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Towards a Bionic Architecture in the Context of Sustainability

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ABSTRACT

Bionics is the complex interdisciplinary field in which biological systems and evolution are applied in solving engineering problems and developing modern technology. Bionic architecture is the organic integration of science, technology, art and nature. Architects everywhere have been trying to break away from traditional methods of designing buildings and now, they have discovered bionic architecture where building designs are inspired by nature.

The principal goal of bionic architecture is to provide the improvement of architectural quality and to deliver new perspectives towards innovation in architecture and design. Bionic architecture looked more alive and vibrant than architecture built based on other disciplines, it creates structures with unique designs in attempts to investigate new approaches to sustainable design that derive from the evolutionary development of living systems, from their material properties or from their adaptive response to changes in the environment.

The main purpose of this work is to outline and present a theoretical framework for understanding and reassessing bionic architecture methods, approaches and levels, in terms of overall sustainability which gives a picture of what the architecture of the future is going to look like.

Keywords: Climatic Bionics; Construction Bionics; Formal Method; Metaphoric Method; Procedural Bionics; Structure Bionics; Sustainability.

1. Introduction

1.1. Overview of Bionics

Bionics which is compound of the two words*:"biology"* and *" technology"* was born. Bionics is the science of studying fundamental doctrines of nature, structural, technical and forming, to be used for solving the problems man faces. According to the short definition of the Colombia Abstract Encyclopedia "Bionics" is the study of living systems with the objective of using their doctrines in engineering [1]. Bionics is an interdisciplinary field on the way to establish itself a science, it is incorporating all areas of biology, medicine, mathematics, physics and chemistry on the one hand and most branches of engineering. Therefore, bionic architecture is the buildings which have been built out the principle of the mentioned bionics science. New challenges need to cope with new environments which will shape the architecture of the 21th century with the help of nature's role models [2, 3].

1.2. Bionic Architecture Past and Nowadays

Nature can teach us about design, where the inspiration for new designs is searched through analyses of biological systems or begin with a fascination of a biological system as the basis of inspiration [4]. After a long evolution and natural selection, the living organisms mostly have a graceful shape, reasonable structure and unique function. It is common that architects, designers and artists take inspiration from nature for the solutions.

The process of evolution on earth during the last approximately 3.8 billion years resulted in a vast variety of living organisms that were able to adapt dynamically to various environmental conditions. The architects have already got inspiration devised a beautiful and practical architecture from these organisms [3, 5]; many movements in the history of architecture have taken their own approaches to nature, and find their assignment by their specific positioning towards nature [6]. Natural forms are not only efficient but they are aesthetically pleasing. The nature shape and its components together with its compatibility with the environment perfect each other reciprocally, and the resulting harmony is one of the most important teachings of nature for designers and engineers alike [3,5].

Look for inspiration in nature is not new to designers or engineers. Egyptian pyramids especially and beside them smaller pyramids are as mountain range that says the king is huge as a mountain for subordinates. Even the Greek temple is believed to be a mimesis of the olive grove [6]. Also, Burunelleschi used the model of an egg to build the dome of The Great Catholic Cathedral in Florence [1], and the works of Leonardo da Vinci [4] are from histories best documented examples in old and middle ages.

The most recent manifestation of bionics has extended the metaphor to include an emphasis on architectural process and technology, in addition to form. Christopher Alexander in his series books of *"The Nature of Order*" redefines architecture of the 21th

century from an entirely new way of thinking about the world; he stated that people used to say that just as the 20th century had been the century of physics, the 21th century would be the century of biology [7]. Moreover, for the past 20 years there has been a renewed interest in lessons that nature can teach the designer [6]. In the followings, a chronological review of bionic architecture and some famous examples of the last two centuries illustrate the diversity of bionic architecture approaches.

