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Bio-urban design and the Hidden Rules of Nature

Seyed Majid Naderi[1] - *Assistaxz t Professor, Department of Architecture, West branch, Islamic Azad University, Tehran, Iran*

Abstract

There was a turning point in each period of time which human has discovered a new sight about the world and nature order in a way, and then has presented this relation by numeral, artful and industrial language. Biourbanism focuses on the urban organism, considering it as a hyper complex system, according to its internal and external dynamics and their mutual interactions.Nowadays when it is talked about technology, different kinds of cars and big buildings are stroked in human mind, It is clear that if the technology result which is the answer of fundamental human needs is considered, it almost will be clear the reason of some circumstances, that each industrial or structural phenomena has been inspired from which natural alive pattern, so it has to be a relation with logical and scientific principles between mechanical system and alive constant system.The main aim of using important nature achievements is that instead of recreating from alive fauna , study nature principles and their consistency because all things in nature are powers balance , so that world has structure , therefore architectures and experts commissions and trainings to find better solution for symbiosis with nature serves as today world need.Bio urbanism endorses principles of geometrical coherence, Biophilic design, Bio Architecture, Bio mimesis, etc. in practices of design and also new urban policies and, especially Bio politics, to promote urban revitalization by ensuring that man-made changes do not have harmful effects to humans.

Key Words: *Bio-urban, Nature, Hidden Rules, Bio urbanism.*

1. Corresponding Author, Tel: 09125430975 Email Address: majid-naderi@gmail.com

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Introduction

Each natural element has always been a system consists of several components and elements, which will boost the overall complex, the total of all goal (or goals) to meet the specific makes. Nature is a system analysis, the analysis is more accurate. In fact, we can say that the study of nature is able to achieve this vision system, understand the power structures of rule-based analysis to understand the nature provides. Each of these natural systems are converted to a number of subsystems, in which each of these subsystems are also a number of runs, each of these components is also a separate system. So, for centuries nature has worked out and updated itself, creating forms and mechanisms ofsurviving, the analogies of which we may find within the today technical means: planes, opticalequipment, radiolocation equipment, navigation tools, etc.The material world surrounding us is made up of objects that have some of the shapes andpeculiarities of these, and what we call shape.Any form is the result of one of the processes below:

1. Uncontrolled processes, when the shape depends only on the conditions of the environment (formation of mountains, rocks, river gravel, etc);
2. Processes that depend on the laws of physics and chemistry of nature and of their formation environment (ice crystals);
3. Processes guided genetically and by the conditions of environment (living organisms);
4. Processes guided by human demands, insects, and animals and by the conditions of environment (the shape of the industrial products, beaver dams, bird nests, etc.)

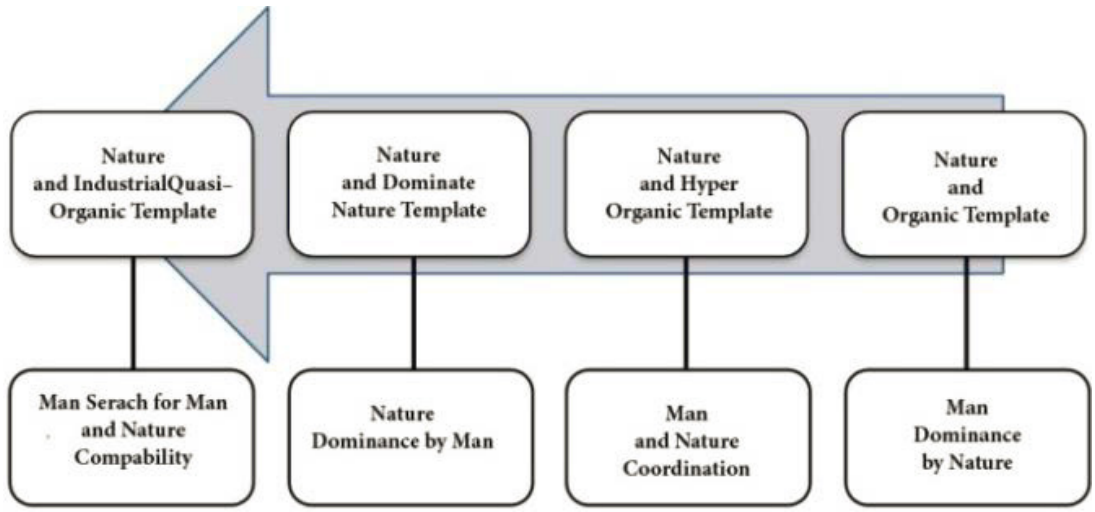
Contrary to the notion that the nature model-being was founded by a group of modern architects andengineers in architecture, the nature has been always throughout the history of human life a comprehensivemodel and reference in meeting the human needs and formation of the artifacts manufacturing process.Centuries ago, Leonardo da Vinci studied the body structure of the birds to build the flying machine. Incomparing the body structure of different birds, he considered the only way to build the flying machine toinspire from the Bat wings; since the wings of other birds let the wind to pass through them, but the bat wingsprevent the penetration and passing the through themselves as a complete membrane or curtain.Dolphins' body form was a good idea for making submarine. Dolphins can move with a high speedunderwater with consuming low energy, which is due the two-layer skin on their bodies that the outer layer actsas a shock absorber in contact with the water and causes the reduced water turbulence in the surrounding withits elastic behavior (Lucian, 1982).These effects in the nature show themselves in the architecture in other ways.

