# Movement in Architecture

## *An Analytical Approach Towards Organic Characteristics*

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*Nature is the fundamental and recurring inspiration of organic architecture. Living organisms, both in their outward forms and in their inner structures, offer endless ideas and concepts for design. Organic architecture works with metamorphosis (the process of growth and change), the notion of "design from within". Why should architecture be lifeless and static? Here, Movement, a unique quality of living organism is used to contribute to architecture. We cannot make a new life but we can take the characteristics to make changes in our environment, seeking not to imitate nature's appearance, but instead to imaginatively apply its profound principles. The focus of this paper is to examine and categorize the different kinds of movement that exist in nature, understanding how their purpose can be effectively used in architecture. The topic explores techniques of living organisms used for function and defense and discusses possible implementation in architecture. Movement has the potentiality to introduce flexibility, ecological efficiency and building defense through deformable, transportable, shape shifting and morphing forms.*

***Keywords:*** *Organic Characteristics; Movement.*

### Introduction

Organic architecture is a living tradition that is taking on new and exciting directions. …It has a long and celebrated history, from the Ancient Greece to art Nouveau. (Pearson, 2001) Many architects interpreted organic architecture in different ways. Imre Makeovec thought of organic architecture as "Building as Nature", Bruce Goff as "Continuous Present", Frank Lloyd Wright "Form Follows Flow" while Nader Khalili considers it something "of the material". Frank Gehry echoed the heart of a rose in the Guggenheim Museum and got inspired by fish in many of his projects. So far, the implementation of organic architecture was about form, space, material and sustainability. Indeed everything was in a static form. Santiago Calatrava has succeeded in producing a vast number of diverse projects and forging a new approach to design that fuses Structure and Movement, a poetics of morphology.

This is just the beginning of a new era; architecture is heading towards a practically moving world from a static state. To understand the discipline and principles of organic forms and their movement, a study would be conducted on a subject. The references would be examined for applicable technology and Architectural use. Case studies would be done. The structure and their movement would be ana-

lyzed. The final experiment would be on the future possibilities and application of movement from nature in the field of kinetic architecture.

## Life, organic world and movement

The abstract definition of life is "the process by which an organism reaches death". The operational definition of life is "In an organism a condition in which there is reproduction, growth, development, metabolism, use of energy, excretion, response to stimuli and composition of cells". The organic world is the world of living creatures that possess life. Life itself is integrated with the continuous change and movement available in all living organisms from microscopic to macroscopic. When motion ceases, life ceases. "Movement" is an integral part of life, as it is evident in all living creatures. All species has their own mechanism to tune with their own particular motion.

## Reference from the organic world

### Categorization of movement present in the organic world

Each individual movement in the natural world serves a specific purpose. A bird engages its energy at the wings to make it fly. The heart pumps in human bodies to filter our blood. The understanding of movement and its purpose in the natural world along with the process of performance seeds a new dimension in the filed of architecture to flourish in full bloom in the course of time; adding new hope to rethink our unsolved problems in architecture and 4th dimension to visual, aesthetic world. For establishing a better relationship between natural and architectural world, the movements in the organic world are categorized according to the following headings:

- Movement of Components
- Movement of Surface
- Movement of Form (Deformation)
- Metamorphosis

## Movement of Components

"Component" refers to body parts found in different kinds of plants and creatures. The natural world moves the body parts for function or defense. It deals with the free body or entire entity movements. The whole system moves in conjunction to its environment. Through these movements a creature adapts to its needs, such as for the active need of mobility, food energy, or passive need of environmental protection. In architecture, component movement is for various adaptive needs, such as functional change, environmental response and defense. However, many of the moving features of nature provide significant reference.

## Types of Movement of Components

### Linear

Literally, "linear" refers to extending along a line or proceeding straight forwardly from one stage to another. Here, linear refers to movements of any component or entire body that goes in one direction back and forth.

### Angular

In Angular movement the component moves by forming an angle in between two lines or surfaces at the point of meeting. Animals with jointed legs Phylum Arthropoda-robber crabs, fleas, hourseshoe crabs and sea spiders; Insecta- damselfly, Crustacean Eumalacostraca-different types of shrimps and lobsters, true crab; Mamalia- tiger, monkeys, man; and class Aves- the birds are rich in angular or pivoted movement in the joints of their mouth, legs, hands and wings.

### Radial

"Radial" movement refers to the movement of components radiating from a central point.

### Spiral

In this kind of component movement the body part

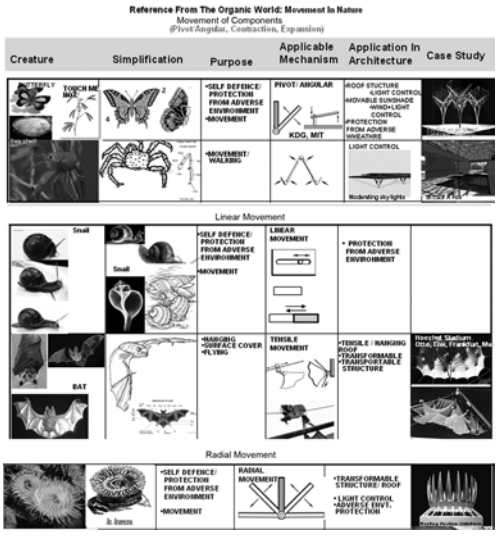
forms a continuous curve round a central point or axis.

