulating it, also known as (biomimetic or biologically inspired designs, learning from its balanced genius and aesthetics that are made by the Almighty Creator, the nature of systems, materials, processes and structures that have long been the ideal medium and the book whose ideas are endless to inspire solutions to the needs of successive generations It involves finding solutions to design problems by simulating the natural world. More effectively, it is also a framework for nature's work systems and hence a productive and inspiring tool for restoration.

6-1 Design approaches of Biomimicry:

6-1-1 Direct approach: Problem – based approach
This approach has different naming "Design looking to biology", "Top -Down Approach", "Problem – Driven Biologically Inspired Design". In this approach, designers look to the living world for solutions and are required to identify problems and biologists then need to match these to organisms that have solved similar issues. (Figure 12)

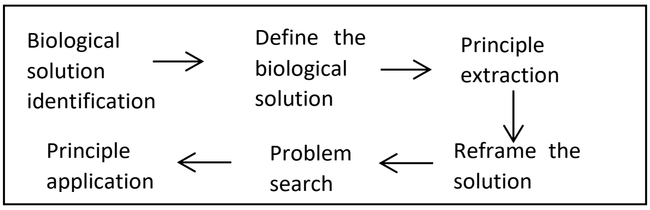

Figure 12. The steps of problem- based approach

6.1.2. Indirect approach: Solution- based approach
Identifying particular characteristics or behaviors in an organism or ecosystem and then translating that into human designs. (Figure 13)

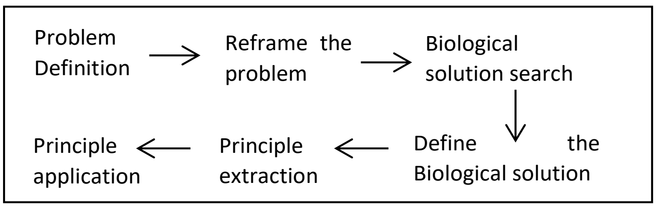

Figure 13. The steps of solution- based approach

7-The future of biomimicry in the interior environment

Now, biomimicry is still in its infancy in the interior environment. It is expected that it will continue to be applied most wildly in architecture and interior environment in the future, particularly as a tool of sustainable design in terms of day lighting, energy consumption and ecological footprint of new facilities. The architectural and interior design profession are cohesive enough to allow innovative approaches and new technologies to spread rapidly particularly when the profit is clear. As an example, the ability to effectively provide daylight into an interior space that has limited access to it reduces the need for artificial lighting. As a result, less heat is generated and less cooling is necessary, which could reduce cooling equipment's size (a capital cost). Overall energy use is reduced (a cost of operation), and the dependence on fossil energy is lessened (an environmental cost). This is in addition to the important aesthetic and human benefits that daylight offers. We can say that using biomimicry as problem solving methodology can help create a new sustainable standard for interior spaces, buildings, communities and cities worldwide. For architects and other design professionals, it opens up a whole new world of innovative ideas for transforming the interior environment, while optimizing human wellbeing. And beyond the projects themselves, the principles of biomimicry will help in providing design smarter, and connect the work with the natural environment. In the future, the interior spaces we live in and the workplace we work in might be designed to function like living organisms, specifically adapted to place and able to provide all of their needs for energy and water from the surrounding nature. The architecture and design will have inspiration, not from the machines of the 21th-century, but from the butterfly that flies in the sky or the flower that exists in the landscape that surrounds them.

8-Biomimicry to increase sustainability

Biomimicry is often described as a tool to increase the sustainability of human designed products, materials and the built environment. It should be noted however that a lot of biomimetic technologies or materials are not inherently more sustainable than conventional equivalents and may not have been initially designed with such goals in mind. As discussed, most examples of biomimicry are organism biomimetic. While biomimicry at the organism level may be inspirational for its potential to produce novel architectural designs, the possibility exists that a building as part of a larger system, that is able to mimic natural processes and can function like an ecosystem in its creation, use and eventual end of life, has the potential to contribute to a built environment that goes beyond sustainability and starts to become regenerative .This does not prevent organism biomimicry at a detail or material level. A building that is exhibiting form biomimicry, which is stylistically or aesthetically based on an organism, but is made and functions in an otherwise conventional way, is unlikely to be more sustainable than a non-biomimetic building. A building that is able to mimic natural processes and can function like an ecosystem in its creation, use and eventual end of life has greater potential to be part of a regenerative built environment. Both buildings could be termed biomimetic, but the potential for increased sustainability would obviously be quite different. It is suggested that if biomimicry is to be conceived as a way to increase sustainability of an architectural project, mimicking of general ecosystem principles should be incorporated into the design at the earliest stage and used as an evaluative tool throughout the design process. [12]

If we can biomimicry at all three levels; organism, behavioral, and ecosystem, the designer begins to do what all well-adapted organisms have learned to do, which is to create conditions conducive to life. Creating conditions conducive to life is not optional; it is a rite of passage for any organism that manages to fit in here over the long haul.