Litterer review

It is common that architects, designers and artists take inspiration from nature. During the course of history, human being endeavored so that they can dominate to nature and acquire advancements. However, they not only lacked considerable advancement in terms of understanding the idealistic dimension of nature, but also faced downward movement (mahmoudinejad, 2010, P. 378). Mother Nature has devotes its countless gifts and resources generously to human beings to be able to develop their civilizations all over the world. Each with its own culture, beliefs, values, traditions, attitudes and ethics; are the elements of people differentiation in different societies (Ansari and Mahmoudinejad, 2007, p. 103). In the other hand, we are nature.

Semantic Bionics

Bionics in the dictionary means nature of the application of artificial organs. The term "bionics" was created in 1958 by Jack. E. Steele, a worker at the Aeronautics Division House at the Wright-Patterson Air Force Base in Dayton, Ohio; He Considered bionics and the foundation of all knowledge systems as living systems. Bionics science or study of organisms living today as one of the world's top sci-



Dig 1. History of Nature Templates; source: author.

ence (IT, Nano, Bionic) has been introduced. Of a general definition can be said to "attentively bionics science foundation system that they are living systems or features live system or systems to survive". Bionics is combining of two words "biology" and "techniques" means the knowledge of technical solutions to biological responses.

Biourbanism

Definition prepared by the "Biourbanism Task Force" consisting of Antonio Caperna, Alessia Cerqua, Alessandro Giuliani, Nikos A. Salingaros, Stefano Serafini. Biourbanism focuses on the urban organism, considering it as a hypercomplex system, according to its internal and external dynamics and their mutual interactions.The urban body is composed of several interconnected layers of dynamic structure, all influencing each other in a non-linear manner This interaction results in emergent properties, which are not predictable except through a dynamical analysis of the connected whole. This approach therefore links Biourbanism to the Life Sciences and to Integrated Systems Sciences like Statistical Mechanics, Thermodynamics, Operations Research, and Ecology in an essential manner. The similarity of approaches lies not only in the common methodology, but also in the content of the results (hence the prefix "Bio"), because the city represents the living environment of the human species. Biourbanism recognizes "optimal forms" defined at different scales (from the purely physiological up to the ecological levels) which, through morphogenetic processes, guarantee an optimum of systemic efficiency and for the quality of life of the inhabitants. A design that does not follow these laws produces anti-natural, hostile environments, which do not fit into an individual's evolution, and thus fail to enhance life in any way.

Biourbanism acts in the real world by applying a participative and helping methodology. It verifies results inter-subjectively (as people express their physical and emotional wellbeing through feedback) as well as objectively (via experimental measures of physiological, social, and economic reactions).The aim of Biourbanism is to make a scientific contribution towards:

• (i) the development and implementation of the premises of Deep Ecology (Bateson) on social-environmental grounds;

• (ii) the identification and actualization of environmental enhancement according to the natural needs of human beings and the ecosystem in which they live;

• (iii) managing the transition of the fossil fuel economy towards a new organizational model of civilization; and

• (iv) Deepening the organic interaction be-

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tween cultural and physical factors in urban reality (as, for example, the geometry of social action, fluxes and networks study, etc.).

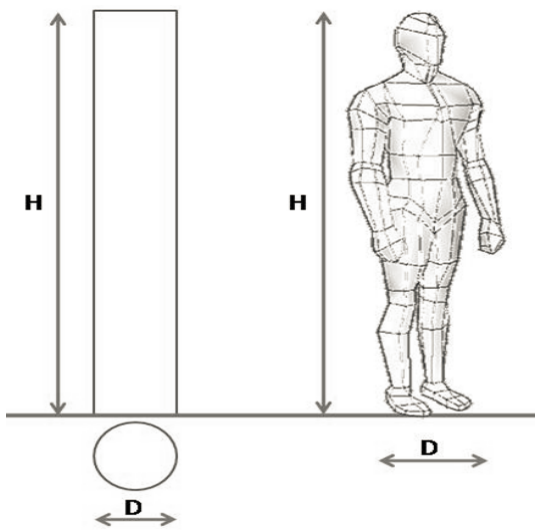
So, we should respect and learning from nature. The Traditional architecture is full of aspect regarding to nature; lessons from the past will not only improve energy conservation but will also result in pleasing architecture in harmony with nature (pourjaafar & Taghvaee, 2002). Human's connections with nature can be divided into four historical periods:

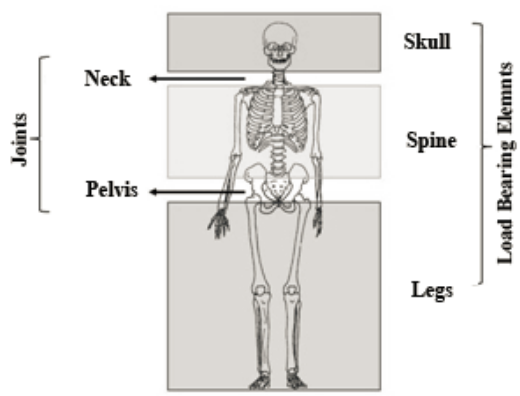
1. Organic Pattern (Hunting or Stone Age): During this period, man was under the direct influence of nature and their whole living patterns were dominated by nature. Human beings always try to safeguard their needs i.e. security and survival.

2. Ultra organic: Level of human desires reached from security domain to luxurious domain. Man is incapable of adverse patience and intends to coordinate nature with them or vice versa. This period is divided into two sectionsanimal husbandry (migratory life pattern) and cultivation (settled life pattern).

