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# Biomimicry: A Pathway to Sustainable Built Environment

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**Abstract—***This research aims to critically analyze and explore the varied expanses of holistic approach to one of the sustainable and innovative alternative design formula of architecture and built environment, BIOMIMICRY. It is about a disparate pathway from nature to our surrounding. The main objective of this research is to find out how biomimicry aspects and principles succor in building sustainability through architecture and its regenerative built environment.*

*This paper describes about the various approaches and applications in current architectural design, resulting in creating a set of design approaches levels and principles. It is postulated that biomimetic approaches incorporated the principles of ecosystem if evolved and understood appropriately can be a vector for creating a built environment that goes from simply sustaining from current scenario but becomes imperative component in integrating architecture and reformation of natural ecosystem. The paper also discuss about architect's work inspired by our very nature and context.*

## 1. Introduction

Through history the chasm between mankind and nature has steadily grown and at the same point humanity stopped asking nature for answers.

"The best way to predict the future is to design it". [9]

Sustainable development has often been criticized as being ambiguous as an underlying principle for built environment [16]. Further obstacles within the planning, design and construction of built environment include design approaches that lack feedback loops [18] and lack of common language for multiple disciplines to assess built and natural environment impacts [3].

Over the years, Biomimicry approach to technology and innovation has increasingly received attention as such an alternative for the ecosystem destructing technologies of the industrial age.

"In reality, we haven't escaped the gravity of life at all. We are still beholden to ecological laws, the same as any other life form. The most irrevocable of these laws says that the species cannot occupy a niche that appropriates all the resources – there has to be some sharing. Any species that ignores this law winds up destroying its community to support its own expansion." [2]

Biomimicry or biomimetics is "a new science that studied nature's models and then imitates or takes inspiration from these designs and processes to solve human problems" [10]

## 2. Through history

Since 1960's linear thinking within the building industry has attempted to control environmental variables through design by limiting and environmental resources [18]. However, a paradigm shift from linear thinking (table 1) has occurred in recent decades to acknowledge the environment as a dynamic system that behaves ace to stocks and flows and feedbacks and thresholds [18]

**Table 1: Linear thinking versus systems thinking**

| Linear Thinking | Systems Thinking |
|---|---|
| Approaching each building phase in isolation of one another | Acknowledging the interconnections between a number of life cycle stages |
| Internalizing the building's performance through Integrated Building Design (IBD) | Allowing large spatial scales to dictate proper environmental design instead of solely focusing at the building level |
| Integrating sustainable concepts on new buildings | Improving the performance of existing buildings |
| Viewing the environment as one physical system | Acknowledging the interconnections between ecological, social and economic issues |

Sustainability has become a foundation stone for the built environment to be resource efficient and biomimicry helps to further expand upon system thinking through 'principles' that include interdependence, integrating processes and transdisciplinary.

Since the very beginning of human existence we have fought to control, use, dominate and gain independence from nature. The struggle began 10,000 years ago with 'Agricultural Revolution'.

Despite the technology, modern gadgets and machines we are still inseparably bound to the laws of nature.

At a current world population of 7 billion and growing (according to UN world population reached 7 billion on oct. 31, 2011), with present unsustainable habits, man must go back home, back to nature, back to forest.

"When we stare this deeply into nature's eyes, it takes our breath away, and in a good way, it bursts our bubble. We realize that all our inventions have already appeared in nature in a more elegant form and at a lot less cost to the planet. Our most clever architectural struts and beams are already featured in lily pads and bamboo stems. Our new "smart materials" can't hold a candle to the dolphin's skin or the butterfly's proboscis." [2]

### 3. Biomimicry and its influence on architectural design

"Biomimicry where flora, fauna or entire ecosystem is emulated as a basis of design is a growing area of research in the field of architecture and engineering. This is due to both the fact that it is an inspirational source of possible new innovation and because of the potential it offers as a way to create a more sustainable and even regenerative built environment". [11]

It is assumed that application of biomimicry to the architecture design serves as a platform to create a sustainable built environment.

Approaches to biomimicry as a design process typically fall into 2 categories: Problem based approach and solution based approach.

