Innovative Approaches To Organic Architecture: Nature-Inspired Architectural Design

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Abstract

Nature has been the inspiration of architecture since ancient times. In the design process, these forms are realized as the shaping of humanoid, animal, plant and microscopic organisms in their living environments, the façade, the structure and the transfer of them to the form. Developing natural sciences and computer technologies architects are beginning to see terms such as development, adaptation, mutation, evolution morphogenetics in biology and its sub-branches in architecture as well. ‘Biomimesis’ and 'Biomimicry' are frequently referenced in the recent past, investigating, explaining the workings of nature and adapting them to human use. In the field of architecture, the term biomimicry has only been adopted in recent centuries, often mistakenly perceived as studies limited to mimicry of morphological aspects of the biological world. Biomimicry, introduced to the literature by Benyus, is a branch of science that studies the models, systems, stages, and elements of nature [1]. It aims to solve the problems encountered by taking inspiration or imitating the information it has obtained. The word’ mimicry ' is defined in this branch of science as follows; it is an act of searching, finding, and making visible the found results of the principles that constitute the life knowledge and qualities of a thing. Regulate the environment we live in and a product of human art and architecture, regulate the relations between man and his environment, to control and also is involved in the formation of an environment conducive to human actions. The effects of form on people and life in architecture is an important issue. The façades of the places that make up the city bear great responsibility in this influence with their formal features. Accordingly, the evaluation of the architectural environment in the context of the façade which is an important database for scientific investigations. The façades, which are the appearance of the structure, communicate with the environment through the signs it carries. Therefore, the façade is more than a formal composition but a phenomenon that is understood by the users of the city, and in terms of the meanings it carries, it creates the language of a city and provides impressions about the city. Within the scope of this study, examples

of architectural façades applied and experimentally developed in the field of architecture were examined in the context of the concept of biomimicry. Examples are the interactions of the façades with nature. The contribution of architecture to the design process and the impact it left visually has been studied. The reason for a façade inspired by nature, its purpose, and the emotions it evokes in the user is emphasized. For this purpose, the study investigated what formations can be presented using the knowledge of the biology branch from the design and functional aspects of architecture. The focus of the paper is to make the complex structure of nature more comprehensible by analyzing the architectural environment and to produce answers to the problems encountered. Building façades and prototypes that were applied or developed as ideas were studied based on the interaction of architecture with nature.

Keywords: Organic Architecture, Biomimicry, Nature inspired design, Façade,Sustainability

1. Introduction

From the framework of architectural design, nature has always attracted people and been an inspiration. In the process from ancient times to the present, humanity has explored nature. Nature has a more ancient history than man and art. The dynamic, similar, and following forms of nature have been of interest to humans since early ages. Art, on the other hand, has a duty of remembrance and imitation from those times, and it comes across as a reflection of nature by some forms and means of man. The nature-inspired design aims to solve the problems encountered by taking inspiration or imitating the information it has obtained. The word' mimicry ' is defined in this branch of science as the act of searching, finding, and making visible the found results of the principles that constitute the life knowledge and qualities of a thing.

Architecture, which is a human product and the art branch that regulates the environment in which we live, also regulates and controls the relations between man and his environment and also plays a role in the formation of an environment conducive to human actions. Keleş describes nature as all that is outside of man; for example, Earth, subsoil riches, water, air, plants, and animals constitute nature. Human beings, who are part of nature and one of the living organisms, cannot survive without the support of nature. According to Aristotle, nature is the primary source in all the actions and works of man [2]. By engaging in artificial interventions in natural areas, the act of architecture, which causes the most damage to nature within human actions, is important with its approach to nature. In other words, architecture, by understanding the workings of nature and by shaping architecture by these workings and principles, is the act that has the most responsible for its role in the destruction of nature and its protection. Biology and ecology are the disciplines that can affect design projects in unexpected and interesting ways.

The new keywords, 'Biomimesis,' 'Biomimicry' is a new branch of science that explores the workings of nature, explains, and adapts them to human use. Biomimicry, introduced to the literature by Benyus, is a branch of science that studies the models, systems, stages, and elements of nature. According to Benyus, biomimicry aims to be able to see nature as a model, consultant, and criterion. The word' mimicry ' is defined as follows in this field of science; it is an act of searching, finding, and making visible the found results of the principles that constitute the life knowledge, attributes of a thing.