3. Dominance on nature (Age of Industrial Revolution):During this stage, human desire crosses over more than security and luxury and followed comfort and pleasure. Man intends to maximum benefits from the nature and lays ground to damage the nature. Genetic engineering and dominance of automobile can be referred to this age.

4. Quasi-industrial organic pattern:Similarly, comfort impulse also existed in this period but understandings to environmental damages have gone up. International community has planned industrial adaptation to the environment. Although, networks and new methods today propounded in conforming and adapting architecture with nature as recent architecture attempts to model with nature but naturalism has been merely in its form and has led to the emergence of imaginary environment. This period can be known as mechanical, exterior and figurative. The actual reason of the absence of exact modeling from nature is the inaccurate yield from natural geometry. Therefore, this identification is necessary

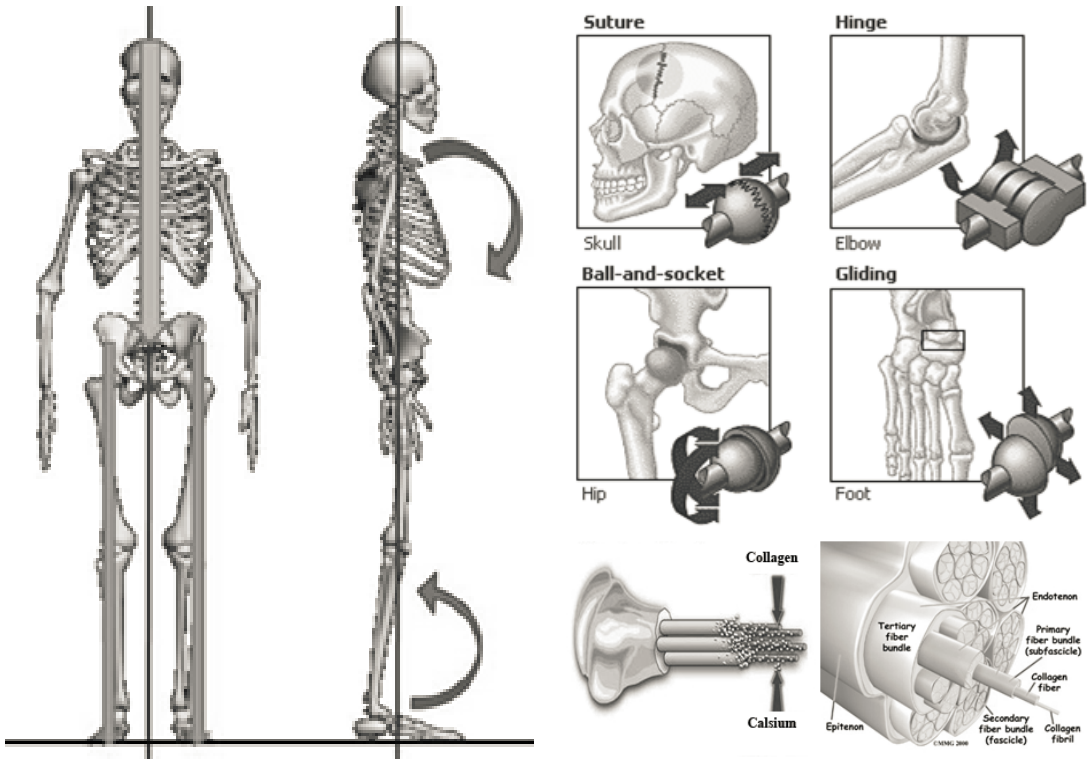




Ratio of height to cross section H/D	1.5π	π	0.5π	1/3π
Building Type	Very Tall	Tall	Average	Short

Diag 2. Human body load-bearing elements and joints and Height ratio of the cross section scale for high levels and High Definition based on Ratio of height to cross section; sources: author.

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Diag 3. Types of human body connections and Neutral Axe position and balance by inverted moment and Collagen fibers in the tendons of pipes and intra-specific categories; sources: author.

from natural organism substance and natural geometry [Kosheshgaran, 2004:21].

Define a building as tall buildings, the proportion of building height or diameter that determines the type of geometry, which is high in these categories, is given in Table 1. According to this definition, for a man is considered, H, and D averaged 180 and 40 cm, so H / D value of 4.5 is obtained, the human body among the structures is long to very long.

There are several general steps involved in the bio mimicry process. First, a scientist or engineer will think about aproblem and what he or she wants the solution to be able to do. For example, perhaps doctors need a better way todeal with certain kinds of surgical wounds. Regular sutures and adhesives don‘t work, and they need somethingstronger. Scientists and engineers will then look at how the natural world deals with this problem. They first thinkabout where such natural models might be found. For example, in looking for strong suturing materials theywould look for animals or plants that have incredibly strong threading qualities, such as the spider. They thenbrainstorm different ways to emulate or modify this natural model so that humans can use the spider‘s design. Thebest solutions must serve a purpose and work better and be cheaper than other possibilities. The end result in thiscase might be a synthetic spider silk that can be used as a biomedical device. Not only is spider silk stretchy andflexible, but a strand of it is stronger than the same diameter strand of steel. In fact, engineers are currently atwork on this synthetic material. The hope is that not only will it be useful as a suturing tool, but it might also workas fabric for lightweight bulletproof vests and biodegradable fishing.

