



## Back to nature with Bionic Architecture

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### Abstract:

Human from the beginning of the creation get inspired from the environment and their around nature and put it on creativity and design. But over time and the improper use of nature and its resources, was faced with many problems. Problems such as air pollution that gripped the major cities of the world and involved serious threats to human life. These problems have prompted people to live in harmony with nature, hence was raised the Bionics science that was in sync with nature and get inspired by it. Due to the energy crisis and natural resources, architects have been working with a new attitude in Bionic architectural and structural solution to get out of this crisis and preserve their energy and food in their future world so that, with the combination between nature and technology a step toward energy self-sufficiency and food in their future world. Familiarize with the history of Bionic science, basic definitions, concepts and principles of science permit a first step to taking advantage of it in a variety of fields including architecture. The aim of this research was recognition of concept of Bionic architectural and determine its place in architecture, in order to achieve a type of architecture that sync with nature with a its application and the principle of minimum energy consumption and green architecture to create an optimal plan and answer to the existing problems in the best possible way. The research methodology was through analysis via the survey the Bionic architecture and for data collection was used the library studies.

**Keywords:** nature, inspired by nature, bionics science, bionic architecture, bionic structure



## **Introduction**

In the process of human interaction with nature throughout history, sometimes the man was subdued by power and domination, and sometimes be tolerant towards it and seek harmony with it and in the time practice to the exploitation of nature. In the present ear, attitude to nature is faced with a fundamental change. Human found that nature is not the only resource to benefit of it, but also is full of the inspirational model for enhancing the quality of his life. Nature is the holder of the secrets that enjoying them, will bring peace. So, needed to achieve a worthy architecture, human being as user and recognition of nature. Thus, nature and architecture will be two concepts that are inseparable from each other. Bionic architecture in an attempt to enliven the building. It is obvious that mimic nature has many advantages. It could be assumed that the present animal is the product of several million years of evolution. In the meantime, nature is destroyed everything that is incompatible with its aims and created hopes that humans by studying the evolutionary process could transcription new mechanisms of living organisms transcription of the new mechanisms of a technology of the living creatures. In the field of architecture as well as other areas it has been achieved to some extent. The Man has tried to get inspired from their around nature for designing their place and equipment.



## **Bionic**

Bionic in the sense of ecological knowledge or the use of artificial limbs nature for the first time were used by American scientists Jak.Iy.estil 1959. He knows the bionic science of systems that are the basis and foundation of all living systems. The word "bionic" is the combination of two words of "biology" and "techniques" means the ecological nature of cognitive or use of nature artificial organs and in Persian means that "Biological Engineering" are resolved a way of life that technical issues. (Ahmadi 2009). Different definitions were conducted from different persons in relation to the bionic that all trying to tell the same concept with different words. Definitions such as: Bionic means the abstraction of an appropriate plan of nature or the Bionic as activities to obtain information from the field of biology (general nature) to technology, they are trying to convey one concept. Bionic generally refers to the method that deals to study natures of best ideas and then use it in everyday life by using a tool that called technology. (Golabchi and Khorsand 2013)

Today, whenever we speak of technology the image of the great achievements of technology comes to mind but if we look at the technology or construction of industrial phenomenon, the living model is inspired by nature. Now Bionic from every direction, the art of living systems to apply knowledge in solving technical issues. For years, researchers seeking to establish causality and the existence of this relationship through the quality of formation of different systems to review and justify their life. (Ali Abadi, 4939 Design Magazine) Although the Bionic is still a young science, but the activity of bionic researcher are always in searching of a living model to explain the phenomenon that can be proposed in the field of applied sciences. Charlie Luxton is the pioneer in the field of architecture Bionic that knows focus point bionic architects is an appropriate use of items in nature that strengthens the building and create diversity and peace in space (Ahmadi 2009).