- At the turn of the 19th century, the proponents of the futurist movement were convinced of the coming technological development, and designed architecture far away from the formal natural interpretations, which can be found in "*Art-Nouveau"*.
- Half a century later *"Organic Design*", represented by Frank Lloyd Wright's Guggenheim Museum in New York, makes use of natural geometries.
- The examination of *"Natural Constructions"*, which was carried out in Germany by Frei Otto and his group, takes a more technical approach.
- The movement of *"Metabolism*" in architecture became prominent, particularly in Japan: Kisho Kurokawa's Nagakin Capsule Tower in Tokyo. The main principles are the packing and repetition of industrially fabricated units, inspired also by new technologies in the transportation industry and spaceflight.
- Increased technological possibilities lead to a general revival of organic free form without a direct role model from nature, which can be found in the *Ecological Design Movement*.
- Paolo Portoghesi compiled an extensive summary of the transfer of natural form to architecture in "*Nature and Architecture"* which revival of "*Art-Nouveau"*.
- More recent developments in architecture include the movement of deconstructivism by introducing cosmic ordering systems, morphogenetic and evolutionary design principles [8].

The "*Design and Nature"* conferences launched in 2002 served as a forum for a broad approach exploring nature and its significance to design. This approach is embedded within a biological paradigm that offers new insights into higher-level functionality of living organisms, from which design principles are drawn and design methods are developed. The potential of bionic architecture remains to be seen as a cutting-edge aspect of design concentrates on the replication of adaptation and survival mechanisms these organisms [6, 8].

2. Bionic Architecture from Formal to Metaphoric Methods

With the introduction of the bionics, therefore, one is able to observe a major shift in architectural thinking towards nature. Nature is very smart in optimizing the shape and material; comprehensive understanding of how nature handles such tasks is a key issue to many researchers nowadays, as application of natural rules is the best for getting natural inspiration. Here, we bring some bio-inspired methods that are used in architecture: formal method, there is no deep attention to fundamentals of structure and metaphoric method as an abstract form of nature is used for equilibrium and sustainability. Metaphor keeps us from being superficial towards extents as a way towards creativity in architecture [9]. In the following, some examples of the two methods will be presented and shall to illustrate how bionics is implemented.

2.1. Formal Bionic Method

Architects inspired by the varied patterns of nature, and apply these inspirations to architectural design. However, this method depends on the imitation of natural model after some changes and institutional accordance in their structure to match human aims and new functions but still within the surface level. The remarkable architects in this genre including: Antonio Gaudi's Sagrada Familia, inspired by the shape of plants and Frank Gehry's Fish Dance Restaurant in Kobe, Japan; the shape of fish creates a unique phenomenon for the space, and became a landmark in Kobe [10, 11] (Fig. 1).

Fig. 1: Antonio Gaudi's Sagrada Familia (left) [10] and Frank Gehry's Fish Dance Restaurant (right) [11].

There is another formal translation in the case of the Ricola Mulhouse factory by Herzog & de Meuron, the facade panels are printed with a repetitive plant motif derived from a famous photograph which delivering the symbolic information on the functional use of the building. Facades lend themselves for the application fields of 2D as well as 3D elements having aspects of nature as an underlying model [12] (Fig. 2). Finally, the formal bionic method departed from the real meaning of bionics, it's just a mere translation of form as a source for novelty, which misses to allow more comprehensive sustainability strategy.

Fig. 2: The simplest translation of bionics, Ricola Mulhouse factory, Herzog & de Meuron 1993 [12].

2.2. Metaphoric Bionic Method

The challenge of successful bionic architecture is going beyond the mere translation of form with the deepest insight into the all common features connect elements of nature or technology. Analogies serve as a starting point for bionic translation which means similarity, correlation, and equivalence in terms of function or behavior. Similar functions require similar structures, and inspirations by this method can deliver new insights within the deep analogies between the different fields are supposed to bring innovation [13].

To select a natural form in architecture don't make just for beauty or attractiveness of a natural model but forms make on the base of needs, conditions and their cultural limitations. It means that should follow meaning not surface or pattern that has seen. We should recognize principals that cause organism development, living in their environment [14].

One of the first metaphoric methods was carried out by Jean Nouvel in the Institut du Monde Arabe in Paris, using a system of technical apertures to control light conditions inside [13]. The small metal plates automatically control the amount of natural light that streams in, ensuring the maximum beauty of the objects on exhibit while preventing any damage caused by the sunshine [15] (Fig. 3). Finally the mechanical iris system on the building façade doesn't like the original shape of human iris but it simulates the real function to achieve shading and ventilation.

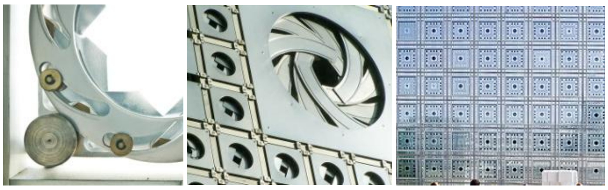

Fig. 3: The mechanical iris system for the adaptive facades, Institut du Monde Arabe, Paris, 1988 [15].

