Advances in Environmental Biology, 8(7) May 2014, Pages: 3566-3572

AENSI Journals

Advances in Environmental Biology

ISSN-1995-0756 EISSN-1998-1066

Journal home page: http://www.aensiweb.com/aeb.html

Analogy of Contemporary Nature - Based Architectural Styles with Biology

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ARTICLE INFO

Article history:
Received 11 June 2014
Received in revised form 21 August 2014
Accepted 25 September 2014
Available online 5 October 2014

Keywords:
biology, living organism, sustainable, genetic, biomimetic, organic

ABSTRACT

The research investigates the biology specifications in various contemporary nature-based architectural styles. First a comprehensive introduction of biology branches provides an overall view of this science. Since some of the branches have recently integrated the architectural field, the paper has tried to focus on those which have the more interaction with the architecture. Four architectural styles have been selected including: sustainable (green) architecture, biomimetic, genetic architecture and morphogenesis design approaches and finally organic architecture which one can call that the mother of all nature – based architectural styles. When it comes to conclusion, the research emphasis on the categorizing noted styles in to two fields. Each style is chosen for one of the specific group according to the fact that in which part (structure or function) the style interact more with the nature and biology. The final tables derived based on the research illustrate also an analogy between the characteristics of living organism and their existence in the styles.

To Cite This Article: Marzieh Imani and Iman Sayah, Analogy of Contemporary Nature - Based Architectural Styles with Biology ***Adv. Environ. Biol., 8(7),*** *3566-3572, 2014*

INTRODUCTION

We have witnessed lots of movements in the history of architecture which have taken their own specific approaches to nature. These well-known styles have laid their emphasis on the connection of biology and organisms found in nature to architecture. The biological root of the noted styles in this research is undeniable since biology is the essential part of human existence and due to the connection of human comfort and architecture the biology role proves itself consequently. The paper has tried to come close to an analogy between some architectural styles and biology to discover which style and in which parts makes a link to biology.

1. A comprehensive Introduction Biology Branches:

The Biology Council is organized primarily on the level scheme, with the headings: molecular and cellular, developmental, genetic and systemic, regulatory, and environmental and group. Some feel that this particular breakdown underplays the historical and population aspects of biology; and a primary dichotomy has been suggested, between physiological biology, with a biochemical, reductionist, and historical biology, with emphasis on higher integrated units, their interaction with other units and the environment, the population concept, statistical variation, and origin rather than mechanism. Under the first would be subsumed cell physiology, comparative and regulation biology, cell interrelations and interactions, growth, embryology, physiological genetics, perhaps caste determination. Under the second would come the new systematics, comparative human biology, physical anthropology, taxonomy, population genetics, ecology, evolutionary biology, paleontology, and animal behavior- presumably including the concepts of communication, information and signals, while leaving the power or energetic and material aspects in the other rubric. There is certainly room for argument as the location of particular items; perhaps growth, development, and physiological genetics being most debatable. Other suggested ways of organizing biology are: genetics, composition, metabolism, development, taxonomic relations, population dynamics, behavior; or organic evolution, reduplication of genes and chromosomes, sex-diploidy, stability stable gene, homeostasis, ecologic equilibrium, the population concept-variance, means [8].

Among the different ways of categorizing biology, this research proposes anatomy, morphology, genetic and embryology (developmental biology) as the structural subsumed and physiology, taxonomy and ecology in the functional subcategory. The reason for this categorization was the interconnection of the nominated subjects with architecture; in other word a kind of intersection where specifications of architecture interrelate to biology

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and vice versa, the research finds its own way to succeed. The characteristics of living organisms include: cell, responsiveness, reproduction, growth, coordination, homeostasis and cell death.