Nature's functioning cycle and the basic

principles found in this cycle find a place for itself in today's architecture. They are used by today's architects to create a more sustainable and liveable environment. Instead of completely imitating these studies, they begin by exploring the unknowns behind nature's structural changes and transformations. The goal here is to understand what changes or transformations lead to in nature. It is aimed to integrate the comprehended data into the design process. [3] According to Knight, *"The conscious simulation of the genius of life is the survival strategy of the human race and a path to a sustainable future. The fact that the world continues to function like natural life means that life in this world, which does not belong only to mankind, becomes more possible for man"* [4]. Nature lives in an unconscious cycle and in this cycle, the world contains just as nature or the person it needs to emulate. As a result, designers must take inspiration from nature. This is because nature is the best inspiration for sustainable designs. When taking inspiration from nature, a discipline followed by designers and called biomimicry can be used. Biomimicry is the branch of science that transfers analogies and ideas in biology to architecture, technology, and many different disciplines. Although it is known as a new branch of science, it is an old branch of science [5]. In another definition, biomimicry mimics models in nature and helps turn them into the solution needed to address the problems facing humans. Biomimicry uses nature as a scale and also a mentor for learning to learn about what works, what is true, and what is longest-lived [3]. Also, two worlds far apart biomimicry *'nature and technology,' 'biology and innovation,' 'life and design'* can be described as an interdisciplinary approach that combines. The use of biomimicry as a design criterion in architecture plays a major role in increasing the sustainability of the built environment. If designers are to use ideas from nature, they must understand the biological system before it can be used as an inspiration [5]; to make sufficient use of nature's genius, a passage must be created between architecture and biology. Using biomimicry as a form source as well as a design strategy will ensure that more sustainable designs are achieved.

2. Biomimicry and Architecture

Biomimicry is an approach that seeks solutions in nature to problems faced in both architecture and engineering fields. It is defined as learning the way of sustainable solutions from nature while finding solutions to the problem encountered. 20. Century with the impact of the Industrial revolution the buildings in the architecture were designed and implemented by showing similarity with the machine. 20. century as a result of the dominance of the Century Machine Age over nature and the destruction it created, technology has tended to continue its development by adopting the principle of being ecological. Berkebile and McLennan criticize the inability of Western civilization to have a close relationship with nature. To them, the West is a society that follows Bacon's rhetoric that 'science must torture nature to reveal its secrets.' [6] Benyus says against Bacon's approach: *'our first challenge in emulating nature should be to explain nature by its rules'* [1]. The devastation of Western thought created by the industrial revolution can be solved by the approach of learning from nature brought by the Biomimicry revolution. Berkebile explains this change of approach in Einstein's words: *'the great problems we face today cannot be solved by the level of thought that created them.'* [6]

It is getting harder and harder to have the proper living conditions for us to live life

intertwined with nature, where we can be involved in the cycles of nature. However, today, the city is at a breaking level of human relationships with nature, and it can even be called severed. As cities move away from nature, many environmental problems arise. As a result,' uninhabitable cities ' are formed. Adaptation to nature is not just the shape, texture of the land for the structures, the natural and artificial formation in the environment in which it is found, the vegetation around it. The formation of the structure, the use of the elements that make up the structure as part of nature, enables the formation of designs that are compatible with nature. Today, the process of biomimicry can be realized by being inspired by structure, form, or the entire ecosystem. Oral and Karakoç stated that "a micro-scale behaviour affects whole system." The most important result of this new and original perspective, called biomimetic architecture, is the ability to create sustainable designs. [7]

'Processes of function, scale, and formation' differ from the concepts observed in nature from the structures that are human production. Despite these differences, materials, energy conservation, etc. it is used as an inspiration by many architects and engineers with its durability as well as factors. In 20.century, learning or application in specimens observed until the middle of the were often limited to form. Also, it has been used as an inspiration for façade, form and decorative elements within nature-inspired design administrations[8]. Nature-inspired forms are divided into five different groups;

- Vegetative formations,
- Zoomorphic formations,
- Anthropomorphic formations,
- Microscopic formations,
- Forms of living environments of organisms it is classified as.

Vegetative Formations: It has been used since ancient times in decorations. Vegetative motifs are encountered on Colonnades in ancient Greek and Roman architecture, and on façades in the Art Nouveau period, it also appeared on a micro and macro scale. To give an example, it was inspired by the 'Lotus' flower in the Bahá'í Temple in Delhi, which was finished in 1986.

Zoomorphic Formations: it is observed in different areas of history. Architectural designs (buildings, bridges, structures, roofs) inspired by the structure of animals are designed. Animal motifs in the structures made in the Art Nouveau period also appear on decorative columns.

