

Natural Building - Reflections on Bionic Architectural Design

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ABSTRACT

This paper starts from the etymology of "bionic", re-examines the meaning of bionic in design, takes bionic architectural design as the starting point, and categorizes current bionic architectural design to explore the pulse of thinking about the ride. From the three dimensions of "nature", "body" and "universe", we try to sort out the thinking mode of bionic architecture by taking biology as the way in. At the same time, through the study and discussion of the similarity between the physiological structure of "living creatures" and the spatial structure of buildings, it has certain positive significance for the future bionic design theory and cross-field bionic research, and for the development of architectural bionic work.

Keywords: *bionic, architecture, nature, biology*

1. INTRODUCTION

With the emergence of the ecological crisis and the rise of natural environmentalism, people have turned their attention to the natural world, hoping to create their ideal "artificial nature" or "natural city" through the study of natural ecology and life mechanisms, in order to explore the harmony between man and nature and to protect the ecology of the earth. The aim is to explore the harmonious relationship between humans and nature and to protect the sustainability of the earth's ecological environment. At the same time, the in-depth study of the image structure, physiological function and limb structure of natural organisms not only helps to solve certain problems of human production and life in architecture and urban planning, but is also important for exploring the relationship between artificial buildings and the natural environment. Therefore, bionic architecture has become an important direction for the exploration of the diversified creation of contemporary architecture.

2. ETYMOLOGY OF "BIONIC (BIOMIMICRY)"

The English term "bionic" is not a conventional term with a historical heritage, but a new term created in the twentieth century, more precisely, there are two

different terms that are currently in use, namely, "Bionic" and "Biomimicry".

2.1. Bionic

The term Bionic was first coined and used in the 1960s by Jack E. Steele, an American scholar who convened a symposium on bionic biology in the United States in 1960 with a number of scholars in related fields, and named it "Bionic" in Greek, meaning "the science of studying the function of living systems. The name of the symposium was "Bionic" in Greek, meaning "the science of the function of living systems. The slogan of the symposium was "The living prototype of artificial systems is the key to new technologies", and the formal birth of bionics was announced, and scholars at the symposium even said that this discipline is an imitation of living systems, and in a sense, it is the expression of the characteristics of natural living systems with human-made objects [1]. Systems science, similar to life systems, is a cross-disciplinary and comprehensive discipline that solves engineering problems with the help of life sciences and mathematics. The bionics here is bionics for functional bionics, also known as biomechanics or bioengineering.

2.2. Biomimicry

The use of the term bionism in Chinese is inferred from the available data to have been started by researchers in the field of biology. The earliest known bionic research unit in Chinese speaking countries is the Institute of Biophysics of the Chinese Academy of Sciences, which was established in 1958. However, to understand the Chinese etymology of the word "Fangsheng"(Chinese Bionic), we can refer to Xu Shen's "Shuowen Jiezi" in the Eastern Han Dynasty: "Fang" means a kind of human cooperative activity; "Sheng" means growth; it also refers to the sprouting of grass and trees, and the sprouting of life from the earth.

As we can see above, the word bionic was first advocated and initiated by Western experts in the field of technology to address the human desire to imitate the various abilities of living things, such as the ability to fly, or to have super-sensitive perception. Although the term "bionic" starts from the West, the Eastern traditional philosophy of creation does not directly talk about "bionic", but has similar views, such as the view of nature, the body, and the universe, etc. The East and the West obviously have very different views on bionic.

3. CLASSIFICATION OF BIONIC ARCHITECTURE

Returning to the concept of biomimicry, one wonders whether the thinking and practice of learning from "Fang" or "Sheng"organisms began with the Western technologists in the 1950s, as mentioned above, when one delves into the meaning of the words "imitation" and "living". In fact, the history of artificial building construction that imitates the living forms of natural organisms goes back to the ancient times. For example, the oldest building, the "nesting house", is said to have been built by the ancient sage "Youchaoshi" in imitation of animal nesting [3]. The three pillars of Western ancient Greece, with the analogy of the three gods, are in essence simulations of human forms of different ages and genders. With the birth of bionics in 1950s, German Lebdo wrote a book "Architecture and Bionics" in 1983, which promoted the development of the integration of bionic science and architectural art and laid the theoretical foundation for architectural bionics [4].