2. Living Organisms' Biological Specifications:

Cell: are basic functional units of living organisms. These cells are highly organized into complex structures from the simple-cell organisms to the most complex multicellular plants and animals.
Responsiveness: all organisms are able to respond or are sensitive to changes in their environment.
Reproduction: all organisms reproduce young ones. It is through this process that inheritance is perpetuated. the lives of all organisms come to an end sooner or later; therefore, reproduction is the means whereby organisms ensure continuation of their genetic traits.
Growth: as a functional unit of the organism, the cell utilize energy from chemical bonds and convert them to a usable form of energy. all organisms utilize energy to grow.
Development: is a process in organisms In which different activities are achieved at different stages.
Coordination: all organisms have systems that coordinate all of activities in the organisms through a central processing unit like central nervous system.
Homeostasis: all organisms have the ability to maintain a constant internal environment that ensure their survivals and does not fluctuate with the external environment.
Cell death: is defined as inability of a cell to carry out its programmed functions like energy acquisition, waste disposal, transport and etc. [14].

2.1.Biological Diversity:

There are many different life forms in the universe, which are classified into kingdoms. Evolution creates the biological diversity and natural selection is the mean by which these organisms evolve. Evolution is a natural process of changes that emerges in an environment or in organisms over a considerable period of time.as time progresses, natural forces impose changes that magnify and become very significant. Such change is referred to as evolution [14] there are levels of organizations among the kingdoms. When the components of these cells and DNA are arranged in a manner that displays the smallest to the largest order, it is referred to as hierarchy. [14] referring to those paragraphs, architectural styles evolve too. There are always natural forces interfere the process of design and manipulate it in order to a higher level of progress achieves during the design method. The diversity is the fruit of this forces, as we whiteness the large variation of buildings emerge daily throughout the word. Changes are employed and natural selection appears, the natural selection has a criticism rubric accompanied it and that's the authors and human community who ignore the undesired architecture and so the style related to that fades away after a while. The analogy here is more complex than a normal comparison of a small biological part and a defined character. On the other hand for the levels of organizations we can say that the same is true for a building that contains different spaces, for instance a house which includes kitchen, bathroom, living room or closet, so architecture can be broken down to its smallest components. as single cells can be broken down to macromolecules (DNA<proteins, lipid), molecules (water, glucose), elements (Carbon, Hydrogen, Zinc..) and atoms (protons, electrons and neutrons), architecture can also do the same and reaches its elements known as wall, floor, ceiling and window … generally all organisms are adapted to their environments and the structures of all organisms are modified to fit their functions. They interact with their environment too. Conclusively architecture as a living organism follows the biological rules and has components that play the role not specially in a biological order but in a conceivable arrangement.

The word "biology" comes from two Greek Words as well: bios, meaning " life," and logos, meaning "word," " rational account," or " science." Thus, biology is the kind or type of science that studies life, which most of us already know. Whereas biology can be characterized as a set of sub-disciplines (the biological or life science) under science, the concern of which includes the description, classification, analysis, exploration, prediction, and ultimately control of living things [2].

Concerning the classification of biology within the general discipline of science, it is usually envisioned as a natural, empirical, pure science, as we illustrate in figure 1.and architecture belongs to applied science category.(fig.1) [2].

3. Darwins theory and the Evolved Architectural Styles:

Charles Darwin offered a meta-level analysis, explanation, and systematization of the biosphere. Darwin's contemporaries even referred to him as philosopher. and Darwin's theory regarding natural selection and evolution has greatly benefited the biological science. Architecture as a part of applied science owes its levels of improvements to biology as well.

biology studies parts, process, and principles associated with living things primarily as its subject-matter. [2] in the Introduction to the Origin, Darwin (1859/1999) notes: "…..each species had not been independently created, but descended, like varieties, from other species….species inhabiting this world have been modified so as to acquire that perfection of structure and co adaptation which most justly excites our admiration. it is therefore, of the highest importance to gain a clear insight in to the means of modification and co adaptation [3].

Considering architecture as an organism, it is obviously impossible to describe this complicated living thing only through its components. whereas living creatures have hierarchies, ranging from simple to complex, hence architecture should not be confined to boundaries which exclude it from the environment. It is also worth mentioning that even though we referred to components of architecture as simple parts (non – environmental related building' characteristics) but it is undeniable that these parts are argued as fundamental to biological system of architecture as an organism, they have got their own enormous complexity and proved to show a repertoire of capacities with new dimensions emerging every day. to clarify the subject, DNA which is the most fundamental part of organisms cannot be equated with simple, since it is originally complicated.