Enliven the building is one of the tendencies of Bionic architecture that designers of this field due to structural strength to breathe (live view) by using straight or curved lines and slow induction to achieve the pure and structural integrity and the most important thing for bionic architecture that buildings can induce it's being alive(Ahmadi2009). This science does not seek to copying or imitation of nature but to the correct modeling of knowledge derived from nature. (Golabchi and Khorsand2013). One of the best-known designs of bionic science is Leonardo da Vinci, the famous painter who designed the flying machine based on the anatomy of a bat. His argument was bat wings are completely covered and does not pass the air through its wings and have skin like membrane that it will strengthen its wings. (Moghtaderi, 2012)



Bionic actually consists of three parts:

Science of system that they have been taken their function through living systems (In the main structure or system)

- Science systems that have similar characteristics to the properties of living systems (Mechanisms and functional elements)
- Science systems that it looks to living systems (get a sense from the standpoint of the form (Moghtaderi 2012).

### **Bionic science subset**

Bionic is a very young field of science than that which has wide subsets. However, it can be divided into the following two examples, one by "Nachigal" German scholar and another presented by two researchers in Taiwan. Although this division can be divided into smaller subsets. "Werner Nachigal" offers the following three sub-categories for Bionic Science:

- Structural Bionic: the inspiration of structures, structures and materials in nature such as cable-style structure, Membrane Structure style and shell style structure.
- Bionic process: The use of existing processes in nature, such as how recycled materials by natural structure or photosynthesis process in plants.
- Information Bionic: processing and data transfer from nature to science.

In a division by two other researchers that was conducted in Taiwan in the name of "Shan Wang" and "Jian Ming Yi". The Bionic simulation methods have been divided into four sub-categories:

- Control Bionic: by simulation functions such as orientation, navigation and control organisms, we can create a new control system.
- Mechanical Bionic: by simulation mechanical principles and structure of organisms can create a new structural and mechanical systems.
- Information Bionic: by simulation system of organisms, such as how reinvented itself, how they feel or how they transmitted information can create a new information system.
- Chemical bionic: by simulation of catalytic performance, chemicals and chemical products, such as energy transfer by organisms can produce crystals with high efficiency and develop new energy and chemicals technologies.

We realize from above classification that that bionic design methodology is based on characteristics of the organism. During the process of thinking on these characteristics can be used to decipher the



principles behind them and applied as a basis for man-made technological matters (Golabchi and Khorsand 2013).

### **Advantages of inspired by nature**

Over the billions of years have passed from the emergence of nature and solved the problems that we are facing today. Animals, plants and unicellular organisms are engineers that are well adapted to their environment and show us how to interact with nature. In 8.3 billion years, what remains for us is a lesson that learns from it reduce a lot of material costs and avoid waste of resources and time.

Whatever our performance is similar to nature provide more guarantees for our longer survival. The process of creating natural forms, long change process have over millions of years. Natural forms over the centuries, to achieve acceptable solutions to the external factors have been developed. During this process, only the most efficient, most powerful and most flexible natural forms have survived for millions of years. With a deep understanding of nature and the idea of trying to recreate models to simulate it, in reaction achieved to results such great force that can mobilize dream. The architecture is a combination of art, science and technology are also not exempt from this rule due to its inherent strength, will benefit from nature. (Golabchi and Khorsand 2013) Approximately inspiration from nature can be divided into three levels:

- Duplication of natural methods in production
- Duplication of mechanisms in nature
- Research the basic structures of social behavior of organisms (Moghtaderi 2012)

### **Bionic architecture**

Since the creation of the earth, nature, has become the designer and during this period, plants and animals with proper design can overcoming to environmental problems and Man throughout his life, always trying to build and design their locations and equipment needed to take inspiration from nature and the environment around them(Ahmadi2009). For centuries, humans lived in close relationship with nature and to meet their basic needs inspired from it. Bionic architecture at the beginning and in the history of pharaonic civilization in Egypt, the Shah of Iran, King of Greece and the Roman Empire and Byzantium therefore is traceable.