In comparison between the two mentioned methods, it appears that the imitation of nature by formal methods has one way, copying shows things as seen. Instead, metaphor methods have many different ways with different models along with natural development observing which gives the bionic architecture to be better realizing of the world that lives in it.

3. Categorization of Bionic Architecture

Within the context of this paper, a set of relevant architectural bionic approaches is presented and explained since they are important for the understanding and comprehension of the forthcoming theoretical framework. The development of bionic architecture today can be divided into four major approaches: structure, construction, climatic and procedural bionics.

3. 1. Structure Bionics

Structure and construction are commonly used for elements of architectural projects which have to fulfill the tasks of load bearing. Yet, the focuses of structure bionics are biological structural elements, materials, surfaces, packing, folding and patterns. Also, contains many examples belonging to nanotechnology [13].

The idea of looking to nature for inspiration is a notion perhaps most notably associated with the arts, particularly painting and poetry. But nature isn't a muse exclusive to the artist; it can also inspire scientists, engineers and industrialists [16]. An example is the scientific analysis of the lotus flower emerging clean from swampy waters, which led to many design innovations.

The classic example of structure bionics is the *"Lotus Effect"*, which enables buildings to be self cleaning. The surface of plants, especially the outer layer of the surfaces of plant leaves, is covered with fine wax excretions, which make the surface hydrophobic. This fine fractal structure is also responsible for the weak adhesive forces of dirt particles, which can easily be removed with water (Fig. 4). The same effect appears on the surfaces of insect bodies and wings [13, 17].

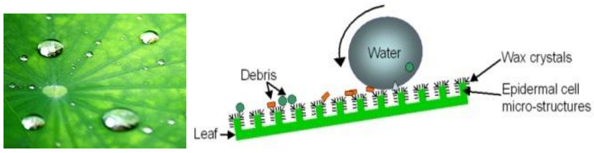

Fig. 4: The Lotus Effect, water forms droplets collect pollutants as it rolls off the leaf [16].

Bionic architecture is mainly dependent on the inspiration from biological materials which found in the universe and studies tries to simulate in artificial forms. Structure bionics could be also called materials bionics which engaged with biological materials. The followings are common characteristics of these materials:

- Biological materials are often highly specialized and build in many layers; materials are often placed in layers, time after one another, and each layer having its own specific structural and functional specification.
- Biological materials are often strictly functional and still structured in a hierarchical order.
- Biological materials are often ultra light construction.
- Many biological materials are self repairing or can be recycled [4].

3.2. Construction Bionics

Construction bionics is the most promising field of bionic architecture especially in the field of light constructions as cable constructions, membranes, shells and transformable constructions [13].

Through the understanding of the organisms' construction and mechanism of the forms, bones and plant stem are among the natural surfaces that serve as potential sources for new construction systems. Borrowed from organisms' forming structure and apply to the similar patterns of architecture, the control of shape and scale of bionic architecture can therefore be possible.

From the pioneering work, The Crystal Palace of Joseph Paxton in 1851, the building imitates the vein tissue of plants, eliminates the region of stress concentration and bears the maximum load by the minimum materials (Fig. 5). The ceiling plan has inspired from water lily to provide the support needed to make a strong and rigid building [14, 18].

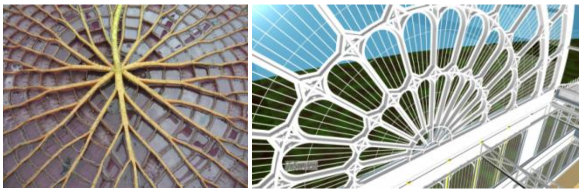

Fig. 5: The Crystal Palace, Joseph Paxton, London, 1851 [19].

In the early 20th century, there are many investigations of d'Arcy Thompson (Fig. 6). He pointed out example after example of correlations between biological forms and mechanical phenomena, through the examination of mollusk shells, crustacean carapace, mammal skulls, skeletons, fish shapes, and the venation of insect wings, the radial patterns of diatoms, and the maximal packing patterns of leaf cells. Perhaps the most famous work of the book’s entitled *"On the Theory of Transformations*", is the final chapter, *"The Comparison of Related Forms,"* where Thompson explored the degree to which differences in the forms of related animals could be described by means of relatively simple mathematical transformations [20, 21]. Nowadays, the modern computational techniques of morphing facilitate his study.