Nature and structure function

Shapes in nature are formed in nature for the best function andtransfer large amount of power with using the least material.Timpson in his book “about growth and figures” says that livingcreature shapes are the result of matching with physical powers.Finings in

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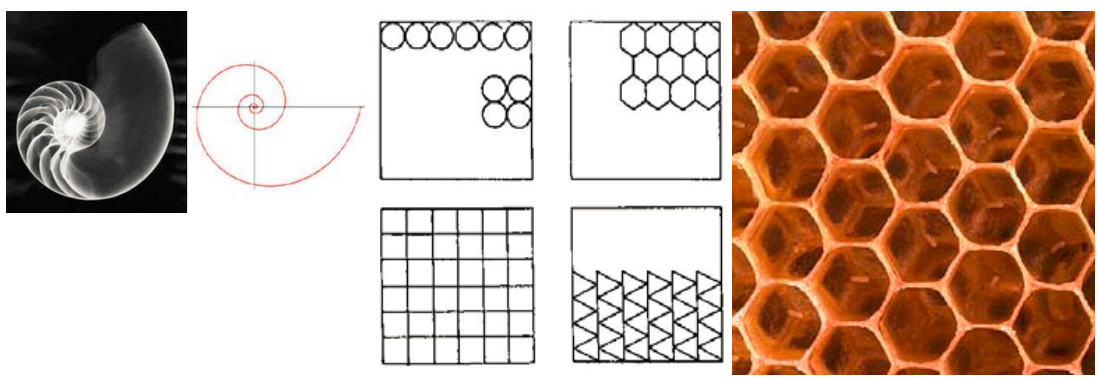
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his book "the anatomy of nature" says the structureevaluation in form is a wise reaction for living. In fact form andstructure are the result of compromising with the environmentalPowers. Usually all natural structures have textural layers whichcause these form changes under pressures and makes elastic orpressures reactions in them.This issue is seen in wheat stalk or strong trees and used increating airplane structures and skyscrapers which is namedmonochromic system or mesh case.On the other hand all the natural structures must be fixed whenfacing elastic physical powers and pressures. As an example, wecan consider spider web which is a mesh of strings and spiderand victim are the pressure axes. Another example is the elasticstructure in Munich, Germany in which steel string meshes areelastically and huge steel rolling pin tolerates the pressure.

Organic and principles in architecture and urban design

Till now, numerous researches have been conducted in order to describe the principles and specialties governing native architecture and reasons of these being valuable and constant. Naturalistic specialties of organic architecture make it evident that this architecture has also been perceived as organism and as such all the construction that emphasizes these specialties can be named as organic architecture [Calinez, 1996:183]. Organisms notwithstanding variety, complexity, elegance, richness and beauty have formed and come into being on the basis of real survival and proclivity to continue life and thus structural form and perfection in the nature is the vigilant reaction for survival. Actually, form and natural structure is the outcome of contiguous flow compatible to environmental forces. Specialties of organic architecture, in reality, are important principle governing upon natural organisms that are the secret of their being valuable and enduring. In this architecture, human attention merely is in their natural aspects and human being have perceived partially from natural ingredients and architecture are being shaped higher in grade from other animal and that are proportional to their environmental perfection. However, human and natural existence do not summarize to their external organism rather important, deep and to some extent the more hidden layer is observed as an ultra-organic layer in human being and nature that in reality, differ human being from animal. On this aspect, new group of ultra-organic specialties are evident in most of the native and traditional architectures.

Today, large part of world's architectures confronting to organic flow are ultra-organic but in most of these architectures, the systematic natural principles have been ignored with the claim of absence of nature. By this way, this architecture can be named as infra organic rather ultra-organic. Exploitation of nature in most of the architectural writings today merely is in segregating process. By this way, global architectural arena can be classified into



Dig 4. Composition from regular polygons. Structure of the honeycomb and Principle of spiral - Nautilus shell as an example of logarithmic spiral; sources: author.

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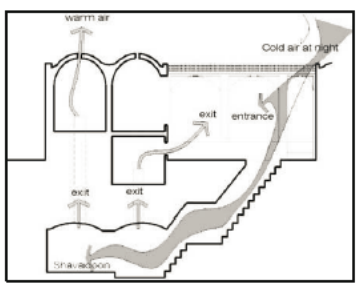


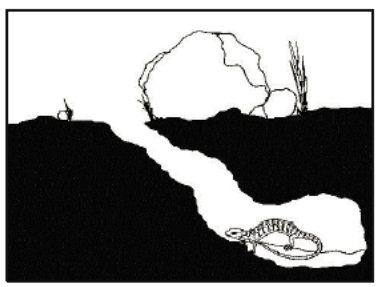
Pic 1. Draw-strut frame system (Frei Otto); sources: author.

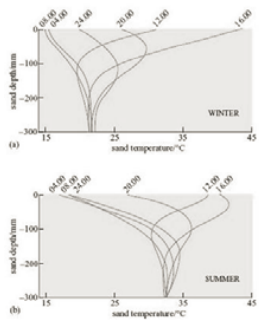




Pic 2. Vasculature of Victoria Regia flower and application of this principle in roof construction; sources: author.