The architect that has been finalized during this period, flora and fauna have been able to design the necessary overcoming the problems of the environment and humans during its life, always trying to build and design facilities and equipment needed to take inspiration from nature and the environment





around them. (Ahmad, 1388) In fact, engineers and designers of ancient time are forced and utilizes the natural behavior of materials in the formation of structures that ever are stable. Until before the seventeenth century, due to limited knowledge, fusion of architecture and engineering as an integral part of overall and naturally because of the weakness of human knowledge, engineers (architects) plan based on the natural behavior of materials and get inspired that human beings that normally offered and thus no distinction can be drawn between engineering and architecture and architecture and the size of architecture is same as erected. Using natural creations for innovation in architecture and technology was observed at the beginning of the second half of the nineteenth century (Ghafarpour, Shemirani AND Fallah 2013).

In the late nineteenth century, "Darcy Thompson" founded a science of morphology or morphology. He showed in his two-volume book that shapes and natural structures despite the diversity, complexity, elegance, richness and beauty based on the principle of survival and have been formed the desire to continue living organisms. In fact, the natural form and structure is the result of continuous flow compatibility to environmental forces. Optimized use of natural forms and patterns of architectural and constructional can build forms in addition to reducing the time and cost, the flexibility to design layouts and provided create new forms in architecture and design architecture.

The "Andreas Fenninger" in his book by named Anatomy of nature is known the evolution of structure and form in nature as a cautious reaction to survive. Its association with the twenty-first century and the growth of computers; has the special places and has been affected the world of engineering and architectural ideas and could lead scientists to reunification in the application of science. (Gharoni, Omrani and Yazdi. 2012) . Today due to the need to find a way to solve architectural problems, nearly four decades, the idea of "Frei Otto" based on the result of the collaboration between architects and biology have looked to nature as a model for architecture. (Gharouni 2015) Bionic architecture or science assessment of animal life, today has been introduced as one of the world's top science. Enliven the building of bionic is one of the architectural tendencies. Building in Bionic architecture or natural architecture is built by using fragile and unstable materials, or in the middle of a natural hole formed in the ground or rock. One of these natural places were the caves. Cave architecture that has an effect in the form of monuments architecture, there is from ancient times and as the most striking example of which can be pointed to grave and Rome Katukomb tomb and Naples tomb of Lebanon's. Stone churches in Armenia and discovered residential huge caves in Gourmet Turkey and Matera in southern Italy is other examples of this style of architecture. These buildings probably something like a large nest of termites that have been placed thousands of termites in them, in addition the mud or soil architecture can also be considered a branch of natural architecture. (Moghtaderi 2012) .the architectural purpose of entering into the world of Bionic is innovations in the fields of architecture. Architects with research in common areas between architecture and biology



between architecture following the appropriate patterns and discover new ideas and transfer biologic in characteristics. Transfer biological criteria to architectural, need to discuss areas of interface between architecture and biology. The aim is to use the bionic as a tool in architectural design. (Golabchi and Khorsand 2013).

Resolve some issues in architecture can be done only through innovative solutions. A model inspired by nature can rise to creativity and innovation in the mind of the architect. Natural pattern exposed to various conditions offers the best adaptive way to the environment ahead of the architecture. (Golabchi and Khorsand 2013) In fact, by looking at nature often we realized its unique function in different conditions. Maybe is responses in the amazing capabilities of nature to crisis situations. But on the contrary, after thousands of years of starting the construction of the building, what humans are made in comparison with nature is inefficient and also have shown in terms of structures with very high consumption of natural resources and unable to cope with the natural climate crisis. Construction of harmful to human health and the environment, and in many cases are ugly and incompatible with around nature. In contrast, evolutionary approach is based on an optimum efficiency of nature that lead to creating a broad and exciting range of forms and none of them are not the basis of public preference, familiar form and compliance. Since the inception of various organisms naturally inspired by a precise internal insight, to properly know where to build, what materials should be used and how the materials should be combined. While people seem to lack the knowledge inherent in the design and construction. They should learn. In our world every new idea has its roots in the discovery of the hidden aspects of nature that surprisingly become apparent through observations and natural reflections.