**Problem based approach:**

Throughout the design world this approach has been given different names such as "design looking to biology" [11], "Top down approach" [6] and "Problem driven biologically inspired design" [5].

In this approach designers look to the living world for solutions and are required to identify problems and biologists then need to match these to organisms that have solved similar issues. This approach is effectively led by designers identifying initial goal and parameters for the design.

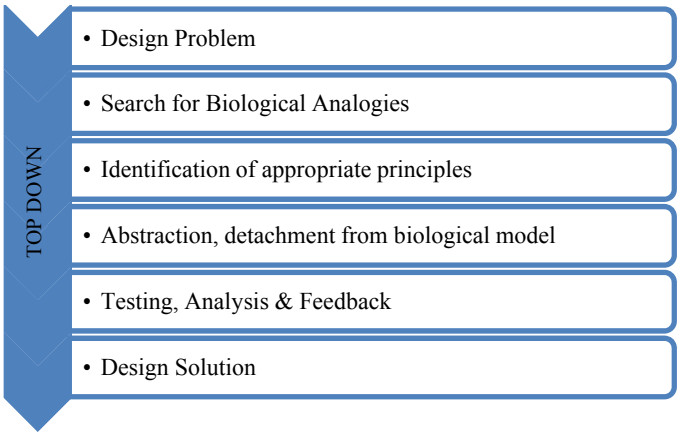


**Figure 1: Top down approach**

An example of such an approach is DaimlerChrysler's prototype *Bionic Car*. In order to create a large volume, small wheel base car, the design for the car was based on the boxfish *(ostracion meleagris),* a surprisingly aerodynamic fish given its box like shape. The chassis and structure of a car are also biomimetic.

In this model, the designers are able to research different biomimetic solutions even though they do not have in depth knowledge of biologist or ecologist and just by mere observations. But due to this, the translation of such knowledge into a design setting remains at shallow level.

**Solution-Based Approach:**

As stated in the previous approach, this approach was also found to have different naming such as ―Biology Influencing Design, Bottom-Up Approach and Solution-Driven Biologically Inspired Design.

When biological knowledge influences human design, the collaborative design process is initially dependent on people having knowledge of relevant biological or ecological research rather than on determined human design problems.

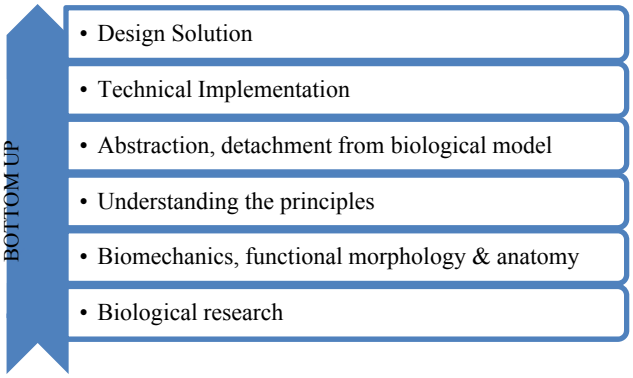


**Figure 2: Bottom up approach**

A popular example is the scientific analysis of the lotus flower emerging clean from swampy waters, which led to many design innovations as detailed by Baumeister, including Sto's *Lotusan* paint which enables buildings to be self-cleaning.

This approach proves to be advantageous as it influences the design solutions that are unthoughtful in technology & approaches. The main disadvantage from a design point of view is that firstly the biologist or ecologist must recognize the potential & hence application to the solutions.

## 4. Biomimicry as a holistic approach

Life, the collection of processes that tamed and maintained themselves on planet Earth's once hostile surface long ago confronted and solved the fundamental problems facing all organisms. Given life long history of persistence it is logical to then be a guide for the living world.

### Nature as Model, Measure, and Mentor

Biomimicry is a new way to look at nature. If we consciously look for its genius, we may look at it as a model, measure & mentor.

### 4.1. Nature as Model

People tend to draw new models from nature to provide insights for design solutions for day to day life. If we look at nature, it's a whole identity that is supporting all the relevant systems interdependent & interdisciplinary in respect to each other's need. A community in nature not only balances the whole bunch but rather tells us to stay put while balancing the ecosystem. It teaches us to optimize rather than maximize.