Pic 3. ventilation in shavadoon and shelter of lizard in desert, source: Zare, 2011.

following three layers:

1. Infra Organic: Emphasis on overpowering nature and ignoring their principle (machine and mechanized architectures).

2. Organic: Emphasis on naturalistic and attention to natural principles.

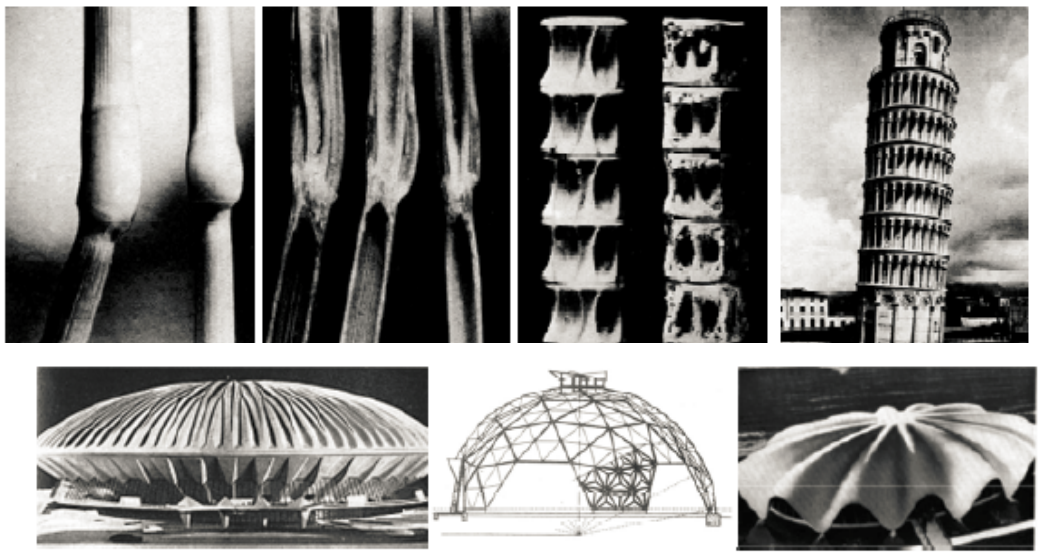
3. Ultra-Organic: With naturalistic preservation and attention to natural principles, restoring ultra-natural layers in the human existence [Hamzehnejad, 2006:168-169].

Nature as an organic model

Organisms generally can be divided into two groups of living and non-living. The phrase anti- combination is the most important characteristic of non-living organisms, the word combination can be known as the most important characteristics of living organisms, and under any circumstances, organisms are

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Pic 4. Constructive systems of column type and Tegument structure in forming of architectural constrictions; source: author.

in close contact with the nature. The present study aims to achieve a systematic and ordered unison towards the nature, increasing the power of understanding and analysis and perception of ordered structure and exploration and withdrawal of the recreation of ordered tools such as variation and diversity while having unity and solidness in art and architectural creations [Aliabadi, 2004:60]:

1. Unity and solidness in variation and diversity: A system that does not need similarity of different parts to achieve unity and solidness rather different parts can have unity with following aim and ordered structure.

2. Reciprocal needs of the systems and unity of the leadership: Indigence and the relation between parts of a system is one of the most fundamental factors that cannot be omitted that shows the presence of order in the systems. Unity in the management is necessary for the uniqueness of policy and managing any system.

3. Symmetry of form with the function: The form of any part results from the effective forces in its design and creation in the nature, which is symmetrical to the different functions from any point of view.

4. Symmetrical and simultaneous growth of parts in a system or natural order: One of the most fundamental criteria which make the existence of a system possible is the remains and maintenance of symmetry and balance between different parts of a system.

5. Measurement of the system parts: The measurement of any part and order of the system is a fundamental factor, on the basis of which any part with its special scale and special structures are related to each other and meet the system's needs (Every part in its own functional zone).

6. Unity or plurality of parts in the systems: Every part has unity and polarity based on function, capability and demands.

7. Hierarchical order of the system parts: Any part in a system is ordered on the basis of the functional process of the system.

8. The growth control: The control of the actual needs of parts and proper nourishment are important for the harmonious growth control of a system. Taking into the account of organisms, "Unity" and "Diversity" are the most exact and constant fundamental factors of the life aesthetics [Ibid: 65-75].

Natural Patterns subsystems in architecture and urban design

External forces that try to have highest rate of functioning while being formed affect a nonliving natural form. For example, soap

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bubbles are always connected in the form of irregular triangular grids. Triangular grids are the basis of the natural organism's geometry, which function on the minimum parts and maximum operation inspired from plants:

1. Formal patterning; in this type of patterning imitation, there is no attention to fundamentals of structure. For example the earth's layers can form the force that affect it and takes its form while the architects omit these forces and use just the layers forms;

2. Metaphoric patterning; Here, an abstract form of nature is used for equilibrium and sustainability. Metaphor keeps us from being superficial towards extents and we know it as a way towards creativity in architecture;

3. Pattering from natural rules; Application of natural rules is the best for getting natural inspiration[Antoniades, 2002:63].

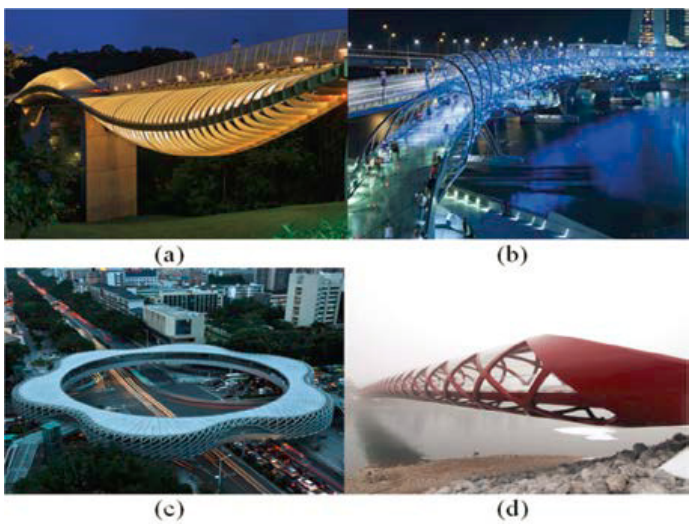
Rules and ways using them in architecture and urban design

