Learning through Biomimicry

Dr. Amit Kumar
Department of Electronics
Bhaskaracharya College of Applied Sciences (University of Delhi)

Abstract— Nature acts as huge manufacturing unit where the faults are kept minimal by taking most suitable materials for all purposes recycle these and even by changing the ingredients as per imposed conditions. The biomimicry is the science of examining natural models and imitating these designs for providing solutions to people's problems. The objectives of this paper are to introduce, review and find relevance and methodology of this subject in present educational system.

Key words: Biomimicry, Biology-to-Design Approach

I. INTRODUCTION

During our childhood we all have fantasized to fly like birds, swim like fish or have eyesight like a bat. The uniqueness of each organism to fully adapt its own environment by responding to its needs and finding solutions for its living, nature got its evolution. So the biological systems are the ideally structured for performing certain tasks which inspires human to mimic them in designing new products and finding solutions to various problems. The designs which are seen in birds, animals, fish, plants *etc.* more often proved to be superior to what engineers could come up with for the same task. The science of copying such natural designs for the purpose of technological advancement is regarded as biomimicry. The widespread practical application of biomimicry as designing tool has been realized. The initial attempts while making manmade flying machines, both Leonardo da Vinci and Wright brothers studied the way birds and insects fly. In fact modern planes are only the imitations of controlled flight of birds. Even today engineers are trying to find out new inspirations for latest design trends to meet military aspirations like miniaturization of airplanes with wingspans less than six inches (MAVs, Micro Air Vehicles).Some other examples of imitated products that are proven to be world engineering marvel are discussed below:

1) An older example of biomimicry is Velcro, or hooks and loop fasteners which was patent in 1951 by Swiss engineer George de Mestral. He took the idea from cockleburs stuck to his clothes and his dog's fur after a hike. He began the Velcro Company in 1952 to manufacture manmade imitation of hook and loop fasteners, since then it is in use. Recently in 2009 Dean Cameron got International Next Big Thing Award for inventing a new joining system that replaces screws, bolts, glue, flanges and nails. This system is expected to be industrial Velcro, named as Joinlox system and could find applications in products ranging from food crates, pipes, cars, planes and bridges.
2) The color shifting property of Morpho butterfly's wing used by Japanese company Tejin Fibres Limited to make a fibre material Morphotex. It is composed of sixty-one layers of two separate polymers with different refractive indices using nanotechnology. It uses light interference rather than dyes or pigments to create color so requires less energy and proven to be more eco-friendly.
3) A group of researchers from University of Leeds set up a company in 1998 named Sound Foresight designed and manufactured device called UltraCane. This device was developed to assist the vision impaired to find out their way and it used the sound waves to locate objects in front of the users. This device was imitation of echolocation mechanism used by bats to find their way and avoid even small objects in total darkness. This device uses a small electronic echolocation device which is attached to a white cane and provides sensory feedback through the cane's handle.
4) The New York based Panelite's ClearShade insulating glass is based honeycomb. It is designed by making hub of tubular polycarbonate core just like on hub of bee hive creating the hexagonal structure. The light rays can only make it through when hit glass perpendicularly so when sun is highest in sky at midday it becomes most obscured. This makes Clear Shade glass to have low shading coefficient and have low solar heat gain coefficient. In fact Panelite claims it as four times better than typical insulating glass unit.
5) In University of Utah, scientists created synthetic glue imitating the sandcastle worm that makes a protective home out of beads of zirconium oxide. This glue is capable of repairing fractured bones.

There are number of more biomimicry examples which produce technological innovations and ideas each taking inspiration from nature's genius [1].

II. OVERVIEW

Janine Benyus, the pioneer women, a biologist regarded as leader in the emerging discipline of biomimicry defined it as imitation from natural forms and processes to solve the problem of human being [2].The word "Biomimetic" driven from "bios-life" and "mimesis-to imitate" i.e. learning from nature. She stated that for more sustainable future biomimicry can lay the foundation as world around us is living encyclopedia. However, she argued that biomimicry neither refer to just reproduction of natural objects/system nor it is designing something considered to be "green" or sustainable. It is to be emphasized that learning about nature is one thing but learning from nature is another. The biomimicry first do a close examination of organism or ecosystem and then perform the meaningful application of its underlying principles in the form of natural solution. The natural world around us presents time-tested patterns (after 3.8 billion years of evolution) and solutions

to all problems we are facing today. In addition to this, these solutions come with natural thrust as well since following nine features added to it:

1) Nature runs on sunlight
2) Nature uses only the energy it needs
3) Nature fits form to function
4) Nature recycles everything
5) Nature rewards cooperation
6) Nature banks on diversity
7) Nature demand local expertise
8) Nature curbs excesses from within
9) Nature taps the power of limits.