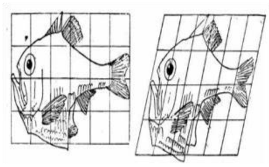

Fig. 6: D'Acy Thompson's laws of morphing [21]

Nervi proposed the lattice grid that mimic from human body’s bone structure. The bone acts as a role model as inspiration for architecture which represents a natural lightweight construction, has dynamic characteristics and a perfect example of a dynamic adaptable structure. The column structure of Roman Gatti factory (Fig. 7) show stiff architecture’s strength in the thinnest tissue system [13, 18].

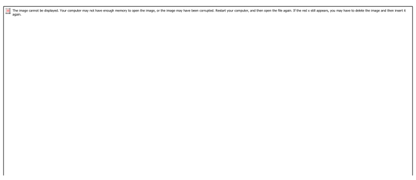

Fig. 7: The column structure of Roman Gatti factory, Luigi Nervi, Roma, 1951. The imitation of human body’s thigh bone [22].

3.2.1. Light construction: Analytic and Synthetic Approaches

The analytic approach evaluates similarities and development processes, the synthetic approach initiates experimental self-organization processes in order to compare the outcome with the role models from nature [13].

The shell is interesting as a role model as inspiration for architecture. The most obvious one is the Sydney Australia Opera House. Complex and able to withstand anything that nature has thus far thrown its way [22], the behavior against the imposed forces and loads is one of the most important reasons of existing structures [9]. Seashells were investigated as three-dimensional structures as a basis for architectural form in many recent researches in architecture and civil engineering (Fig. 8) [20].

Fig. 8: Cut cross-sections of seashells found in nature (left), Scan of seashell (middle) and computer generated shell model (right) [20].

Organisms often reach to the best structural form with the least amount of materials. This principle is most often observed in the works of some Frei Otto [9]. Organisms choose their geometry on the basis of performance and coordination with their other parts as well as to respond the functional, economic and firmness circumstances. For example triangular grids are seen in nature repeatedly that is an organizing pattern. Examples of this architecture can be seen in the Geodesic Dome (Fig. 9). Frei Otto stated that Richard Buckminster Fuller was almost overwhelmed by the new stereoscopic photographs of the shells of diatoms. Fuller patented his geodesic domes in 1954, which are optimal for the relationships between volume and weight, efficient use of material and floor area, time needed for erection [13].

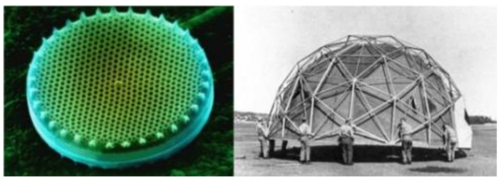

Fig. 9: Diatom, analogous to a Geodesic dome: Diatom skeleton (left) [23] and the installation of a magnesium-framed geodesic dome (right) [24].

The examination of natural constructions which was carried out during the 1960s in Germany by Frei Otto and his group, takes a more technical approach. The famous research work on soap bubbles and minimal surfaces considerably increased knowledge of the characteristics of pneumatic structures in nature and technology development of membrane constructions. Also, Heinz Isler uses the methods of experimental form-finding, refined over decades, with hanging models in various materials to build amazingly ephemeral shell structures. Both Frei Otto and Heinz Isler use analogue models to find the form of a building in relation to the flow of forces (Fig. 10) [20].

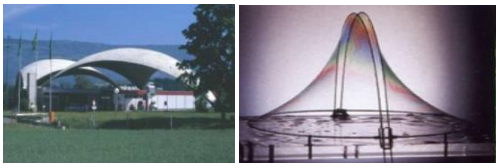

Fig. 10: Concrete shell structure designed by Heinz Isler (left) and soap film experiment producing minimal surface (right) [20].

Whenever we talk about bionics we should simply bear in mind just how amazingly superior a spider's web is to any load-bearing structure man has made [8]. Frei Otto and his group, takes a lighter technical approach in the Munich Olympic stadium, Germany (Fig. 11). Generally, this project initial form could compare with spider web in stability and beauty. This project is an example to use the less material in a wide area [14].