### 4.2. Nature as measure

When the question arises that whether nature is providing the right guidance & innovative behaviors and decisions, the nine laws of nature, Life's Principles leads the path. One measure of rightness is ensemble living. In nature, an ensemble is a group of harmonizing parts that contribute to a single effect. It means to establish a dynamic stability.

The nine principles are:

a) Nature runs on sunlight.
b) Nature uses only the energy it needs.
c) Nature fits form to function.
d) Nature recycles everything.
e) Nature rewards cooperation.
f) Nature banks on diversity.
g) Nature demands local expertise.
h) Nature curbs excesses from within.
i) Nature taps the power of limits

### 4.3. Nature as mentor

The relationship with nature changes from a master to mentor. The new relationship between this teacher – the source of knowledge or rather a trusted friend, counselor which has an experience of over 4.2 billion of evolution years helps the humans to create complex, efficient, resilient and adapted systems. The answer to all our problems is given by nature as in terms of what is appropriate and what lasts as survivors. As mentees, we humans should show humility rather than arrogance towards it.

## 5. Levels of Biomimicry

There are 3 levels under which nature can be translated into built environment:

a) Organism level: In this an organism itself is referred for designing a space or building shape.
b) Behavioral level: mimicry of a specific type of behavior of any organism or nature to the living condition for its existence.
c) Ecosystem level: it is referring to the ecosystem in context to its functionality and also the parameters or principles that help for its behavior.

### 5.1. Organism level example:

**Project: The Minister of Municipal Affairs & Agriculture (MMAA) in Qatar**

The architect was keen to design a building that responds well to the hot and dry climate of Qatar without increasing the cooling and electrical load. The team starting studying "Cactus plant" which is the most prevalent plant in desert area and survives the harsh weather conditions by incorporating certain natures gifted technology for survival.

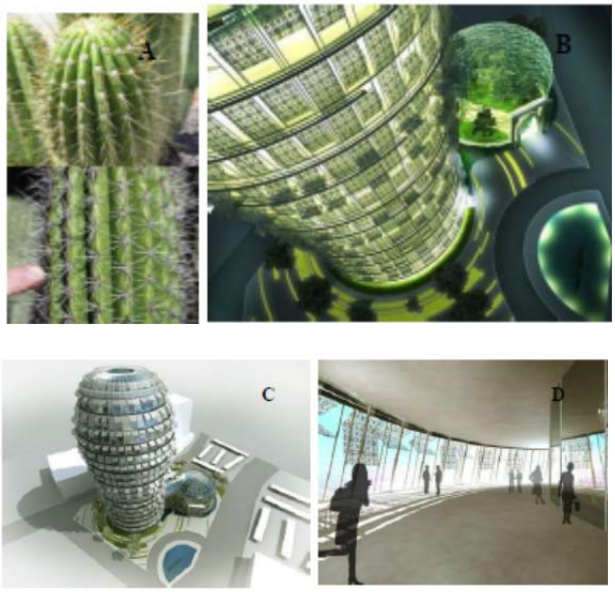


**Figure 3: Fig. 3a Cactus plant, Fig. 3b & Fig. 3c exterior shades & Fig. 3d interiors**

**Biological investigation**:

The main characteristic of a cactus is the "spines" that serve more than just one purpose. Firstly the spines are for protection from herbivorous animals. Secondly to channelize the rain water to the base of the plant where it gets collected and stored. The above two not necessarily applies for a building but the most important function that was adopted by the designers was that the spines help shade the plant from the intense sun.

**Mimicry of shading device of cactus to building form**:
Architects designed the MMAA in Qatar using these natural techniques to create a unique sustainable solution addressing the problem.