The challenge is to deduce the procedures adopted to take these time-tested natural ideals into sustainable designs for human purposes. It is not that simple as it seems and people who want to incorporate biomimicry into their design may not know starting point. There are several approaches that have been utilized in using biomimetics as a designing tool for various fields of study. All of these methods either find a design problem and then look for ways the other organism or ecosystem have solve it, or find out specific feature in an organism or ecosystem and then translate the same into a design for solving human problem. The former method is called top-down approach, or problem based approach, or design looking to biology, while later referred as bottom-up approach, or biology influencing design [3]. In order to function either of these approaches a framework for the application of biomimicry is necessary. At different levels of mimicry form, process and ecosystem have to be identified. It is essential however that design to imitate the characteristics of an individual organism, or to be inspired by how organism behaves, or to draw from the entire ecosystem of organism and its surrounding.

Biomimicry is becoming design methodology itself by considering nature as model and design process to entirely new innovative levels at full potential. There might be a cross fertilization of ideas but at the end juggernaut of biomimicry will provide ideal solution to the problem. Benyus think that a "biomimetic revolution" will happen in the following years if this learning process is popularized in all disciplines like architecture, sculpture, painting, interior architecture, industrial designs *etc*. The fact is that global patent involving biomimetics designs have been increased by a factor of 93 from 1985 to 2005 which is a sufficient proof of it becoming an interested field [4]. More people seemed to be invested and interested in the field of biomimicry because it has produced some of the most successful and innovative designs seen today. The evolution in the biomimetics field also enhanced knowledge about our own species.

III. CONVENTIONAL DESIGNS VERSUS BIOMIMICRY

Any design tool adopted by designer will look for novel ways to achieve the purpose. For any design process it is necessary to set new standards and follow the cross-disciplinary innovative approach. The conventional designing process begins with defining the design problem, followed by research to start ideation phase. The multiple variations of ideas may come up which could solve the purpose but the final implementation phase will be targeted by narrowing down the ideas and choosing one the only best to accomplish the successful design. However, the methodology adopted for biomimicry designs function on the deep pattern of life. It is based on the simple rules and principles of nature for the survival over long-haul. Biomimicry is an iterative process which also includes challenges and slowly evolves to adapt the environmental and social conditions. So biomimetic design has to begin from somewhere and then continue with possibility of going back for making this better. For a critical analysis of both design tools, let us look these side-by-sides in following comparison chart [5].

Conventional designing (technology by human)	**Biomimicry (biology by nature)**
Designers create that does existed	Biologist study that exist naturally in all its splendor
Technology enhanced by inventions, discoveries, development and planning	Evolution by process of natural selection (Darwin Principle)
Designs could be borrowed from others based on history	Designs are followed natural inherited plans based on genetic codes and evolution
Designers tend to use geometrical shapes using right angles with affinity for flatness	Nature use curves and gradual gradients with very few flat surfaces
Involve manipulating with addition of something and discarding the unused	Involve reassembling the something and optimizing with little to no waste
Overproduction resulting in excess, waste, pollution	Protection due to conservation
Based on what technology can provide	Based on what is needed and nature provides

Both human designers and nature deals with same variables but natural biomimetics designs are more sustainable, protective and optimized.

IV. METHODOLOGY FOR BIOMIMICRY

Biomimicry could be applied during the design process in either of two ways: biology-to-design or design-to-biology. The first approach is solution driven in which interesting biological phenomenon is taken as motivation for the appropriate application. The second approach is problem driven wherein for a given problem; biological analogy is identified then tried for design solution. The following paragraphs discuss the basic principles of these two methods [6].

V. BIOLOGY-TO-DESIGN APPROACH

Biology-to-design method involves designers to get inspiration from a biological model with potential qualities which could provide new design ideas. The qualities of so designed product determined, by functional requirements and design parameters for the product. A stepwise procedure for biology-to-design biomimicry is presented in Fig. 1. The invention of the Velcro hook and the fastener is an indicative example of biology-to-design biomimicry.