The continuous source of creativity and human evolution is rooted in a deep knowledge of nature. In fact, nature and design have turned to hide the unconscious of man. Human exploration and development have paid attention of all aspects of natural phenomena. As Gaudi said: "Man does not create, but it's discovered, it means that because everything is hidden by nature, the artist must have gone into it and discover. All details of things are written in the book of nature ". Spider with plaits, build homes as strength as steel. Bees in compliance with all geometry rule design safe haven for itself. Termites that built their homes in the desert and in the hot wheatear, try digging complex corridors in the soil with heating and ventilation system, keep cool inside their nests. Today Human by making real architectural models that inspired by nature have competition with the power of creativity and constructive nature.

Architecture can be called the science of artificial life. Occurs as in the world of nature and replication system and biological and genetic principles. Aspire to a complete architecture with assessment the life and behavior of organisms, the metabolic balance will be available. Architecture mentality comes from the law, therefore, its evolution can be fast. "Charlie Lukeston" of the pioneers of Bionic



architecture is focused on bionic architects in the appropriate use of the items in nature and strengthening of the building and creating comfort in space. (Shojaei.nejati 0.138)

### **Classification of Bionic architecture**

Development in Bionic architecture is depended on the research of scientific researchers in the field of Bionic science as a comprehensive science that Bionic architecture is also one of its branches. In 1983, German researchers' J.S Lebedev “and published a book with title architecture and Bionic which have been resolved issues that arise in architecture and in natural systems. Can be observed system with high efficiency and minimal power consumption in living organisms and these issues can be found with a little research into the field of architecture. Bionic architecture in a general division can be classified into six main groups: Stencils, structures, materials, form, function, process

### **Stencils**

Stencils in English called Pattern, has always been one of the interesting topics in architecture. Stencils in the past often been used as decorative and today, in addition to playing the same role, in some cases, has also taken a functional role, such as the patterns facade, will vary according to the amount of sun exposure. In Islamic art and architecture appears signs of the emergence of nature. (Golabchi and Khorsand 2013). Often there is a strong connection between man-made decorative patterns and what exists in nature. Many designs in architecture are the repeated patterns that have been harvested from the wild forms (Rafati, 2008). "Antonio Gaudi" in his works frequently been used as a natural stencils. In Sagrada Família Church, the most prominent effect of Gaudi, plants plays a role in interior and exterior decorations. (Golabchi and Khorsand 2013).

### **Structures**

Inspired by the structure of organisms and apply it to the architecture with understanding the structure and mechanisms of living organisms is possible. Inspired by the designs in nature, requiring more research about emulating from the stencils. To translate natural structures to architecture, should have a deep understanding of the structure and mode of transmission of them. This is not possible except through numerous experiment. The most famous architectural structures in which existing structures inspired by nature, can be noted to crystal palace at the beginning of the second half of the nineteenth century. Due to lack of time, the organizers were looking for a solution that can be prepared in the shortest possible time to hold exhibitions. (Golabchi and Khorsand 2013).





## **Materials**

Types of materials and how to use it is one of the key issues raised in the formation of human artifacts and structures. For the construction of the building can be used for various materials, and the materials that in addition to style is more preferred. "Frank Lloyd Wright" says: the materials have its own message and for a creative artist, provides its own melody. Nature with an extraordinary diversity, provides endless opportunities for discovery new material. The remarkable properties of biological materials, can be smart materials as a source of inspiration for scientists and engineers. Bionic Products as a part of nature, compatible with nature. The issue is not just simulated a biological structure or building, but also the successful implementation of biological tasks and functions, the aim is above and beyond. (Gharouni 2015). Researchers by the survey in nature have noticed that some features of living organisms can be transferred to human-created artificial materials. An example would be named materials for the manufacture of bulletproof vests which are derived from tough Spider silk or Lotus leaf membrane to prevent dust. (Golabchi and Khorsand 2013).