John Dupre mounts an argument for non-reductionism in biology. he argues that " properties of constituents cannot themselves be fully understood without a characterization of the larger system of which they are part" and, hence, the " notion that complex systems, such as those found in biology, can be fully understood from a sufficiently detailed knowledge of their constituents, is mistaken. [2] there are powerful reasons proving that the explanation of presence traits of organisms can be traced back to their function, and the function can be traced to the past advantage of having traits with that function [2].

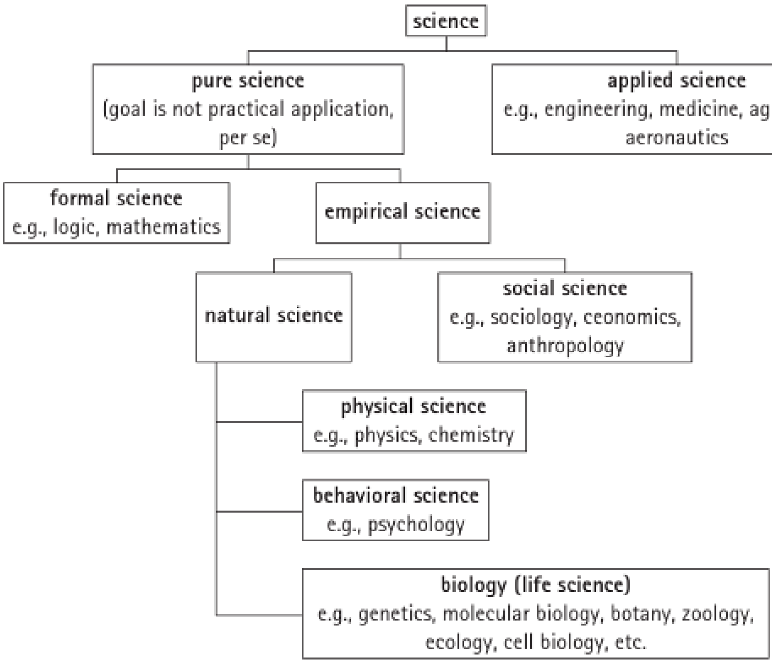

Fig. 1:

This phrase reminds us of the importance of how contemporary architectural styles with nature-inspired considerations, have treated architecture as a living organism. Evaluating these various styles will recommend the specific one which includes the holistic view towards biologic aspects of architecture and will give the noted style the chance to evolve to more sophisticated existence. On the other hand the styles this research is going to introduce represent biological characteristics by which the some architectural styles exemplify. The sustainable, green, organic and biomimic architecture have been analyzed exclusively to help the research to retrieve the common specifications of biology and architectural styles. In addition to these styles some more sophisticated and intricate ones as genetic architecture and morphogenesis debates have emerged recently, obtaining the possibility to count for the biological related styles.

4. Sustainable Architecture:

'Green', 'ecological', and 'environmental' are labels that embody the notion that the design of buildings should fundamentally take account of their relationship with and impact on the natural environment [15]. As these labels offer biology in this style integrate with biology from the view of its ecological aspect. As living organisms deal with their environment and ecological issues, sustainable architecture is also makes a vital connection to nature.

'Sustainable' is defined in dictionaries in terms of continuity and maintenance of resources, for example:

1: capable of being sustained

2: of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged

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3: of or relating to a lifestyle involving the use of sustainable methods

The noted meanings embedded in sustainable architecture truly define the characteristic of a building which has been emerged to sustain. The biological approach here notifies that architecture as a living organisms should follow the method explained to ecologically coexist with the environment. Ecology is the science of the relationships between organisms and their environment. Ecology provides insights about how natural systems work, including systems subject to human interference. Indeed, natural systems ecology very often serves as a model that provides a scientific justification for sustainability [15]. A 'sustainable design' is a creative adaptation to ecological contexts [15]. Ecology is the study of spatial connectivity between organism and environment. Conceptually, sustainable design expands the role of design program, moving the design goal from object to community [7].