Fig. 11: Munich Olympic stadium, Frie Otto, 1972. The Stadium makes extensive use of tensile roofing construction [25, 26]

.

Finally, Frei Otto distinguishes between analytic and synthetic approaches to analogy research to achieve natural and light constructions. Analogue physical models demonstrate form-generating forces, which depend on material and construction [13]. Moreover, structure and construction bionics in recent decades have made many extraordinary achievements to create a series of brand-new bionic architecture.

3.3. Climatic Bionics

The idea of bionic architecture, in which buildings are not only self-sufficient but eco-friendly as well, is growing nowadays especially with the sustainable concerns. Architects can develop architectural ideas without the punishment of natural selection. Climatic bionics or energy bionics is about energy issues, e.g. ventilation concepts, cooling and heating. The best example is found in termite mounds (Fig. 12).

Long before the building was created, passive cooling was being used by the local termites. The buildings of termites show this impressively. The mound above ground consists of a porous but very hard material, with a system of channels responsible for ventilation. The termite mounds serve as a role model for an effective passive ventilation system for the control of the internal climate. Also, the mound itself is designed to catch the breeze as the wind blows. Cool air is sucked upwards from subterranean channels, cooling the mushroom shaped nest below the mound.

Termite mounds could build green and sophisticated buildings which entirely from natural and biodegradable materials. Its inhabitants live and work in quarters that are air-conditioned and humidity-regulated, without consuming of electricity. Water comes from wells that dip deep into the earth, and food cultivates self-sufficiently in gardens within its walls. This metropolis is not just eco-friendly it is rather beautiful too by its curved walls and graceful arches.

Termites also have to struggle; they chew up wood but cannot actually digest it, so they have carefully tended gardens of fungus, which convert the wood into a form they can digest. The fungi are very particular about temperature and humidity, and the termite tower is designed to keep them comfortable with natural convection and lots of fresh air [14, 27, 28].

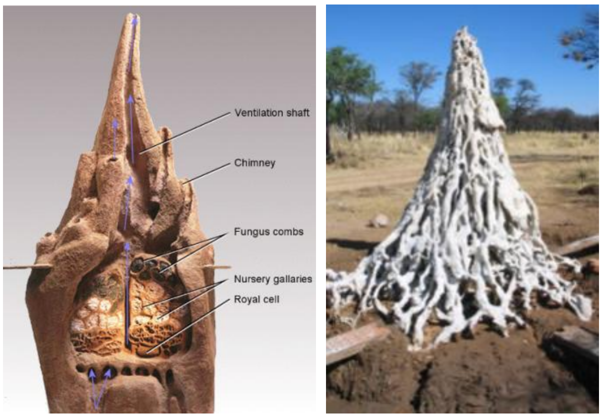

Fig. 12: Termite Mounds: the inner system (left) [27] and a plaster cast of ventilation chambers (right) [29].

Protection from heat is an essential criterion for design in hot climate zones using the form, structure, materials, and flexibility of nature organisms. Efforts have been made to translate termite mound principle in architecture as found in Green Building in Zimbabwe (Fig. 13).

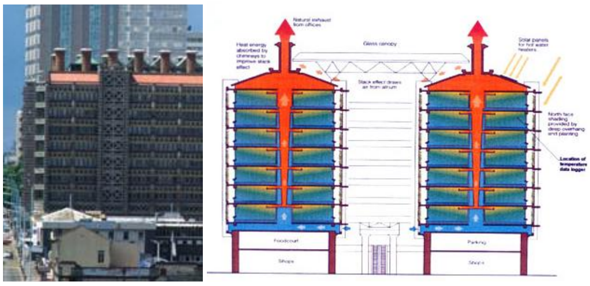

Fig. 13: Green Building in Zimbabwe modeled after termite mounds [28].

Climatic Bionics not only found in insects, but also there are many examples could be found in plants. Architects will get many solutions to solve climatic problems in architecture especially in hot-arid climates by simulating the plant's behaviour. Root moves to depth to obtain water, leaf rotate to absorb less sunlight and leaf convert to spine to make less evaporation. In architecture, by depending on these behaviors, the buildings can use smart facade to change the color in different sunlight intensity and use smart windows to modify the natural ventilation [30]. Most of this climatic bionics will get higher results when integrated and combined with the procedural bionics.