## **Form**

The form is one of the important criteria in architectural design. In Bionic architecture transfer of natural forms to architecture is not worthy. In fact, the only from translations cannot be considered successful experience, however, if combining form with function and structure can have a good architecture. (Golabchi and Khorsand 0.1392) The study forms in nature after millions of years and evolution by the forces of the environment have reached to the optimum form, and can be used as a model for optimal design. Modeling of natural forms is possible in two ways: Imitation of the form factor and concrete implementation of design and other is using the natural processes of shaping the form and its application in creating exquisite designs. The second approach would be more valuable and more efficient. (Gharouni 2015) using a form of natural patterns can be classified into four sub-categories: animal forms, human forms, plant forms, and lifeless nature of forms.

### **Animal form:**

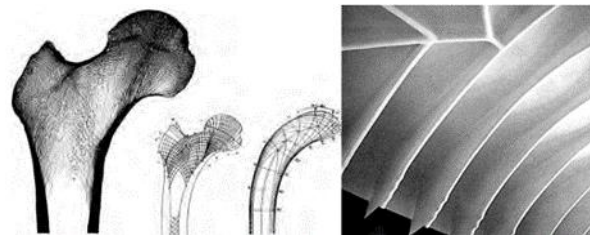
Using the characteristics of form and different animal shape is able designers to mimic symbolic linking to your ideas and values of society. Traits characteristic of animals and using their body parts (wings, claws, skin, etc.) has been done in the construction of buildings in order to achieve the magic form. Considered form of animal can name turtle immune from to turtles to bird's body fluid forms or aquatic and serpentine body of the snail. (Figure 1). Another case study is the human thigh bones to make affordable and lightweight structures. These studies were conducted in the 11th century, but



today by observing the microscopic structure of the bone tissue, try to imitate them in building structures (Fig. 2)



**Figure 1. The roof of the Runshan church that inspired by the crab skin**



**Figure 2. Biological studies for the construction of lightweight structures in the 19th century**

### **Human forms:**

With its unique shape and formed and it is composed of multiple and distinct parts, human beings have learned the first rule of composition. Unity in diversity of the human body what is design conscious or not, is formed an essential part of all human civilizations, regardless of the time and the place. The surveys in human thigh bones are to make affordable and lightweight. These studies were conducted in the 11th century, but today by observing the microscopic structure of the bone tissue, try to imitate them in building structures.

### **Plant form:**

Flowers centralist model not only gives endless ideas to architects from decorative forms, but also exhibit the principles of distributive and natural organisms formed the basis of the vertical axis with various forms of layered structures, overlapping beauty layer of flower leaves arrangement around the center and extends vertically. One of the first uses of natural creation in the architecture is related to Crystal Palace buildings Exhibition in London in 1851 in by "Joseph Pakistan ". English experts for the first time in Europe managed to cultivate huge water lilies that its leaves diameter reached two meters. Pakistan by seeing the stability of lotus leaves, paid to the survey of circular shelving and the



flower-bearing structure. The result of this investigation, devising a new structure for the lightweight roof made of glass in architecture that was used in the Crystal Palace and was won the attention of architectural critics (Fig.3).



Figure 3. Crystal Palace inspired by lotus

### **Forms of lifeless nature:**

Always shape and various forms of natural forces on the lifeless body of the Earth inspiring human construction, from the several thousand years of pendulum vault from non-linear fluid forms in today architecture that reflects the instability and inflammation values in society. (Moghtaderi 2012) (Golabchi and Khorsand 2013).