Anthropomorphic Formations: To inanimate objects (cars, buildings, etc.) is the design realized by the application of characteristic features belonging to humans. From the past to the present, it has been observed that the body of men and women is used effectively in the façade, carriage, plan and structure design. An example of this is the' Eye of Wisdom ' Project.

Microscopic Formations: It is defined as making designs inspired by the cells or DNA of microscopic organisms. Forms Of Living Environments Of Organisms; The spider web, which is the living environment of spiders, appears in the structure design. Also, termite towers can be seen as a source of inspiration in multi-story buildings in architecture.

3. Numerical Design Methods Inspired By Nature

Developing natural sciences and computer technologies enable architects to integrate concepts such as evolution, development, adaptation, mutation, genetic code, morphogenetic into architecture. This integration is the result of the collaboration of architects,

biologists and software engineers. Scientific disciplines and fields include mathematics, algorithm knowledge, genetic engineering, cell physiology, artificial intelligence, electronics, robotics, computer-based programming, information technologies, nanotechnology, and biology. Digital design methods inspired by nature, beyond mimicking nature, offer architectural forms that deal with natural growth processes and take their parameters from nature it self. In doing so, we come across as comprehensive and complex architectural designs that can be changed, developed and thought to be implemented in the future with an algorithm determined by the architect taking into consideration the parameters.

Botanical architecture: a numerical design method that is developed under the leadership of Dennis Dollens and is studied to produce new architectural forms with special computer programs taking into account the growth processes of plants in nature. In Dollens ' designs, many plant elements are found, from seed to leaf [9]. In addition to implementing the growth process of the plants, the movement as a response to the stimulus called tropism is suggested as an analogical model for agent-based systems to simulate human behaviour [10].

Evolutionary Architecture: an artificial way of life in which the principles of genetic coding, repetition, selection, and morphogenesis apply. The goal of an evolutionary architecture is to ensure the behavior of symbiosis and metabolic equilibrium in the built environment, as in nature. In evolutionary architecture, there is no exact imitation of nature; the morphogenetic process in nature is taken into account.

Genetic architecture: it is defined as a sequence of morphogenetic values that have established their internal logic, shaped around productive architecture. Another definition can be defined as a knowledge-theoretical approach to research and laboratory work that challenges the principles of genetic formation, embodies scientific knowledge. Research on genetic architecture is divided into two groups. The first is research on the object of architecture, which can create artificial DNA in a digital environment and produce it with modifications made on it. The second is research on organic structures that will be produced by manipulations made on the cipher by interfering with real DNA in the physical environment.

4. Nature-Inspired Façades

Architecture is the branch that is a human product and regulates certain views of the environment in which we live. It also regulates the relations between people and their environment. However, it plays a major role in creating an environment conducive to human actions. Architecture, which is most damaging to nature through the act of construction, is trying to repair the broken relationships between the human and natural environment in today's world. Today, many architects seek answers to the problems experienced in the city in nature. They aim to create more liveable spaces for the community. Architecture, which turns its face to nature, seeks to produce the forms in city like nature. As Çakır stated, producing like nature means understanding the process of formation of form. It is also seen that composition is created in itself by certain repetition, rhythm, color, texture, proportion, balance in nature, and that the formulations in nature are created perfectly. It is thought that the analysis of the forms produced in nature and the understanding of the processes that develop during the process of forming are very important in terms of giving new perspectives to the architects of today and the future in their search for form. [11]

There are various designs inspired by

nature. Work is ongoing for the practical application and expansion of biomimicry as an architectural design strategy. Currently, these works are mainly on building materials. However, studies and applications on the morphological structures and carrier systems of buildings are also carried out. The use of biomimicry as a design strategy in architecture is defined in two categories. The first is the “view to biology”, which is described as defining the human need and going to search for a solution in nature for this need. The second is “biology affecting design”, which is described as developing a new design by searching for function in an organism. Designers who design spaces and buildings need to be inspired by nature not only for innovations in materials and building techniques but also for space design, façade design, and their future environment and sustainable function of buildings.

Biology-facing design: the main approach here is that designers identify problems related to design, collaborate with biologists to find the most suitable organism for defined problems. Biology affecting design: the main approach here is this: the designer and the biologist determine the behavior, functions and other characteristics of an ecosystem and organism, and design for an existing need [12].