The following points, known as the Hannover Principles, were developed to develop guidelines of design for sustainability. Recognize interdependence, the elements of human design interact with and depend upon the natural world, with broad and diverse implications at every scale. Expand design considerations to recognizing even distant effects. This item refers to independency of architecture and its interaction with the world. All is a reference to ecological issues.

Eliminate the concept of waste. Evaluate and optimize the full life cycle of products and processes, to approach the state of natural systems, in which there is no waste. This part talks about the evolution part in living organisms' life cycle process. Rely on natural energy flows. Human designs should, like the living world, derive their creative forces from perpetual solar income. (Architecture as *organisms* can be either producers or consumers in terms of *energy flow* through an ecosystem.)

On the other hand, the life cycle of a building can usually be broken down into four distinct stages:

• The production of the building, including initiation and design, the manufacture of materials and components, and their assembly;
• The use of the building, with its requirements for operation and maintenance;
• The renovation/rehabilitation/recycling of the building, which parallels the production process;
• The demolition of the building, with the reuse or waste of materials and components [15]. Plants and animals have life cycles that include being born, developing into adults, reproducing, and dying. Life cycles are different for different organisms.

Table 1: Three images of architectural sustainability.

Image	*Dominant concerns*	*Dominant horizon*	*Symbolism/aesthetics*	*Approach*
Natural	Environmental place, ecosystems, health, balance	Local	'Touching the earth lightly' with forms echoing nature	Study local natural systems; emphasize sensitivity and humility in relation to nature.

(Williamson, [15])

Contemporary architecture always tries to imitate natural rules in order to integrate with biology via organizational, mathematical, technical and arrangements hidden in natural pattern. The symbolic/aesthetic representation of natural image is technical proficiency in using the materials of contemporary architecture and Passive and active devices that supplement this international language of architecture [15].

We can also observe architecture as a close system from sustainable view. According to System theory which is inherently reductionist, many real life conditions are of a different, more complex, kind in which the parts are not significantly linked to each other except with reference to the whole. Systems may be classified as closed or open. An open system does interact with other systems external to itself. A building is an open system. Katz and Kahn list the characteristics of open systems as:

"The import of energy or information from the environment, the transformation of that energy into some form that is characteristic of the system, the export of the product into the environment, and the re-energizing of the system from sources in the environment" A common aim in sustainable architecture is to create 'more closed' and 'less open' systems in buildings, by feeding back (for example, through recycling) and minimizing import of materials and export of waste, so that the input and output rules are easier to satisfy because there is less of both [15].

When buildings are conceived as organisms instead of objects, they become part of the ecological neighborhood, and since they operate off existing site and regional renewable energies, they are sustainable. There is a difference between Green design and sustainable design. The former is an element of the latter. Sustainable design includes continuing, surviving, thriving and adapting. Green design incorporates ecologically sensitive materials and creates healthy buildings and process that do not negatively affect the environment.

Eventhough green design incorporates efficient mechanical system and high-performance technology, but still functions primarily through the use of fossil fuels [7].

5. Biomimimetic:

Holistic visions of biomimetic architecture range between naive romanticism and futuristic experimental design [9].

Biomimetic in architecture is an emerging field that is recently being defined and explored. While bio inspiration may be limited to a morphological analogy, biomimetic make use of functional analogies, process, mechanisms, strategies or information derived from living organisms [9].

Biometrics is one of the strategies of sustainability applicable across many of the the sustainable scales. This is possible partly because of the connection between sustainability and the basic axioms of biology- cells are the basic units of life, new species are a product of evolution, genes are the basic unit of heredity, organisms regulate their internal environments to maintain the stability, and living organisms consume and transform energy. Inspired through biology, biometrics, or alternatively termed biomimicry, developed as an interpretation of the landscape through science and the art of exemplifying nature's forms, process in architecture and urban design. According to Micheal Pawlyn, biomimicry contained sustainable principles and initiating inspirations, such as superefficient structures, high strength biodegradable composites, self-cleaning surfaces, low energy and waste systems, and water retention methods [6].