### **Operation**

Natural organisms have evolved over hundreds of thousands of years and have been developed in terms of complexity, diversity and versatility. Humans can learn from different organisms, according to their own needs and in architecture. But the operation in nature, will be worthless without having a creative mind and without having the ability to create it. (Golabchi and Khorsand 2013). Architecture, not only is the physical appearance, but also is in combination with the structure that gets a form, but the contribution of each is different in shaping the final design. Sometimes architectural form is the responses of functional, and just has the task of carrying the burden and sometimes structural step toward architectural form in response to the needs of function. (Gharouni 2015). German architect, "Teutonic Holest " is designed rotating house with inspiration from a daisy. This 180-ton building is supported by a single circle that was formed as a 6 column. The moving 6 column can turn home 180 ° and causes the house is always on the sunny side and finally at night return to its original location. The building is a successful design in the field of solar ecological houses. (Golabchi and Khorsand 2013).



## Process

Inspired by the processes of nature is leading to the formation of phenomena that can be more attractive of modeled form and function. Perhaps this kind of inspiration and impressions of natures is the most valuable inspiration. (Golabchi and Khorsand 2013). All living creatures of nature, has the evolutionary process and over time, depending on your needs will be changed. In this approach, trying to represent the most fundamental principle of life, that is evolution. So, what eventually occurs, is a responsive architecture and will be capable of interacting with an environment. (Raf'ati, 1999)

## Bionic application in technology and architecture

According to the classification of "Lebedev" the main components that should be analyzed Bionic architecture include as the following:

- investigate the function in nature by analyzing the similarities between the natural environment and the built environment
- Structural principles of nature
- Development of form and harmony

Lebedev interprets the relationship between man, nature and architecture in the form of a triangular design. Architecture not only is not responsible for protecting of Man, but also has the interaction between humans and the environment. "Lebedev" is advocate to creative use of the principles of nature and discoveries related to it instead of copying of form. (Golabchi and Khorsand 2013).

## Examples of Bionic architecture

### 1. The turning torso residential tower

The turning torso residential tower in one of the sensitive areas in Malmo, Sweden, is located in the western port of the city. Santiago Calatrava to design the building's architecture and sculpture is combined with an understanding of the power of engineering. Turning Torso is based on a sculpture by Calatrava, called Twisting Torso, which is a white marble piece based on the form of a twisting human being. (Fig.4). This is a solid immobile building constructed in nine segments of five-story that twist relative to each other as it rises; the topmost segment is twisted 90 degrees clockwise with respect to the ground floor. The building is located in a central core concrete that takes place internal





elevator and staircase on itself and through them established communication between floors. The 9 cubes from the bottom up  $90^\circ$  get the rotation which contains 54 floors. Each floor gets rotation to the lower floors of the building to create the form of the structure on all floor. Bracings and external facade structures around the front facade are embedded of white pipes that their two heads become narrowed, which is the integrated structure and architecture. The pipes on the other side are connected to the metal backing within the walls of an incision in the back corner of the building. While the concrete backbone are support of around vertical loads, it around exoskeleton, against a force of winds and vibration of the building. ( Figure 4)



Figure 4. The turning torso residential tower

## 2. Lyon Airport railway station

Long-term concerns of Calatrava was building the monument like an eye and after several attempts and experiments in sculpture, eventually came to the viewpoint that was the basis of Lyon airport railway station. He believed that the building should have connectivity with their surroundings and a perspective never seen as static and there is always a moving and dynamics subject. He knew this dynamic aspect of the environment and used in his work. (Calatrava says about himself and his work, 2003)( Figure 5)



Figure 5. Lyon Airport railway station





### 3. Water Cube, Beijing Olympic water sports stadium

Preliminary concept of the plan has been taken from Foam soap and physics professor, which attempts to study the layout of soapy bubbles in an endless order timeless order. The Cubic structural design is based on a model by the two scientists, the main issues were that how the irregular shapes took place in a regular structure such as a cube rather and will create a smooth surface. (Figure 6).