The building imitates the cylindrical shape that is rounded at the top to help reduce heat gain from the roof and also to avoid straight planes in façade. Most importantly they incorporate sunshades on the façade of the building which act like screens to the sunlight penetrating into any spaces. These shades work automatically to adjust its angle up and down as per the climatic requirement and desired interior temperature, to get only diffused light and avoid glare and heat gain from sun. This technology not only reduces the cooling load of the building but also makes use of the building façade to contribute for the climatic responsive architecture technique which makes it aesthetically appealing also. [10]

### 5.2. Behavioral level example:

**Project: East gate tower in Zimbabwe**
The main climatic issue while taking up the designing of this tower was the temperature variation from 3 °C up to 43 °C and where the air condition plays a significant role in Zimbabwe.
The architects were in a dilemma to whether design the building as per cold or hot climate condition which makes the building energy efficient also.


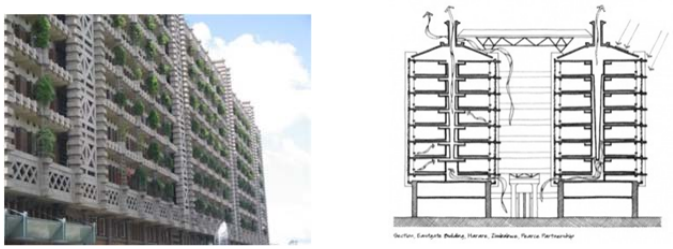

**Figure 4: Eastgate center tower, Zimbabwe inspired from termite mound**

**Biological investigation**:

The architect finds solution by studying the termite mounds in Africa which has a remarkable ability to maintain a constant temperature throughout despite of the temperature variation outside. By researching through the mound structure and having studied the way a constant temperature is maintained the most astonishing discovery was made which can influence human building design in hot and dry climate. The insects do this by continuously opening and closing vents throughout the mound to enhance convection currents of air - cooler air is drawn in from open lower sections while hot air rises and escapes through the vent opening outside.

**Mimicry of passive cooling techniques of termite mound to building form**:

The innovative building uses similar behavior in the design, and air circulation planning it stays cool without air conditioning and uses less than 10% of the energy used in similar sized conventional buildings, hence moving towards a more sustainable building [12]. His solution was to have specially designed hooded windows, variable thickness walls and light colored paints as a part of a passive-cooling structure to reduce heat absorption. By doing so East gate uses 90% less energy for ventilation than conventional building its size and has already saved the building owners over $3.5 million dollars in air conditioning costs [7].

### 5.3. Ecosystem level example:

**Project: Habitat 2020**
Biomimicry design is not only adopting the design from the nature but also considering how to make use of nature for various functions of a building like heating and cooling system, daylighting and ventilation. Working at ecosystem level means mimicking elements and principles that are required for it to function successfully.

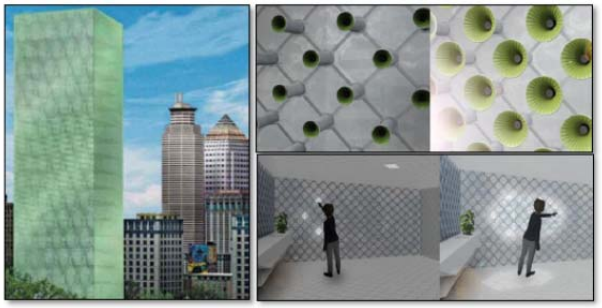

**Figure 5: Living skin of Habitat 2020, China**

**Nature based integration of design elements**:
The Earthships are designed to integrate with nature based on six natural design principles:

a) Constructed with recycled and local materials: Tiers, sand bags, adobe etc.
b) Heating and Cooling: From the sun and the earth.
c) Water Harvesting: Caught on the roof from rain and dew mimicking the Namibian beetle bumpy body.
d) Renewable Electricity: Photovoltaic / wind power system. This energy is stored in batteries and supplied to electrical automated outlets, including grid-intertie.
e) Sewage: Grey water from bathing, washing dishes is separated from black water from the toilet. The grey water is used and filtered for a second time in interior botanical cells. The flush toilet is the third use of the water, which is contained, treated and used a fourth time in exterior botanical cells.
f) Food production: Food is grown inside with botanical planters and outside in landscape irrigated with treated gray water [10].