Looking at the history of architecture, there are many approaches inspired by the natural world (animals, plants, and the man himself). The use of biological models in architectural form and the use of nature-derived building shells and skeletons in design increases the importance of being inspired by nature in today's architecture. Considering that man-made structures and biological structures are subject to the same environmental conditions, it is important to look for the solution of future building shells and skeletons in biological data. The changing external conditions affect the efficiency of building shells, such as walls, roofs, and windows, as well as building equipment such as heating, ventilation, cooling, and lighting to provide and maintain the user's comfort conditions. To adapt to changing environmental conditions in biological organisms, such as structures, they develop different methods through body covers such as skin, bark, cuticle, membrane. Examples of the biomimetic façade will be examined in this paper. The objectives of the implemented projects and the suggestions developed are examined.

5. Examples Of Biomimetics In Architecture

BIQ-Moss House

Figure 1: The image of the Hamburg Moss House [13]

Live microalgae were used in the construction of the “House of Moss” project in Hamburg, Germany. Also, the seaweed house project is the first biomimetic structure. One side of the structure is designed as microalgae that live and grow in a semi-transparent surface. In this way, the amount of light comes to the building is controlled, and it is intended to be used as desired at any time.

Mosses stop growing when there is no sun. When growth stops, the surface becomes more transparent. This allows more light to enter into the structure.

Figure 2: The image of the Hamburg Moss House [14]

Also, mosses are collected when they reach sufficient size. The collected mosses are used in the production of a type of biogas that meets the energy needs of the structure. When we look at the structure, we see an example that responds to its needs in many ways.

Fukuoka Prefectural International Hall

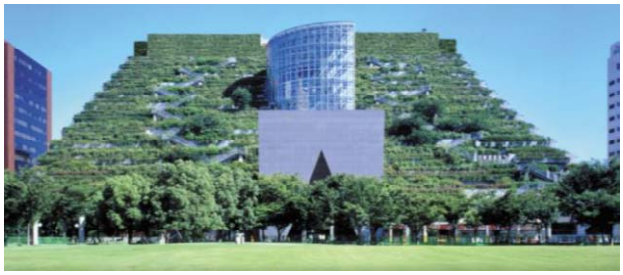

Figure 3: front view of Fukuoka Prefectural Hall [15]

Gaetano Pesce's goal in this design is to solve the urban problem of society. Agricultural space and urban space were considered together in the planning of this design. The Fukuoka-Prefectural International Hall is the strongest synthesis of urban and park forms. The North Face has a proper formal entrance to a building on the prestigious street of Fukuoka's financial district. The South Side of the hall is constructed as terraced gardens, which climb to the full height of the building. In this way, the existing park near the site was expanded and intended to define public space.

Figure 4: exterior view of Fukuoka Prefectural Hall [16]

The aim is not to be a building located in the city, but rather to be a building serving the city. The first look at the structure gives the impression that plants are used in a decorative sense on the exterior. Designed by the Italian architect Gaetano Pesce, it is stated that various plants were grown in plant pots attached to the wall of the façade and that these plants and soil kept the structure cool without the need for a mechanical ventilation system. Thus, the energy used in the structure saves.

Medya-ICT4

Figure 5: Media-Ict4 façade view [17]

The project was conducted in the former industrial area of the city of Barcelona. Today, this region passes as a science

and Technology region. The project is located in this part of the city. In this setting, the media-tic building is called “a kind of House of digital society.” This project is described as a technological showcase serving the purpose of becoming Barcelona's 'Green smart city.'

Figure 6: Media-Ict4 façade view [18]

The building was designed using only CAD/CAM technology. The theme of the media-TIC structure is to identify and demonstrate how architecture creates a new balance with the digital use of energy. This building has a hybrid program and proposes information and Communication Technology Center. The media-TIC building is said to mimic the harmony of nature with its intelligent façades. The most distinctive feature of the structure is its adaptive architectural façade inspired by ‘take a breath’. The ETFE coating surface was inspired by the geometric forms of atoms or elements with concave and convex triangles. The façades are characterized as leather and react to weather conditions.

Manuel Gea Gonzalez Hospital

Figure 7: Hospital Front In Mexico City [19]

Façade design has been implemented for the Manuel Gea Gonzalez hospital building in Mexico City, one of the most polluted Mega-cities in the world. The hospital was built in 1942 and a façade addition was made in 2013. Photocatalytic TiO2 has been known as smoke-eating material in recent years. Along with the technology, air cleaning has also been added to the material.