9-CRITICISM

Biological simulations have been criticized for distancing them from humans by defining the terms as separate and distinct from each other. The need to classify a person as a distinction from nature adheres to the traditional definition of nature, namely that those things or systems that arise to exist in isolation from human intent. Jo Kaplinsky further argues that, in basing herself on the design of nature, the risks of biomimicry presuppose the superiority of the solutions that give nature to man. Biomimetic structures cannot preserve the human-made environment and its problems in expressive nature systems and reduce the value of human design. It emphasizes that the development within humanity is based on a cultural basis in technological innovations, not ecological development. However, architects and engineers do not rely strictly on their designs, only parts of them are used as inspiration for architectural solutions. Since the end product is actually a combination of natural design with human innovation, the tradition of nature can actually be read as bringing man and nature in harmony with one another.[13]

Some critics argue that biomimicry is an indefinite and broad way to approach sustainability, stating that, to apply it effectively requires an extensive study with the help of multiple disciplines. While others criticize that the principle of biomimicry separates man from nature without acknowledging his eminent role in the eco system.

The concept of biomimicry is still in the developing phase and is not largely applied as a design method. To execute it successfully at a grand scale requires the co-operation of multiple disciplines such as biologists, ecologists and designers who can establish the relationships between the organism and systems in nature and the needs of humans in order for them to make ethical decisions for a more sustainable built environment.

10-Conclusions

To have a full emulation of nature engages at least need to follow three levels of biomimicry: organism, behavior and ecosystem level. The organism level entails the designer looking at the form of a specific organism analyzing how it functions; the designer can choose to mimic a part or the organism as a whole. The behavior level, involves the imitation of how an organism interacts with its immediate environment in order to build a structure that can fit in without resistance in its surrounding environment. The third level, involves mimicking of how an organism interacts with the environment and how many components work together; this tends to be on the urban scale or a larger project with multiple elements rather than a solitary structure.

Through each level there are five dimension which determine at which extent the mimicry exists. The design is listed as bio- mimicry in the way it looks like (form), what it is made of (material), how it is made (construction), how it works (process) and what its capability (function). These levels are very important and they complete the biomimicry approaches.

The greatest limitation of this study is that although many architects are interested in taking inspiration from nature, a widespread application of biomimicry as a design method remains largely unrealized because of this there are a very small number of existing projects that have truly integrated biomimicry at a grand scale in theory and in practice. This is because biomimicry as a sustainability approach is very much still an emerging discipline in the development phase. Nevertheless, there is an obvious positive attitude towards biomimicry and this shows a potential for the increased integration of this discipline in architectural design.

As there is a growing need for buildings that work with nature to create a regenerative built environment, architects can no longer ignore the relevance of bio-inspired theories and approaches to achieve a more sustainable future. By using the framework in this paper, a clearer distinction is seen between the different levels of biomimicry and that they all present different potentials.

The Conclusions of Research Biomimicry can be used by the architect to be able to incorporate concepts from nature into design rather than simply copying and imitating living things. And the research recommends to develop an educational curriculum in the architectural and design field linking biology and design, to raise awareness of the possibilities of simulating nature and transferring knowledge between designers and biologists. Which could lead to new disciplines for biological science and engineering.

11- Recommendations

1.Enhacing students thinking in faculties of interior design of to take advantage of natural functions and simulating them in the design process and integrating technology without compromising nature.
2. Enhancing students thinking in faculties of interior design of how to simulate biological system in design

concept not only to simulate the concept of the biological, but functional.

3.Studies biological systems and processes in nature and attempts to simulate them in architecture and engineering through bio-design.

4. Finding solutions for sustainability in nature, not by repeating natural forms, but by understanding the rules that govern those forms.

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