3.4. Procedural Bionics

Procedural bionics depends on the imitation of biological organisms and research on biological system structure, material, function, energy conversion, and applies them to technology system, in order to improve or create new process technology and architecture configuration. All of these procedures belonged to Applied Biology, where biological processes are investigated, imitated or applied in technology. Until recently the methodology of procedural bionics in architecture is only roughly described. Procedural bionics is the most complicated approach which may contain many of other bionics approaches in architecture or other disciplines that could be completing the final image of bionic architecture.

Architectural features are often very complex; life is also provided us with an example of mixed combinations with multi-functional development. Photosynthesis, the development of the artificial leaf, hydrogen technology, recycling processes and desalination are examples which relate to energy and ecological issues and also, related to procedural bionics.

Scientists have long tried to mimic photosynthesis as a way to harness the energy in sunlight and turn it into a usable fuel, just as plants do. There are a few attempts to grasp the process and discern distinct phases and methods especially which bio-Inspired by green leaves. Also, new solar cells were investigated and developed to print thin films of organic solar cells instead silicon solar ones, the new technology can be integrated into all kinds of products as well as architectural elements [13].

3.4.1. Mobile Bionic Solar Power Unit

Recently, photovoltaic panels are not directly mounted onto the roof but with a certain distance to it, so that the air can circulate below to avoid even more heating. Therefore, bionic photovoltaic tree construction is proposed by Zähr et al., in Germany 2010 [31], to carry lightweight flexible and moveable solar panels, with a property to keep cooler than conventional photovoltaic panels or silicon solar panels.

Solar silicon photovoltaic panels lose up to one third of their efficiency for electricity generation. Leaf structures of plants on the other hand, have developed a series of technological adaptations, which allow them to limit their temperature. A suitable model plant was found in the fan palm Licuala ramsayi from northeastern Australia (Fig. 14). Its leaf fan provides a large solar absorber area. However, the leaf is cut into segments, which are tilted in such a way that the air can pass freely through the fan transporting off heat. In addition, during a heavy storm, the fan follows the wind and the segments reorganize to a streamlined pattern from which they recover unharmed.

After analyzing the properties of the biological role model a technical model was designed, the model consists of eight aluminum segments with holes and small thickness that fulfills the task to carry the PV-cells and allow better heat dissipation. In order to finish this bionic photovoltaic tree, thin layer solar cells will have to be redesigned to the shape of the panel segments and correspondingly wired. Efforts were presently made to produce thin flexible solar cells to be better suitable for architecture since the commercially available photovoltaic cells do not fit the optimized bionic structures [31].

Fig. 14: Fan palm tree (up) and the constructed mobile bionic solar power unit with segments moving in the wind as the fan palm original does (down) [31].

4. Bionic Architecture to Increase Sustainability

Thinking within bionics increasingly moves towards more comprehensive approaches within different levels to achieve sustainability especially in climatic and procedural bionics by the applications based on termite mounds and green leaves. There is also, a lot of awful design in nature which every characteristic is optimal as a sign of adoption to the environment [32]. Forms in nature have maximum efficiency and using the least material, architects and engineers also want to do with the less consumption and the most return [14]. The challenges are focused on how to recognize the best analogies between nature and architecture.

Nature possesses the perfect protection system that evolved as high-efficiency and low-energy to favor the organisms in surviving from the evolution. In 1983, the German J. S. Lebedew in his book *"Architecture and Bionic*", indicates that the problems occurred in architectures have already been solved in the nature [32], which has many recognizable patterns of energy relations that can be changed into utilitarian forms and structures in a way that internal forces always searched for the least amount of energy.

Through the examination of nature, it is apparent that our nature system consists of three overlap levels; the organism level, behavior level and ecosystem level, all has many different shapes and scales to reach sustainability. The organism level refers to a specific organism like a plant or animal. The second level refers to translating an aspect of how an organism behaves. The third level is the whole ecosystem characteristics and common principles that allow them to successfully function [17]. Every part within each level of the nature doesn't have just one aim, rather have some secondary aims, in order to help others by taking into account structural, functional, and aesthetic points of view. Also, architects should pay attention to improve their architecture to achieve this characteristic.