If we conceptualize an analogy between architecture and biology, we clearly would be able that how architecture in this style looks at natural systems, are from the structural and functional point of view. In this special style the whole organism is analyzed and the imitation starts with every even little specification of that living organism. This analogy sometimes reaches the material of the creatures.

In other word the key principle of biomimesis is to use the natural biological world as a source of inspiration and as a guide in the development of new materials. Detailed study of systems and organisms within natural system, which may be used as models in science and engineering of new materials, is required. However, one must recognize that such a study must focus on elucidation of relationships between structure and function in natural systems in order to apply the fruit of such study in engineering.

As declared biomimicry owes its existence to the technological process, natural functions and structural principals embedded in natural life. This style of architecture doesn't copy mere morphological issues or even superficial natural patterns, instead of imitating the first apparent discovery of the world life; biomimicry investigates functional and structural rules as well as process and material technology.

The disciplines of design and architecture can extrapolate knowledge from the biological world in order to improve the way human live. The field of biomimicry applies biological principals to design in two main ways. First, a focus of biomimicry is to understand the dynamic context within which we operate and place buildings into the environment. Study of the natural world takes into consideration the interconnectedness and diversity of nature, and architects can learn from this perspective in order to design elements that can become integral parts of natural systems. Biomimetic designers strive to be more considerate of the environment, to be less invasive and more conscious about the fact that human live among other components of nature, second, designers can learn about the functional aspects, or adaptions. Of organisms and translate those principles into design. Biological form is studied for its function, which is a basis precept that can be imbued into architectural design through the study of precedents [11].

6. Genetic Architecture and Morphogenesis:

Morphogenesis is literally a production of shape, when shapes are created as organisms and then develop to a higher level, starting from very simple fertilized eggs and changing into complex animals and plants. The production of shape here is called morphogenesis.

The quest for "mechanisms" of morphogenesis therefore aims to account for the shape changes at the scales of cells and tissues in terms of events that take place only at the scale of individual molecules. A simple molecular interaction is not enough, though an understanding of mechanism can be obtained only when the pathways of control that regulate the behavior of the components have also been identified and characterized. (Davies. Architects use these mechanisms to create shape, they exert rules of changing shapes at the scale of cells and tissues, develop it to the more complex organization as the process of form finding. Architecture enhances and imitates the biology in order to achieve the desired shape which initiated metaphorically from and embryo and developed to some intricate form.

The development of complex structures is not unique to the biological world. Purely physical systems can generate rich patterns. A living organism use physical processes in a biological way. The simplest way in which physical structures are built is self-assembly [5].

There is also a process of cell proliferation and death in morphogenesis. These genetic methods are generically used in different part of construction. The process happens here make a genetically base pattern which with its help, rules are normally extract and employed in architecture.

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Morphogenetic metaphors are particularly apt as describing the digital dialectic between script (code, genotype) and parametric variations (phonotypical adoptions) [10].

Nature of digital theory was an essential component of digitally intelligent design from its very beginnings; it is embedded in, and derives from, the dual genealogy and double allegiance of digital architecture. [10].

This is of particular importance if one considers that the surface defining the critical morphogenetic input is constructed through a bottom-up process which all parts respond to local interactions and the environment. As these internal and external interactions are complex and interpretation of the L- system is nonlinear, the outcome of the growth process remains open-ended. This continual change, combined with the long-chain dependencies of the subsequent generation methods, enables the growth of different system types of member organization, system topology and consequent per formative capacity. Such as integral design approach begins to expand the notion of perm formative polymorphic systems towards digital typo genesis [10].

In architecture process of construction are bottom-up as the process exist in biology and the interaction of generation methods which enables architecture to act as an integral design with the essence of growth, form the morphology of a building.

Morphogenetic design techniques and technologies allow for the rethinking of the nature of design process. A design approach utilizing such methods enables architects to define specific material system through the combined logics of formation and materialization. It promotes replacing the creation of specific shapes subsequently rationalized for realization and superimposed functions, through the unfolding of per formative capacities inherent to the material arrangement and constructs we derive. Most importantly, it encourages the fundamental rethinking of our current mechanical approaches to sustainability and a related functionalist understanding of efficiency [10].