Correct use of organism rules is in a way that probably there may be no formal similarities between organism's structure and the building. Thus we must look into the essence of organism and rules that dominate them. Here, we bring some natural orders that are used in architecture:

1. Behavioral method against forces: The behavior against the imposed forces and loads is one of the most important reasons of existing structure. The strategies of organisms against these forces are so interesting and make one think deeply. In architecture too, we can find so many using these strategies. Resisting the forces by pressure and tensile stresses and evading bending stresses are the usual way of the structure resisting by bearing the stress in its parts. Attention to the type of stress is useful in making the structure more efficient. Organisms always try to make use of compressing tension stresses to the larger possible extent in their structures and use bending stresses merely if structures possess layer essence. The gradual perfection of structures from bending towards compressing and tension like tents and shells is in this direction. Flexibility and deformation in order to resist the forces in natural structures is much obvious.

2. Hierarchy: Priority and hierarchical order in form and proportion are the manner to transfer force transfer and distinguish its course is important and determining principle.

3. Contiguity of parts: Parts define and control each other. In most cases, nature uses an intermediate part at the place of junction

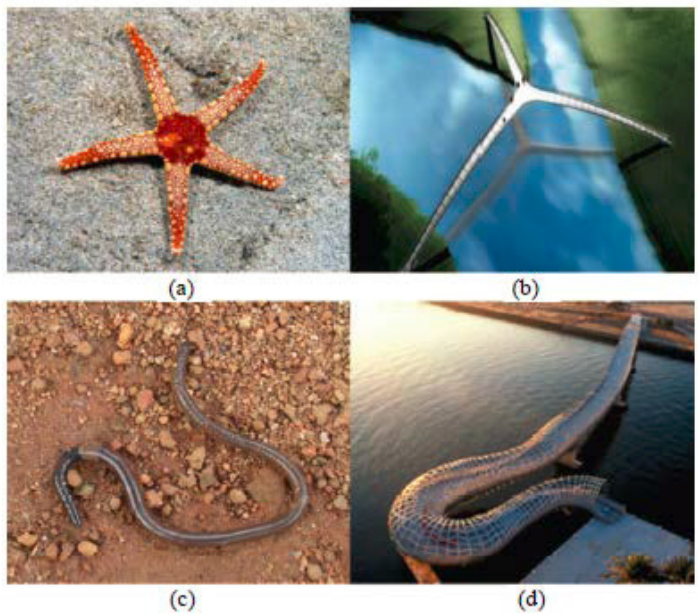


Pic 5. Biological shape and structural shape in bridge design. (a) Shape of starfish (photo: Wikimedia Commons); (b) Hacking Ferry Bridge (photo: Wilkinson Eyre Architects); (c) shape of earthworm (photo: Wikimedia Commons); (d) Webb Bridge (photo: bridgeworld.net).

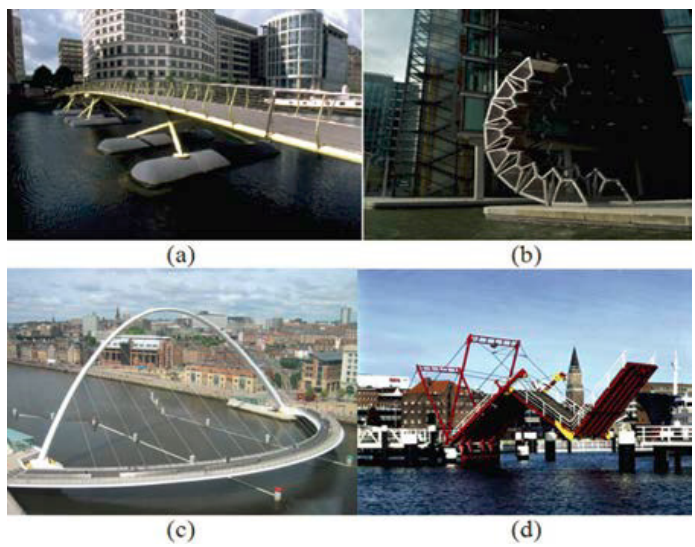
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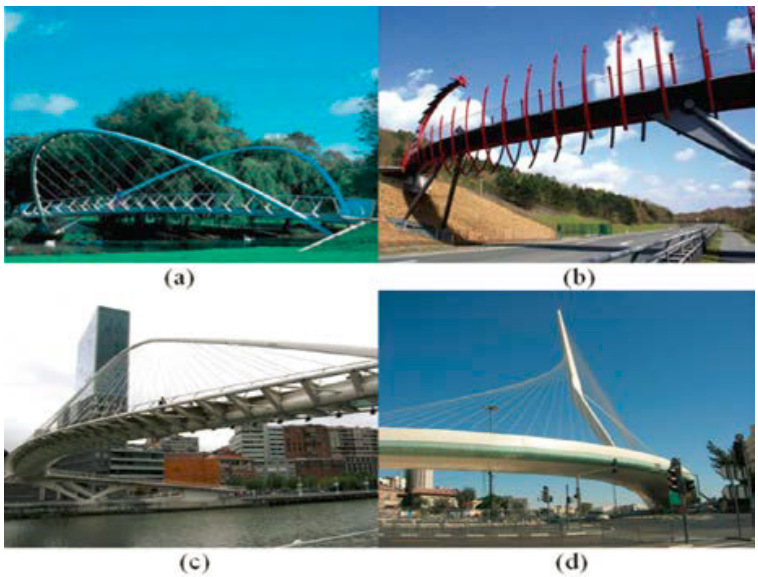
Pic 6. Bio-inspired shapes in recent designed bridges. (a) Hendersonbridge (photo: RSP Architects); (b) Double Helix Bridge(photo: Cox Architects); (c) Chunhua Footbridge (photo: ChinaFoto Press); (d) Pease Bridge (photo: Nelson Hein).