At the organism level, every part in animals or plants is provided to being used in another shape after consumption. Nothing disappears in nature nor comes into existence after changing in shape or form. In architecture, use of natural materials along with encourage of recycling emphasizes this point [9]. It's obvious that the most applicable level in bionics is the organism level as engineers, designers and architects often look for this level to inspire and to have many lessons to learn.

Bionics engaged in bio-inspired approaches to help in changing the world and solve the built environment problems. But bio-Inspiration which takes the sole form as the only reference leads to many poor designs. The architects should search for deeper one that involve innovations and move into a more holistic understanding of bionics which could open up future challenges in architecture design.

Bionic architecture in structure and construction approaches are commonly related to each other and the improvement in one approach advanced easily the other in order to react functional, economic and firmness circumstances. Within the statistical look on the inventions during the history; it's obvious that the models inspired from nature have been more economical, and more useful than the models arising from human thoughts. Also climatic bionics will get higher results if integrated with the procedural bionics which will finally improve the sustainable design.

Finally, bionic architecture has a wide range of levels and applications, from the city in general to the single building, from the mega structure to the nanotechnology can be covered. It also gives the people implies that must follow and pay attention to many of nature laws, environmental**,** economical and ecological benefits [9]. For a long time and so far, bionics still be a source of architectural innovation and ensures the environment an important means of sustainability.

5. Conclusion: The Future of Bionic Architecture

The built environment is increasing caused accountable for global environmental and social problems with vast proportions of waste, energy use and greenhouse gas emissions. It is becoming increasingly clear that a shift must be made in how the built environment is created and maintained. On the other hand, nature has devoted its countless gifts and resources kindly to human beings to be a readily available example to learn from [17].

Bionic architecture is increasingly attracting attention and one might says that architecture linked to biology to support any architectural style whatsoever. The idea of a biological connection to architecture has been used in turn by traditional architects, modernists, postmodernists, deconstructivists and the organic form architects. Therefore, we could say that bionic architecture is an old topic, but in the same time, one of the latest research trends [33]. The human development cannot be separated from the study of the nature because a lot of characteristics and visualizes what the things and phenomena provided with. Human, nature and architecture are triangle three points that are not opposite, but combine and complete one another. Using experiences, life sciences and techniques are creating a friendly bridge between human and nature with architecture help could create a trace that has the nature inside it [14]. The introduction of life science terminology in the context of architecture delivers new perspectives towards innovation in architecture and design. Moreover, it is also an important common interest between architecture and nature and it is an effort to use the least energy. The idea of bionic architecture, in which buildings are not only self-sufficient but eco-friendly as well, began to mature nowadays to solve the problems of the built environment [4, 8].

It has become part of the accepted wisdom to say that the 20th century was the century of physics and the 21th century will be the century of biology. Recently, biology has been bigger than physics, as measured by the size of finance, by the size of the workforce, or by the output of major discoveries [34].

There are many precious of study and research of bionics which aiming at innovation in architecture design. All levels in nature are powers balance from the selection of material, proper geometry, and relation among parts to the way to join them together, and the way to arrange in axis, hierarchical order of the system, differentiations in scales and other forming factors. Architecture and its design is the process to choose the parts and reach to a unified generality, which have an essence beyond the nature. In other words, organisms are the outcome of million years of gradual perfection, so inspiration from natural organisms can be useful in achieving a unified and aimed architecture by identifies natural characteristic organism as well as, rules and regulation governing on their material, structure and function [9, 14]. This may be enhanced if bionic approaches are included in the initial design and used as a measure or evaluation criteria throughout the design process which includes bionic architecture approaches.

Bionics stands for a new interdisciplinary area of research that combines biology, technique, architecture and mathematics. The paper presents a theoretical framework that illustrates different methods and approaches to achieve bionic architecture from the sustainable perspective (Fig. 15). The paper re-starts bionics attention because it is still able to achieve a new major shift in architectural thinking towards and changes our perspective of architecture as a nature system and its relation to other technological disciplines. The idea of back to nature and seeks the related biological elements to solve the problems of designing, is not a new one, but it has been only re-evaluated in the wake of interdisciplinary, innovative ideas and environmental consciousness in recent years.

Architects and those scientists interested in architecture should be focused on understanding of the biological roots of architecture than the morphological imitation of nature. Avoid approaches that come in just looking for bio-inspired and walk away with a holistic sense of reconnecting to the natural world as an important value of bionics to consider a broader perspective.