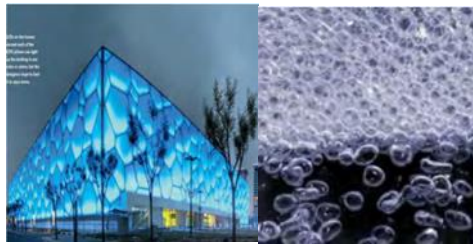


Figure 6. Soap bubbles and the basic idea and view of blue cube building

### 4. The Bionic Tower

The first and foremost point that must be considered in the construction of high-rise buildings, its resistance against wind and earthquake. This issue is solved by the construction of the bionic tower that inspired by the roots of trees. Floating root in the tree soil, is able the amorphous structure transmitted the wind power to the ground and have the necessary resistance against from participating forces resulting from an earthquake. Pivuz and Serura with the knowledge of this point and also aware that the horizontal foundations are not suitable for the structural retrofit that is longer than 500 meters, established root-like design on the foundation. The upper part of the building has the ability to fluctuations, the ability to stand up against heavy winds and storms, though the fluctuations are so slow and it is not perceptible to the residents. The total volume of the vascular bionic shape of the tower clearly shows the idea of taking it from nature. But this is not the only vessel shape that has been used in this project. The efficiency of all 92 column established the vertical relationship of this tower is defined by the vascular system. The task of this street column is moving the residents, water, various kinds of fluid and energy to the whole range just like the vascular function in plant structures. The structure of this street column is the hole that is formed by thin and curled membrane and its surroundings are covered with special concrete and finally taken capsule form. (Figure 7)

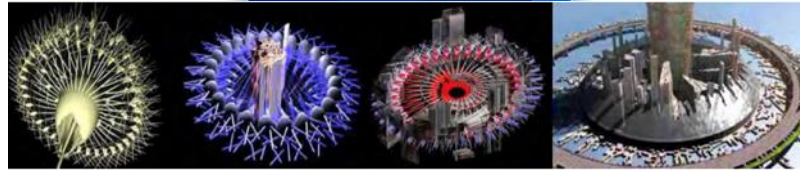


Figure 7. Method of the utilization of natural forms in tower design

## 5. Greg Lynn ideas

Greg Lynn can be considered a leader in this new theory in the bionic architecture. He would like creature creations that have distinct species, flexibility and co-existence with the environment in terms of form. A move that can be said began from the very beginning of the sixties of the twentieth century. However, due to technical limitations obvious do not impact on those years. One of the most famous works of the architect is “embryological house “he designed it in 1222 Christian Year. The project is an attempt to create an architectural behavior of production only against mass production, the same process that modernity is proud of it. (Bionic architecture in the ideas of Greg Lynn, No. 23) (Figure 8)

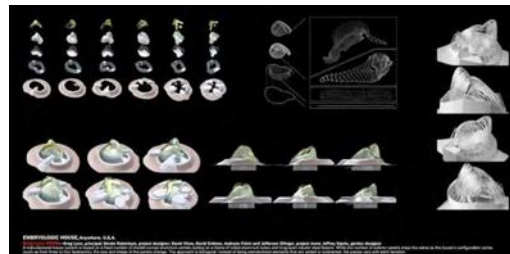


Figure 8. Embryological house



### **Result:**

In the opinion of Frank Lloyd Wright, Nature is the manifestation of God's, nature word should be written capitalized, not because the nature of God, but because all things that can be taught from God can be learned from the creation of God which we called Nature. For centuries, humans lived in close relationship with nature and get inspiration for their needs. Assessment of any natural structures in the form of case studies can be a new lesson in how to coordinate the form and structure that can teach to the engineers. In the third millennium by using technology and return to the integrated design approach should be achieved to the new way to solve environmental problems (Air pollution and destroy the natural resources, etc.), and the interaction between the built environment and the natural environment can be confronted with problems. Making the built environment should consider the natural resources and keep them for future generations. It is hoped that by using Bionic architecture we have ahead to improve the quality of life and preserve the ecosystems and natural resources, energy and natural architecture and a clean and healthy future.



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