Pic 7. Bridge design cases of bio-inspired structural system. (a)Butterfly Bridge (photo: Wilkinson Eyre Architects); (b) DragonBridge (photo: Structurae Website, Id 108893); (c) Campo VolantinFootbridge (photo: Structurae Website, Id 141499); (d)
Jerusalem Chords Bridge (photo: Wikimedia Commons).

and as such these joints act in the best way as the hierarchy in living creatures. Parts of a natural structure are in harmony with each other and absence of any of them confuses the whole system. Since, organism‘s parts are complimentary to each other and thus should be in complete junction and fastened neatly. In other words, omitting any part damages the whole system. According to majority of world‘s thinkers, all parts have got such connection that partial or total organisms are in attachment with each other and any type of

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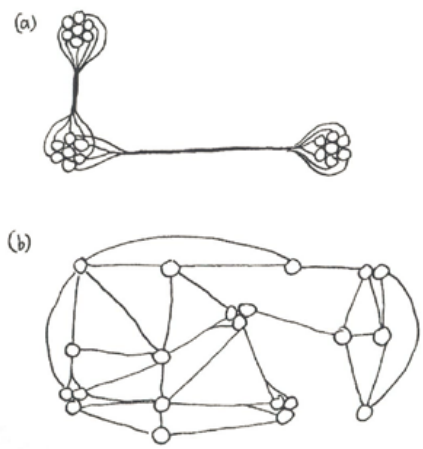
Pic 8. Moveable bridge design cases. (a) West India Quay Footbridge (photo: Bridgeworld.net); (b) Paddington Rolling Bridge (photo: Wikimedia Commons); (c) ateshead Millennium Bridge (photo: Structurae Website, Id 24175); (d) Keil-Horn Folding Bridge (photo: Courtesy Wikimedia).

change might affect the system. Wright and Sullivan have used the best manner in using and joining different scales to each other.

4. Unities and solidness of parts: In structures, since aim is to reach a defined and unified goal, unity will be understandable in all parts. Of course, being simply one piece (one thing) doesn't mean unity of structure; rather it is achieved by harmony and solidness. In natural organisms, parts with joining each other make a complex, in the way that it has real unity. In nature's diversity, branches and leaves around the main axis of a plant are not by chance but its something foreseen and in harmony with functional details and arrangement.

5. Uses of combined structures: Existence of combined structures is one of the fundamental principles of organisms, which is used to face different forces. Human beings too, are multi structural in addition to live in a multi structural world.

6. Material selection: Organisms often reach to the best structural form with the least amount of materials. For example, the foot's bones have the best structural form with the least material. Organism's structure always looks for making use of the least possible material. In the traditional Iranian architecture, minimal use of material has always been of a great importance. This principal in modern architecture was revived by Mies van der Rohe in an exaggerated way with the dictum "less is more" and their "Glass House" demonstrates this view.



Diag 5. Connecting nodes of human activity; Connective paths are multiple and irregular: a) Nodes are concentrated into three clusters with all connections forced into two channels; b) The same nodes distributed with connections that work much better (city and urban blocks)(Salingaros, 2005 & 2008)

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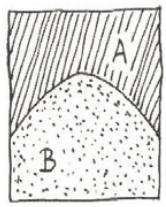


Fig 1. Geometric coupling through contrast in texture.

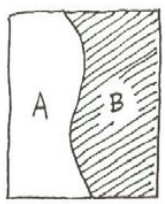


Fig. 2 Geometric coupling through contrast in color.

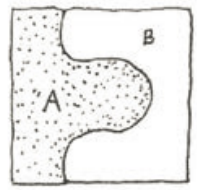


Fig. 3 Geometric coupling through interpenetration.

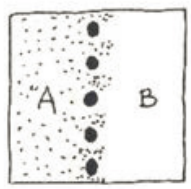


Fig. 4 Geometric coupling through permeability.

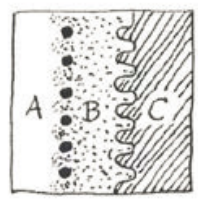


Fig. 5 Inductive coupling via a common third element.

▲ Diag 6. The nature of strong links: coupling of boundaries/ barriers in architecture

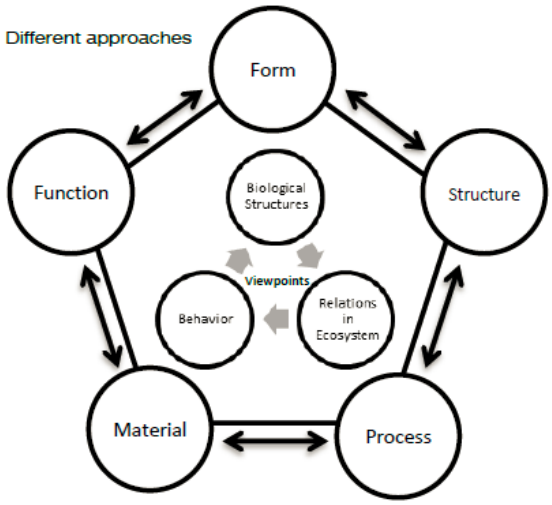
7. Choosing geometry of parts: Organisms choose their geometry on the basis of performance and coordination with their other parts as well as to respond the functional, economic and firmness circumstances. For example triangular grids are seen in nature repeatedly that is an organizing pattern. Examples of this architecture can be seen in Geodesic Dome.