The Habitat 2020 building envisioned for China is a future forward example of biomimetic architecture that fuses high-tech ideas with basic cellular functions to create 'living' structures that operate like natural organisms. Within this cityscape, buildings open, close, breathe and adapt according to their environment. The exterior has been designed as living skin, rather than composing different materials to create a façade. The skin may be considered as the leaf surface having several cellular openings involved in gaseous exchange and transpiration in plants. The surface would allow the entry of light, air and water into the housing. It would automatically position itself according to the sunlight and let in light. The air and wind would be channeled into the building and filtered to provide clean air and natural air conditioning. The active skin would be capable of rain water harvesting where water would be purified, filtered, used and recycled. The skin could even absorb moisture from the air. The waste produced would be converted into biogas energy that could be put to diverse uses in the habitat [14], [21].

## 6. Conclusion and Future Enhancement

Application of Biomimicry principles and aspects has become a reality by exploring the basic facts for design strategies. It can be used as a realization tool for valiant architectural design problems and sustainable built environment. The paper highlights the journey of realization of biometrics can be used as model, principles and way to genuine out of box solutions and approach.

Although this discourse tends to be theoretically at present time, the ideas are still to be tested against time in built form, sustainable and even regenerative ecosystems which have the potential to transform the entire performance benchmark of built environment.

## References

[1] Benyus, J.M., 2007. Transdisciplinarity: Innovation inspired by nature (3rd ed.). N.Y. William and Morrow & Co

[2] Benyus, J. "Biomimicry Innovation inspired by nature". New York: Perennial, 2002

[3] Brandon, Peter S., P.L. Lombardi, & V. Bentivegna (Eds.). (1997). Evaluation of the built environment for sustainability

[4] D.C. Wahl, "Bionics vs Biomimicry: from control of nature to sustainable participation in Nature". WIT transactions on Ecology and the environment, 289-298,2006.

[5] Helms, M., Swaroop, S. V., & Goel, A. K. (2009). Biologically inspired design: process and products. Elsevier

[6] Knippers, J. (2009). Building & Construction as a Potential Field for the Application of Modern Biomimetic Principles. International Biona Symposium.

[7] "Learning from Termites How to Create Sustainable Buildings", http://biomimicry.net/about/biomimicry/case-examples/architecture/

[8] M.P. Zari, "Biomimitic Approaches to Architectural design for increased sustainability", sustainable building conference, Aukland 2007

[9] M.P. Zari, "Biomimetic Design for climate change adaptation and Mitigation", Architectural science review, 172-183, 2010

[10] Mansour,H. "Biomimicry: a 21st century design strategy integrating with nature in a sustainable way", BUE , FISC 2010 – 12

[11] Pedersen Zari,M. & Storey, J.B. (2007) An Ecosystem Based Biomimetic theory for a regenerative built environment. Lisbon Sustainable Building Conference 07,Lisbon Portugal

[12] Pawlyn, M. (2011) Biomimicry in architecture, London

[13] Pawlyn, M. Biomimicry in architecture. London: RIBA publishing, 2011.

[14] Rao ,R."Biomimicry in Architecture", International Journal of Advanced Research in Civil,Structural,Environmental and Infrastructure Engineering and Developing ,vol. 1 (3), 08,Apr-2014.

[15] Roseland, M. (2000). Sustainable community development: integrating environmental, economic and social objectives.

[16] Sue L.T. McGregor, "Transdisciplinary and Biomimicry", Transdisciplinary Journal of Engineering and science, The Atlas, ISSN: 1949-0569,57-65,Vol-4,2013

[17] Van Bueren, Ellen and Jitske de Jong. (2007). Establishing sustainability: policy successes and failures. Building Research & Information

[18] Zari M.P. (2010). Biomimetic design for climate change adaptation and mitigation, Architectural Science Review.

[19] Zari, M.P. (2012). Ecosystem services analysis for the design of building research and information.

[20] Zari, M.P. "Biomimetic approaches to architectural design for increased sustainability", School of architecture, Victoria University, PO Box 600, Wellington, New Zealand

[21]http://inhabitat.com/habitat-2020-off-the-grid-future-abode