The development of bionic architecture can be said to run through the entire history of human civilization. In today's world where cognitive science, digital technology, life science technology and other disciplines intermingle, the scientific study of bionic architecture has come to the forefront of architectural science. In particular, today's world has begun to develop green energy, environmental protection materials and other renewable industries, and the understanding and application of "organic" is gradually gaining popularity,

while virtual simulation, parametric design, digital twin and other new technological means of intervention, so that designers can more accurately according to the "natural" or "biological" or biological "to carry out the digital end of the simulation measurement, so that the program more efficient, optimization is logical. In response to this situation, the author, based on the etymology of "Bio-mimetic", compares typical cases, and summarizes design creations that take "nature" or "biology" as the starting point. We will summarize the types of design creations that start from "nature" or "living creatures".

3.1. Morph-mimicry

Morph-mimicry is a design technique that imitates the morphological characteristics of natural creatures and provides artistic effects from the visual level.

The study of design creation inspired by biomorphism has been frequently seen in recent years in literature and artistic creation. Designs and concepts that are purely biomorphic can be broadly divided into two categories, such as Theo Jansen's "walking kinetic sculptures"(Fig. 1), whose design thinking is primarily art-oriented, and which are often exhibited in art museums. The other type, such as the Spanish architect Gaudí or the American architect Frank Gehry, selects local biomimetic forms or transforms them into architectural elements to give the building a more streamlined, dramatic and lively appearance.



Figure 1 walking kinetic sculptures

3.2. Eco-mimicry

The Eco-mimicry is a kind of design thinking based on the concept of green ecology. It focuses on the study and analysis of the form, organization and function of various materials in nature from the perspective of biology, and obtains inspiration by analyzing the different levels of life forms and survival patterns of different patterns.

The global climate crisis and the contemporary energy shortage problems are constantly appearing, and constantly influencing the architecture towards environmental protection design thinking, so many of

these building types of bionic recently, is pointed to the natural environmental protection design of the building energy saving and environmental protection as the design focus, the period in the human building application of natural environmental protection practices, to effectively use environmental energy, as far as possible to avoid excessive artificial energy consumption. Architects in the creation of architecture should not only follow and respect the laws of natural life, drawing inspiration from nature for environmental awareness innovation, focusing on the organic unity of environmental ecology, economic efficiency and architectural form(Fig. 2).



Figure 2 TAO ZHU YIN YUAN (Taipei)

The above two types of bionic design are compiled from the current bionic design literature and typical design practice cases, and they are also used to lay the foundation for the subsequent consideration of the theoretical architecture of bionic architecture for the actual biological and human buildings under these two design types. However, as the broad definition of biomimicry changes over time, its classification in the design field will not stop at "Morph-mimicry" and "Eco-mimicry".

4. DESIGN THINKING OF BIONIC ARCHITECTURE

When human ancestors lived in the jungle in the past, there is no doubt that the origin of architecture was to escape from the beasts in the jungle, so they sought shelter in stone caves or lived in the canopy of trees, looking for food on the one hand and avoiding the beasts stronger than themselves on the other hand, in order to find a place to live. From the point of view of biological principles, the most basic pattern of life is carried out under such a mode of thinking, which also occurs in the design and construction of living things. The basic concepts of biology and environment and the ethical attitudes that should be developed are understood by looking at the various living materials in nature and their related environments.