7. Organic Architecture:

Organic as biological knowledge related to living things, but it is an entity, which is part of the whole element, either working for yourself or combined into more complex organisms.

At present, organic architecture's finding solutions that correctly implemented the idea in terms of the purpose of the method, the features and to some extent involve inmates who live in it. Organic architecture brings together renowned figures from the fields of architecture, engineering, mathematics, computer graphics, biology and critical theory to share their investigations related to the production and perception of space [1].

In the debate of biological analogy, Wright meant so much: crystalline plan forms, the possibility of growth by asymmetrical addition, the relationship of composition to site and client, the use of local materials, the individuality of every created things, but primarily it meant for him a living architecture; an architecture in which useless forms were sloughed off as part of the process of a nation's growth, and in which every composition, every element and every detail was deliberately shaped for the job it had to perform [4].

Organic architecture comes from biology and it is related to animal and plant kingdoms, for the first time it was used in 1863 in Paris. It is better to say organic is a part of the whole and all of the part; as in biology this is meaningful. As there are hierarchies in biology, we can refer to architecture as hierarchical field.(figure 2).

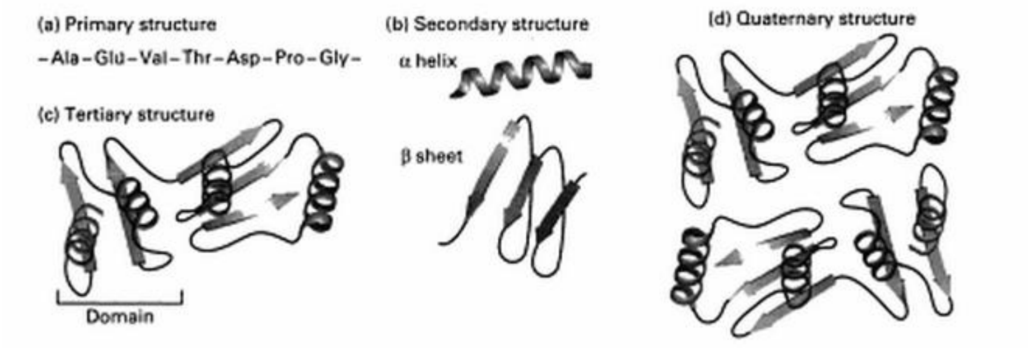

Fig. 2:

8. Conclusion:

Table 2: Analogy of architectural styles and biology.

ANALOGY OF ARCHITECTURAL STYLES AND BIOLOGY			
STRUCTURE		FUNCTION	
ANATOMY: INTERNAL STRUCTURE	ALL	PHYSIOLOGY	ALL
MORPHOLOGY: EXTERNAL STRUCTURE	GENETIC ARCHITECTURE BIOMIMETIC	TAXONOMY	NATURE BASED ARCHITECTURAL STYLES
GENETIC	GENETIC ARCHITECTURE	ECOLOGY	SUSTAINABLE AND GREEN ARCHITECTURE

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EMBRYOLOGY(DEVELOPMENTAL ARCHITECTURE)	MORPHOGENESIS		

LIVING ORGANISMS' SPECIFICATION ANAD ARCHITECTURE	
CELL	ALL OF ARCHITECTURAL STYLES
RESPONSIVENESS	SUSTAINABLE ARCHITECTURE, BIOMIMETIC
REPRODUCTION	GENETIC ARCHITECTURE, BIOMIMETIC
GROWTH	ORGANIC ARCHITECTURE, GENETIC ARCHITECTURE, BIOMIMETIC
DEVELOPMENT	GENETIC ARCHITECTURE, ORGANIC ARCHITECTURE,BIOMIMETIC
COORDINATION	NONE OF THE STYLES
HOMEOSTASIS	NONE OF THE STYLES
CELL DEATH	GENETIC ARCHITECTURE,,ORGANIC ARCHITECTURE, BIOMIMETIC

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