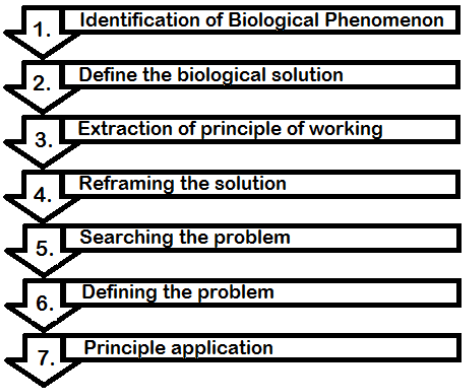

Fig. 1: The procedure for Biology-to-design Biomimicry

The disadvantage of this approach is that a biological research must be conducted at the initial stage itself and then identify the relevant design context. It could prove to be more time consuming where biologist and ecologist must be able to understand the potential application.

VI. DESIGN-TO-BIOLOGY APPROACH

The design-to-biology approach is adopted when a specific problem is solved through mimicking a natural model. The stepwise procedure for biology-to-design biomimicry is presented in Fig. 2.

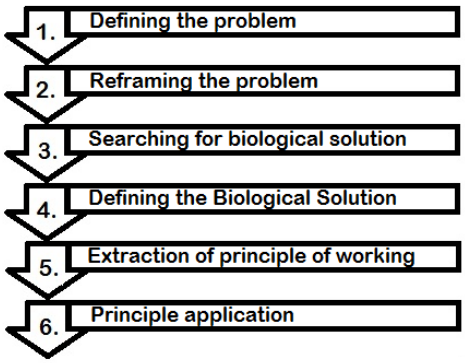

Fig. 2: The procedure for Design-to-biology Biomimicry

Another model named spiral method introduced by Biomimicry Institute is based on above approach. This model focuses on six stages similar to described in Fig. 2. The above two approaches indicates that the biomimetic solution could be either from designer's discussion with biologist or biologist offering nature's solutions to designers.

VII. PRESENT & FUTURE FOR BIOMIMETICS

Even though biomimetics is used from past but until it been acknowledged last decade, it was not considered as subject. Generally, the study of biomimetics is still in its initial phase which suffers some research challenges. The initial breakthrough in the field of biomimicry is credited to Janine Benyuswho have written more than six books related to biomimicry. She founded the Biomimicry Institute, which is known for creating a groundbreaking database called AskNature.org. It contains nature's answers to many complex design challenges. Benyus received Time Magazine's Heroes of the Environment award in 2008 and got the prestigious Heinz award in the sum of $100,000 in 2011. Since 2005 she is appearing in TED, the non-profit organization devoted to ideas worth spreading and shared the ways how nature can influence our current design and technologies. Few examples that suggest why biomimicry is important for the further developments and should be imitated [7].

- Whales and penguin can drive without oxygen tubes
- Multi-frequency transmission of bats is more efficient than the radar
- Damsel flies can be out on maneuvers even better than the best helicopters
- Air conditioning and ventilation in thermite towers is more energy conversant
- DNA helix's capacity to collect data
- Polar fishes and frogs can revive after they are have been frozen for a long time and that their organs are not damaged owing to ice

At present where we are on the verge of losing about a quarter of all species, biomimicry proves to be more than a designing tool. In fact it happens to be the immediate rescue mechanism by telling us the more sustainable ways to live on

earth. The biometrics offers the innovative design solutions which have the potential, if implemented correctly, to produce a revolutionary series of devices and designs that have never thought today. In future we could live in or work in those places that are designed to function like a living organism that specifically adapted to that particular place and is able to get all of their needs for energy and water from surrounding nature. Now on it is possible that architecture get inspired not from 21-century machines rather from bird that fly in sky or flower that lives in landscapes near them.

VIII. CONCLUSIONS

The above discussion reveals that biomimicry is a powerful tool, especially in the designing methods which can bring harmony between civilization and environment. That is along with time-tested exact and stronger functions that nature utilized for working. These methods driven from perfect natural phenomenon that contributes to correct technologies. To the expansion of biomimetics, education system today needs the curriculum so designed that learners could be able to learn the instructions from nature perfect order for the further development and we will be able to utilize everything that existed in nature, in compliance with rules that facilitated the evolution. Also workshops and events must be organized to facilitate the knowledge exchange between biologists and designers. We must set a biomimetic mind set and attitude to have holistic development-the development with nature and by nature.

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