Under the correspondence between the cumulative biological concept and architecture, the first architectural concept that should be able to break is that architecture is not understood in the realm of architecture. The concept of bionic architecture is to cross the barriers of field and time, and to enter into the process of biological generation and accumulated wisdom for billions of years, so we should start from understanding life. The five characteristics of life: metabolism, growth, reproduction, inductive, and movement; the two life directions of architecture are, firstly, to exist as a protection for the development of human life characteristics, and secondly, to reflect life characteristics in the concept of architecture, so that architecture also has these two kinds of tangible and intangible life consciousness.

4.1. Nature

Through the observation and study of natural objects, humans imitate and translate their unique and inspiring forms and apply them to architectural design, integrating them with the function, structure and shape of the building, reflecting the process of continuous transcendence and sublimation of imitation. There are countless beautiful forms in nature, and all kinds of inspirations come from the external forms of living creatures and some objective things in nature, and apply these principles to architectural design through artistic techniques. The famous Spanish architect Antonio Gaudi also believes that "nature is the best source of art, nature has the most beautiful forms."

At the same time, every living creature is classified with internal and external ecological circulation needs, so the internal circulation of the living structure must also depend on the normal operation of the external ecological environment, in order to keep the internal and external cohesive circulation functioning. In this chapter, we will first reveal the scope of the biomass from small to large, including individuals of the same species to communities and heterogeneous community societies, and all individuals, communities, and communities should be friendly to the ecological factors of the external environment: climate factors, soil factors, topography factors, biological factors, and human factors. To be able to handle the relationship between these factors and architecture, architects should also be ecological experts or mathematicians, because inappropriate architecture will not be able to achieve a balance of survival in nature.

The designer Mick Pierce studied termite nests in Africa. Termites build their own living environment to suit their needs. Just like the flowing blood of human beings, inside a termite nest, the air flows with the temperature and pressure of the outside world. A termite nest is like a system in the human body that self-regulates in temperature (Fig. 3). CH2's atrium uses a

prefabricated wavy concrete ceiling, which extends as far as possible to absorb the air released by the users of the space below [5]. Not only is the interior structure of CH2 more aesthetically pleasing to humans, but it is also a recreation of the beauty of termite nests in the African grasslands.



Figure 3 CH2 (Melbourne)

4.2. Body

Living organisms are representatives of the perfect combination of image and function, and biological images are often at the service of their own functions. Bio-mimetic design of architectural images is not a simple imitation of biological images; it is a way to explore the possibility of applying them to architecture by studying the deeper reasons for their creation. This deeper reason can be either the constitutive law of the biological image, or the relationship between form and function, form and structure of the organism, etc. Through the study of the deep causes of biological image, the bionic design of architectural image can make the organic combination of building function, structure and shape, so that the building has the perfect organic characteristics like a living organism, but also can make the building have reasonable ecological functions [6].

Along the line of biology, the purpose behind the thinking or behavior of organisms can be deduced from the results of biological architecture, and it will be found that organisms will perform construction behaviors according to their instinctive blueprints, and these behaviors themselves contain both innate instincts or acquired abilities, just like spiders that can weave webs, in addition to the physiological functions of silk-making and spitting apparatus, from spitting silk to forming webs, their perfect spider webs are constructed to help them hunt for food, to reproduction, mating and even settle down to complete their life. Architecture occupies an important moment and weight in the life of a living creature, and cannot be described separately from its way of survival, nor can it be replaced by material exchange as humans do.

Another more primitive biological perspective is that "the organism is the building" or, more directly, "the body is the building". From the point of origin of the

reproductive relationship between mother and offspring, the mother's womb is the first home of the organism, and many organisms must rely on the mother's body for nourishment during the growth of the young. And the mother's body is even the first home of the offspring, typically such as kangaroos. So the body of the creature, from the perspective of life reproduction is undoubtedly a "building body", is the maternal consciousness of the body to protect the behavior, but also the biological instinct to start.

From the metaphysical point of view, if we take plants and animals, microorganisms and human beings themselves as prototypes, we can boldly foresee the development direction of architectural structures by examining the laws of natural selection and optimization; and by extracting the structural system from the prototypes, we can provide the basis for the reasonable shape of new architectural structures [7]. For example, building from eggshells, shells, etc. can see the tension of free parabolic surface and the performance of thin-walled and high strength. Building designers have benefited from this inspiration to create thin-shell structures with different structural shapes, in which internal forces are diffused and distributed along the entire shell surface under the action of external forces.