Conclusion

Natural organisms that are the outcome of million years of gradual perfection, in a way give very instructive samples of such relationships between the parts are arise from the systematic essence of organisms. The essence that has had a total outlook and not the things and individual phenomenon; but orders, relationships and combinations find identity and genuineness in it. Inspiration from natural organisms can be useful in achieving a unified and aimed architecture. The objective of such bodily and formal comparisons and inspirations are not the comparison between organism and architecture because different insight of this scale and inspiration encounter deficiency. 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, human architecture like human being is a solid, unified and harmonious generality. And the basis to understand this phenomenon is deep insight on the architectural methods. In order to acquire a general outlook of architecture with a fixed aim, acquaintance of parts and their interrelations are necessary. The real aim is to identify natural characteristics and organism as well as rules and regulation governing on their structure. However, it must be kept in mind that human beings besides physical and substantial dimensions, has got spiritual and intellectual dimension too and concepts such as attention to metaphysical spaces, nature's completion, symbolism, time and being timeless and eternal are the most fundamental features of architecture, which is some how is meaningless in organisms. Therefore, to achieve to such metaphysical needs, merely study about spiritual and intellectual dimensions of human beings themselves.

Biourbanism considers the city as an organism, but in a different way, because we apply

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Diag 7. Different approaches based in three viewpoints; source: finding the research.

some of the latest developments in the life sciences to architecture. We are working to create a new human-oriented architecture that [uses] science but at the same time takes into account the artistic aspectwhat is in our brain, in our mind, in our soul.The other element that brings us to the biological model is what we call bio politics, in the sense that we refer to the city as a function of human beings. And by human beings, we mean our bodies. How does my body, my blood pressure, the catecholamine in my brain react to a kind of organizational space? We don't worry about aesthetics, or [stylistic] schools. What we are interested in is not about beauty or ugliness, but about how it works with our bodies.

Bio urbanism introduces new conceptual and planning models for a new kind of city, which values social and economical regeneration of the built environment through developing and healthy communities. Bio urbanism combines technical aspects, such as zero-emission, energy efficiency, information technology, etc. and the promotion of social sustainability and human well being.

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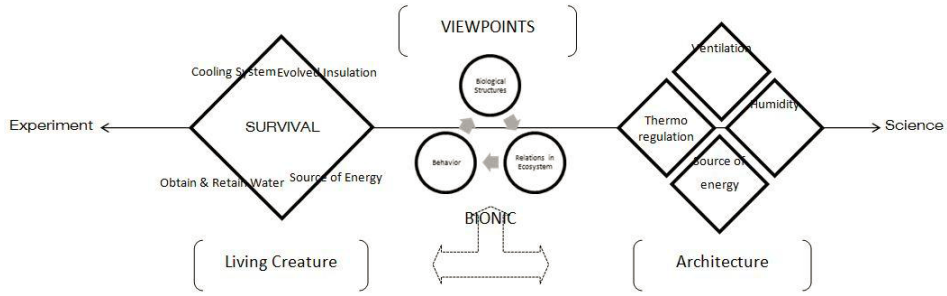
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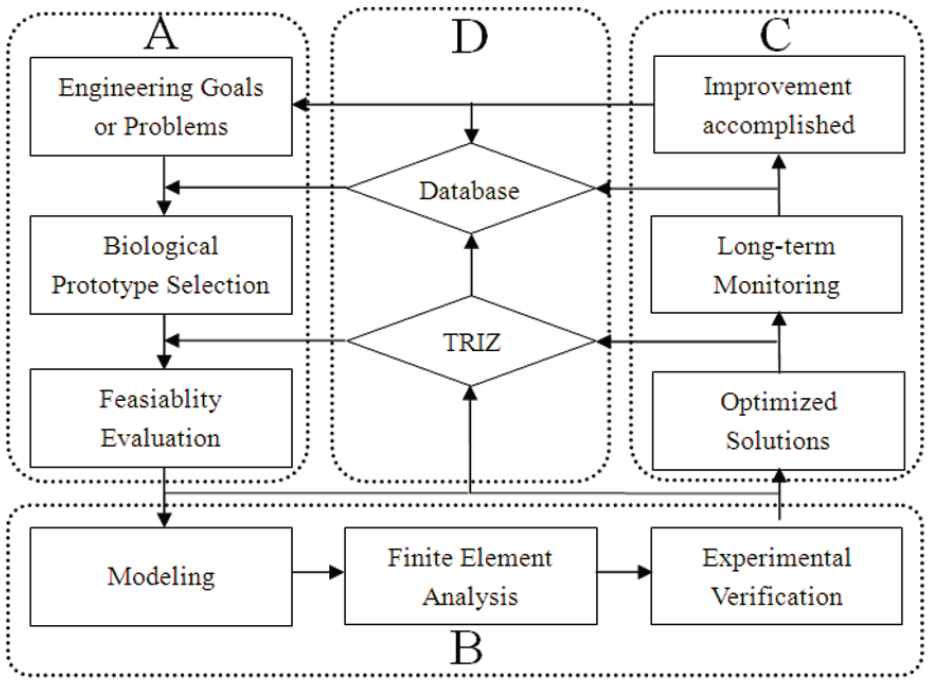
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Diag 8. Relation between architecture and living creatures in architecture and urban design; source: finding the research.



Diag 9. The procedure of the bio-inspired strategy in architecture and urban design; source: finding the research.

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