The simple mechanism of door and windows to open and close is the most commonly used system. There have been several implementation of moving partitions and roofs in stadium and house designs. Santiago Calatrava's dynamic designs reveal the truth of his study on natural geometry and movement mechanism. His work is striking and structurally daring –a fusion of biological structures, technology and aesthetics. In the open air Bauschanzli Restaurant the tree structure metaphor is explored (Figure 1). In Milwaukee Art Museum, he was inspired by birds where the roof opens and closes like a bird to allow people inside the museum to see the changing light of the site in the course of the day.

The planetarium in Valencia can be perceived as an eye that deploys and retract like eye lids.

## Movement of Surface

Movement of Surface refers to the movement of the outside or uppermost layer of a living organism.




### Contraction, expansion

The shortening and thickening of functioning muscle or muscle fiber is contraction, on the other hand the spreading out of muscle is expansion. Tension is obvious at the point of expansion. In fact, in any movement contraction and expansion is obvious with muscles. In Earth worm, caterpillar and other boneless substances such as amoeba, muscle movement results in locomotion. The inner layer of a Golgi substance creates wave like curved surfaces for better function. Fishes under the class Chondrichthyes and other snakes under Reptilia have prominent surface movement along with internal structural movement. A close study on these species reveals the techniques with synchronized movement of both surface and internal structure.

## Movement of Form (Deformation)

The movement of form that leads to deformation is an alteration in the shape or dimensions of an organism as a result of the application of stress to it or the act of twisting or deforming the shape. In this kind of movement, form may change very slowly by evolution, moderately fast by the process of growth and decay, and very fast by internal muscular, hydraulic, or pneumatic action. (Zuk and Clark, 1970). The earthworm contracts and expands for locomotion and defense. Architecturally, the deformation can be of vital importance not only for the new dimension of forms but also for other functional reasons.

Transformation of form refers to an object or structure that transforms itself by itself; one that has an innate property of controlled change. A transforming object may be foldable, retractable, or shape-shifting. Such capabilities lead to functional benefits: portability, instantaneous opening and intelligent responsiveness within the built environment. The unique characteristics of Transforming Structures relate not to their appearance or their material properties, but to their behavior, a process that is: Complete & fully three-dimensional, smooth & continuous, reversible & repeatable. (Hoberman, 2006).

*Figure 1*
*Types Movement of components (KDG: MIT, Google image)*

In fact, the transformative form results from the movement of components, surface or internal change. In architecture, through the process of deformation and deployment the transformative forms can pass from a dismantled to an erect stage as happens with flowers or leaves. Rigidity is the ultimatum of the mobility of the structure. Certainly, the form changes the shape or geometry. The benefits we might think about from the transformative process may be discussed as follows:

- Unique quality and dynamism of space and form.
- Integrated combination of technology and aesthetics
- Flexibility and adaptability according to our changing needs.
- Ecological efficiency: intelligent movement of form can respond to different environment conditions.
- Transportability: for the smoothness and facility of easy installation, erection and dismantling process have the quality of transportability.

**Foldable**

Folding is the process to make compact by doubling or bending over parts. In the natural world foldable structures are found mostly in plants and insects. Plants in every stage of their lives unfold- from the seed, from new leaves, and even from buds to flowers. In a casual plant, leaves might be folded for defense and opened for full sunlight. In flower buds they protect the soft petals until they get matured for blooming. Animals deploy their body structure for movement and function. Similarly, these techniques can be applied in architecture to achieve the benefits of folding, i.e protection and mobility.

The folding techniques can be categorized as

- Planar
- Cylindrical
- Stiff
- Compliant
- Radial
- Spiral

**Retractable**

To draw back or disavow

**Shape shifting**

Shape shifting refers to the change from one configuration to another-to alter in size or overall form. The puffer fish blows its entire body and transforms into a sphere essential for its survival. It changes the assumption of the prey by misleading it about its size.

Designer Hobberman took inspiration from different natural elements including growing plants and observed natural transformation. His Iris dome transforms like the iris of an eye. Kinetic Canopies designed by Otto Frei resembles the umbrella opening technique found in a jelly fish structure (Figure 2). Hoechst Stadium roof is a tensile hanging structure that can be compared with the tensile body of a bat. Maintenance Enclosure FTL Happold (Konenburg) resembles the deployable technique found in insects.