Figure 8: Façade of the Manuel Gea Gonzalez hospital building [20]

The material captures air pollution when the façade comes into contact with light. Then, it turns the pollution into inert salts. Thus reducing the smoke level in the city. The purpose of the front line is to reduce air pollution in the cityThe architects say the building can counteract the impact of air pollution and offer some cleaner air to the hospital's immediate surroundings. The façade eliminates the impact of 1,000 cars a day, according to developers.

Chameleon: A Mixed-Use Office Structure With A Biomimetic Approach

Figure 9: Mixed-use office structure [21]

The project proposal was developed as a proposal to a mixed-use office structure. It was inspired by Biomimicry after an extensive field analysis. It was inspired by the hexagonal shape cell structures that dominate the façades. The façade also answers other problems. Climate control keeps pace with the city with intelligent frontage units that mechanically adapt to the sun's orbit.

Figure 10: Biomimetic approach Project example [22]

When the weather warms up, the hexagons on the front are closed. Likewise, when the weather is cold or dark, the front wall moves and opens againThe office structure gathers daylight throughout the day. The energy collected is used for the energy to be used within the structure. Energy not used during the day is used at night. It façade thousands of LEDs illuminates. It is referred to as 'Chameleon' by building designers. This is because day and night are very different from each other. The change of the façade is also described as a mirror of the mood.

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Eden Project

Figure 11: Eden Project Image [23]

In this project, the designers take a biomimetic approach. The project aims to achieve sustainable and resource efficiency savings. The design team argues that the built environment is the optimal backdrop for the Biomimicry approach. According to the USGBC, structures account for approximately 39% of CO2 emissions. In the United States, structures consume 70% of their electrical load. Like nature, humans need flexible, zero energy, zero waste regenerative environments


Figure 12: Eden Project roof detail [24]

Purifying, creating habitats, recycling, controlled waste, harvesting how people can put these and similar words into their lives has been discussed. On top of this, it was decided to make a built environment and open it to service by imitating nature. The goal of the project is to educate people about the world they live in. This project was intended to demonstrate how a framework can be provided for the successful integration of biomimicry and sustainability with architectural and engineering projects. The goal is to lead us to build a more sustainable future.

6. Result

Given the relationship between human beings and nature that has been going on from past to present, the fact that nature is the suffers from this relationship causes the problems in our environment to be of great importance. The destruction we are inflicting on nature has left us faced with many problems that are not easy to solve. One of the biggest problems encountered is architecture, which is the act of 'construction.' At the point where humanity, which is an indispensable part of nature, comes today, the answers to the problems will inevitably be sought in nature. Understanding the functioning mechanism of nature, shaping architecture by this functioning and principles, is very important both in terms of giving identity to architecture and in terms of its responsibility for the protection of nature and its resources.

The importance of biomimicry, or in other words, learning from nature, is an effective way to learn and use in every discipline, including architecture. Since the existence of civilization, human beings have sought to acquire ideas and information from nature, especially structurally and stylistically. Today, with the development of technology and the developments with the opportunities of research being easier to do, designers aim to gain deeper knowledge from nature for more effective and sustainable ideas. The definition of human needs should be a starting point for designers; in designers who are turning to biology today, their approach to biomimetics is the basis for architectural design. To create sustainable future structures, spaces, materials, and ultimately the environment, biomimicry is gradually being incorporated into architectural designs for both form and functional ideas today. It is thought that using biomimicry as a design strategy in both architecture and architecture education will lead to more sustainable designs. Architecture has many problems to solve to achieve sustainability; designs and ideas can benefit from solving these problems, all of which are contained in nature. This study aims to examine how the façade, which means the exterior of the building, comes together with the concept of biomimetic. Why are biomimetic façades being built? What advantages does it offer to the user and the designer? It is a preliminary process that has been progressed to find answers to their questions. Examples of biomimetic façades were described in this process. The interaction of the façades described by examples with nature has been studied. Its contribution to the process of architecture and the impact it left in terms of visuals were emphasizing. For this purpose, the study focuses on the visual impact and shaping of the object of architecture, the use of biology knowledge to make the complex structure of nature more comprehensible by analyzing and the solution to the

problems can be produced, and focuses on the investigation of nature as a field of benefit rather than consumption. Another reason for this work is to develop a sustainable frontline proposal that clears the example of the façade, which is intended to be developed, it is aimed to use the building shell as an important building element to ensure the balance between the external and internal environment and to ensure the comfort conditions in the interior. In this way, from the façade scale to the building scale and the urban scale will contribute to sustainability. It is thought that the research carried out could be a reference for the frontline to be developed.

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