Moreover, bionics is a tool but is not a universal tool for all solving problems, it just an excellent assisting tool for thinking or observation and the best bionics is not a cure and not a copy of nature. It can also be further broadened to represent as more systematic and internalized into the concept of design as the field of bionics is still profound and broad, it realizes the ways of going beyond the bionic principles to attain a sustainable architecture and is worth being further studied and applied in the future.

Finally, bionic architecture is something that opens our eyes and does architecture have not dreamed of for decades or generations. To work with bionics opens a world source of inspiration, enlarge the catalogue of design methods and sharpens the understanding of totalities and relations. It is important to look at nature after all; it has had billions years to come up with ideas, these flawless creatures and variety in biology is only one manifestation of Allah’s unique artistry.

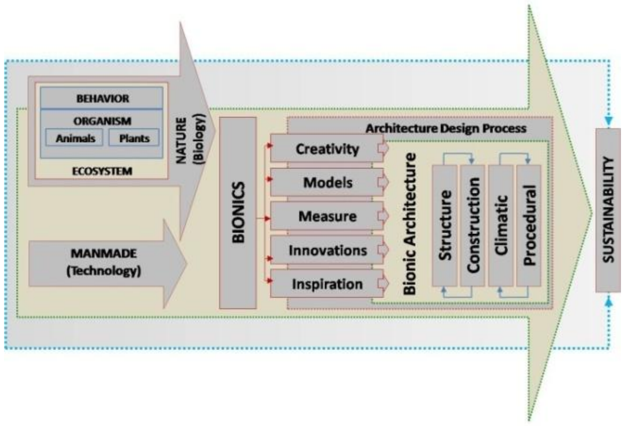

Fig. 15: Theoretical bionic architecture framework.

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ملخص البحث باللغة العربية :

نحو عمارة بيولوجية الكترونية في سياق الاستدامة

تشمل علوم البيولوجية الالكترونية تخصصات متعددة و معقدة تعتمد على تطبيق و محاكاة النظم البيولوجية للطبيعة لحل المشاكل الهندسية و تطوير التكنولوجيا الحديثة بالإضافة لخلق مناخ إبداعي في كثير من الاتجاهات.
يواجه العالم حاليا الكثير من التحديات سواء في نقص الموارد أو مصادر الطاقة بالإضافة للتغيرات المناخية المتغيرة و المستمرة و التي تعلن في كثير منها عن غضب الطبيعة من سوء استخدام الإنسان لمواردها، و يكمن الحل في كثير من الأحوال إلى اللجوء للتعلم من الطبيعة، و لذلك يلجا الباحثون في كل المجالات العلمية إلى محاكاة الأنظمة البيولوجية و قد جاءت أبحاث البيولوجية الالكترونية في مقدمة هذه الاهتمامات على مستوى تخصصات متنوعة و منها الهندسة المعمارية.
الهندسة المعمارية دائما تبحث عن التكامل بين العلوم الفنية و التكنولوجية و الطبيعية للوصول للتصميمات المبتكرة التي تنبع من التطور التدريجي في المنظومات الحية و التي تحاول أن تقلل من مشاكل البيئة المبنية و القادرة على التكيف مع المتغيرات المستمرة، و لذلك يقدم البحث إطار نظري لعرض و تقييم ال مناهج والأساليب المختلفة لعلوم البيولوجية الالكترونية الموجودة داخل عمليات التصميم المعماري، و التي تعتمد على محاكاة الأنظمة البيولوجية للوصول إلى التصميم المناسب، مستعينا بأوجه التشابه الموجودة بين عالم العمارة و عالم الأحياء و الذي نجحت مكوناته و تكيفت مع النظام البيئي الطبيعي منذ ملايين السنين.
و قد مكنت التطورات التكنولوجية الهائلة و بصفة خاصة في السنوات الأخيرة، بالإضافة لبرامج المحاكاة للكائنات الحية و أنظمتها المختلفة، في الوصول بشكل دقيق للخصائص المشتركة في كل من عالم العمارة و الأحياء. و التي بتطبيقها في مجال العمارة سوف تساعد في الوصول لحل جزء من المشاكل البيئية ، و بداية للتصالح بين البيئة المبنية و الطبيعية كجزء من تحقيق الاستدامة البيئية.