## Metamorphosis

Metamorphosis is the manner in which an organism or any of its parts changes form or undergoes development. Here, the metamorphosis refers to and differs from the deformative forms in terms of an entire form change that shapes up to something

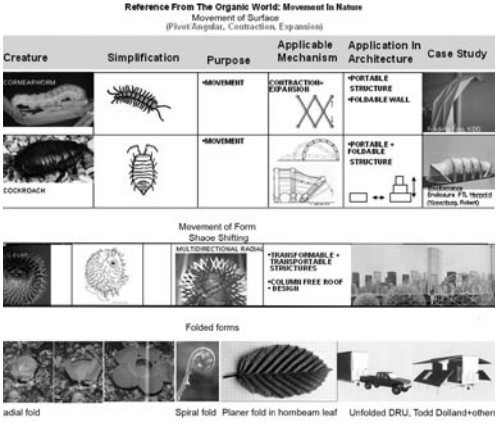



*Figure 2*
*Movement of surface and Form (KDG: MIT, The Private life of plants, Google image)*

new. A caterpillar undergoes transformation or metamorphosis at a certain stage of its life before it becomes a beautiful butterfly. In most living forms, the morphology of growth beyond the seed stage is a continuous one in which the creature essentially remains the same but the change from the seed to a new offspring is drastic and can be called metamorphosis. The egg, embryo, tadpole and the frog stage are the examples of the different stages of the life cycle of frogs that help them to adapt and survive in different environmental conditions.

Architecture can benefit from the concept and function of metamorphosis. Architecture will have more adaptability even with extreme environmental conditions, with our changing needs and more evidently acquire the dramatization of form. The Metamorphosis concept has the ability to make architecture enduring as it adapts under any circumstances and any culture or time to come.

## Conceptual implementation of movement in architectural design:

### Self- erecting furniture

The surface movement can develop a new concept of self-erecting furniture. Here the deadly floor surface is imagined to be alive. The mechanism and our concentration would be in the section of a floor. Instead of a hard core, it would rather have self- erecting kinetic blocks that can virtually shape up to any basic forms of furniture. A lightweight, durable, textile-based pneumatic actuator with high performance can be considered. A synchronized surface material (e.g. technical textile) that expands up to a desired expectation and can retain its shape while dismantled would be used. A network of sensors, monitoring the integrity of all the structural members and the commands given by the user, is woven in the matrix of the kinetic blocks (Figure 3).

### Building defense

The Movement of components can help to rethink building defense. In conventional high rises, total structure is integrated with different parts. If one collapses, so does the other part. Baneberry (Actaea Rubra) or Duncecap Larkspur (Delphinium occidentale) and their species' flowers are arranged in loose racemes on stout stems. Individual flowers bloom and decay without hampering others. This technique can be adapted in high-rise buildings, which will be comprised of several principal units, each 40~50 feet high containing several floors. The core is a blast-resistant concrete block containing the building plant, main elevators, service elevator and emergency stairs. The units are suspended from the central circular core with a steel frame and networked with sensors that can rotate individually about the core under external attack. Even if one block gets damaged and bursts, the consequent blocks will rotate on the safer side, avoiding destruction.

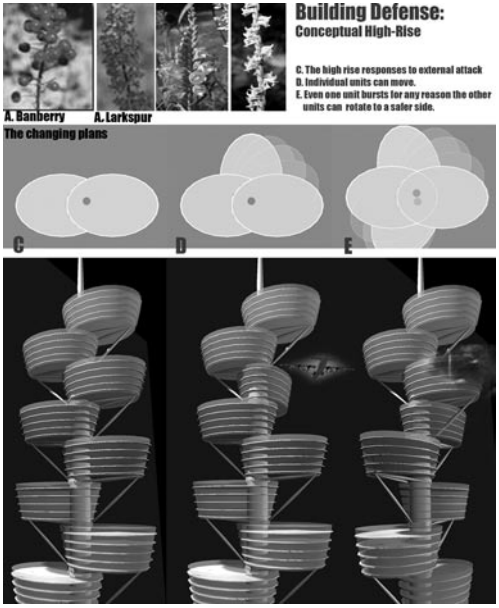



*Figure 3*
*Building Defense with movement (Author: Kona)*

## Conclusion

Nature is a resource of universal principles. Learning from nature opens variable directions. The resultant architecture is countenanced by timelessness and

originality.

The fantasy of our childhood is a reality today. From the ancient world to today's modern time, architecture always prevailed and changed its aesthetics according to the purposes and technology available. Evolutionary architecture's innate curiosity to question and analyze, seek solutions at multiple levels- social, environmental and psychological-a mutual depending of human understanding. The design process is multidisciplinary and comprehensive (Tsui, 1999). Research of eco-biological systems and technology open new design possibilities, safety of structure and energy efficiency.

Study and analysis of Movement in nature concentrates on possibilities with kinetic architecture. It is an additional option offering new freedom of choice. It is more human controlled, where the individual becomes an integral part of the process. The effect of movement on aesthetics is endless. The architect will be designing a range of forms instead of one single one. And even the architect will not actually entirely control the form, rather it would be a combination of environment, owners and users to influence it. Moreover, the form manipulates itself with its own intelligence. But still it does not go beyond us. Rather, implementation of movement including multi-functionality, response to environmental changes, adaptability to different situations and locations make our lives easy and comfortable. In finding the right balance among biological science, architecture, art and engineering, lies the success of this evolutionary design process. The rest is left to creativity and experience.

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