As also mentioned in the Bible, God created man in His own image. Because the Creator considered this natural form to be the most perfect design. So such an image was copied to create more human forms. The idea behind the "reproduction" of such a statement, between projection and creation, is that the physical form is unmistakable.

4.3. The Universe

Living Among the natural philosophies of East and West, there is a cumulative more relevant discourse on the Eastern view of the body in relation to what architecture says. Lao Tzu, the originator of Taoism, said: "Man follows the laws of earth, earth follows the laws of heaven, heaven follows the laws of Tao, and Tao follows the laws of nature. This means that whether it is the foundation of "man" or the upper level of "Tao", it ultimately points to the same goal of "nature".

Lao Tzu's so-called "Tao" is a thing that is naturally generated in chaos. In Eastern philosophy, it is generally believed that the beginning of all things is the Tao, that is, nature. This is very different from the Western Creator, who is a flesh and form God. At the same time, Lao Tzu's Tao existed long before heaven and earth, was formless, soundless and colorless, unborn, independent and everlasting, not dependent on external objects, absolute and eternal. The Tao is also an endless cycle of perpetual motion, and is the root of all things in heaven and earth. This philosophical thinking that "Tao"

exists in "nature" is very consistent with biology and even the evolution of bionics in the direction of thinking, so it can also be said to be the metaphysical thinking of bionics. In the line of philosophical research on bionic design, it clearly illustrates the constant truth that nature is the beginning of all things and the core of all human knowledge. From this perspective, "bionic" imitates the life characteristics of living creatures, and from a higher viewpoint, it is "the way of nature", that is, the "cosmology" and "body view" of nature. "It is the upper guiding principle of bionics, that is, the "body" in bionic design.

Such a philosophical thinking and principle is not a slogan, but an example to prove it. From the traditional Han Chinese architecture of Sanheyuan, we can see that the architecture is imitating the human body form, and from the animal's architectural forms such as arboreal and cave dwelling in different environments, all coincide with the human architecture. Therefore, bionic is not only imitating the form, but also has a deeper thought, practice, and accumulated knowledge such as biological wisdom and technical experience, which is sufficient for human architecture, that is, bionic architectural design.

5. CONCLUSIONS

In the earth where we live, there are various organisms, which existed before human beings, and evolved through known billions of years into a balanced environment where organisms and matter depend on each other and interact with each other. But back to the architectural space related to human beings, its starting point is also the above-mentioned biological starting point, and architecture is a tool for human beings to maintain the basic state of life in the environment, and different organisms have their cultural genes of architecture, so the accumulated wisdom is also passed on to the human wisdom. Therefore, it can be further seen from the basis of protecting the life of oneself and the offspring. Similarly, the relationship between architecture and nature has been interpreted from the perspective of their own cultures in the philosophical view of the form of the East and the West.

The development of human engineering and technology must eventually reach a high degree of harmony and unity with nature, and it is undoubtedly feasible to achieve this goal by imitating living things. Bionic architecture is a creative method of absorbing the laws of world growth and natural ecology. Bionics, in its continuous development, has provided a new vision for modern architecture and has taken on a stronger life force as a result. During their long development and evolution, living creatures in nature have developed their own unique characteristics and ways of being, which have been used as a basis for better adaptation to the natural environment. The study and discussion of the

similarities in the physiological and spatial structures of these representative organisms is of great significance for the better development of architectural bionics work. It is also one of the feasible paths for architectural technology innovation under the current sociology-economic development.

AUTHORS' CONTRIBUTIONS

Wang contributed the central idea, analysed most of the data, and wrote the initial draft of the paper. Liu contributed to refining the ideas, carrying out additional analyses and finalizing this paper.

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