BIO-MIMICRY: - AN INSPIRATION TO DESIGN AND ENVIRONMENTAL PROBLEMS.

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Abstract:
Human activities have gradually and continuously been a source of the degradation of the environment especially through construction activities. Building construction and its related activities has been the major consumer of between 30 to 40% of the global energy consumption according to the studies carried out by United Nations Environmental Programme (UNEP). Although building Construction can be seen as a necessary human need in other to provide shelter, however this essential need can be attained with minimal impact to the environment through the science of bio-mimicry, (the conscious copying of nature to resolve human problems either directly or indirectly).
Bio-mimicry looks into nature as a teacher, as it looks at human being not to be the only creative inventor but rather, it tries to look at other species that have survived with the environment through a symbiotic relationship, where they have sustained themselves not by destroying the surroundings, but by adapting to them and enriching it through cleaning of the air as can be seen in plants and also through the production of organic matter which enriches our soils. However Man has unconsciously been distancing itself from the wonderful teacher (nature) as a lot of problems facing man can be copied directly from it. This paper takes a look at the science of biomimicry and how it has been applied in the various fields of science and technology. It also draws attention to the various concepts adaptable from the science of biomimicry and how the professionals in the building industry can draw some inspirations into creating environmentally friendly developments.

Keywords. Bio- mimicry, Construction, Environment, Nature, Technology.

INTRODUCTION

The name biomimetics was coined from two Greek word 'Bio' meaning 'life' and mimetic –meaning 'imitation'. It can sometimes also be referred to as Bionics or Bio mimicry. The Microsoft Encarta (2006) defined bio mimicry as the application of biological methods and systems found in nature to the study and design of engineering systems and modern technology.

The study of bionics emphasizes implementing a function found in nature rather than just imitating biological structures. It involves conscious copying of examples and mechanisms from natural organisms and ecologies in a form of applied case-based reasoning. Nature itself is treated as a database of solutions that already works. The selective pressure placed on different living organisms

forces the development of solutions to the challenges placed upon them.

The evolutionary forces usually forces living organisms including plants to become highly efficient and adaptive to the environment upon which they live in. A classical example is the development of dirt- and water-repellent paint from the observation that the surface of the lotus flower plant is practically un-sticky for anything. The core idea is that nature, imaginative by necessity, has already solved many of the problems that are being grappled with. Animals, plants, and microbes are the consummate engineers. They have found what works, what is appropriate, and most important, what lasts here on Earth. What surrounds us is the secret to survival.

The science of biomimetics has been asking questions such as, how energy can be harnessed efficiently, how materials can be produced sustainably and also how to live healthy within the environment.

THE PRINCIPLES OF BIOMIMICRY

Biomimicry is based upon two basic principles, the principles of nature and the principles of the qualities of successful organisms. These principles are summarised by Nick (2008) as shown in the table below.

Table 1.

PRINCIPLES OF BIOMIMICRY		
SN	**PRINCIPLES OF NATURE**	**QUALITIES OF SUCCESSFUL ORGANISMS**
1	Nature banks on diversity	Uses waste as a resource
2	Nature demands local expertise	Gather and use energy efficiently
3	Nature curbs excesses from within	Diversify and cooperate to use habitat
4	Nature taps the power limits	Optimise rather than maximize
5	Nature is beautiful	Uses material sparingly
6	Nature runs on sunlight	Don't foul their resources
7	Nature fits form to function	Don't deplete their resources
8	Nature uses only the energy it needs	Remain in balance with the biosphere
9	Nature rewards cooperation	Run on information
10	Nature recycles everything	Shop locally

The principles of biomimicry, source The Lotus Live Guide to Biomimicry (2008)

BIOMIMICRY INSPIRATIONS.

There are a lot of natural inspirations around, by looking at nature for natural, non-toxic solutions to environmental problems, all of these are done with the aim to free the environment from the negative impacts and also to put man's activity on the road map of becoming a productive member of the earth community.

The holy Quran enjoins man to reflect upon the environment and what is contained in it as there are signs for those who reflect. Quran (2:164).

Sean (2004) is of the opinion that Design solutions can draw inspiration from many sources, including the anatomy, physiology, and behaviour of living systems. It is a well known fact that the Wright brothers were avid bird watchers, and their airplane wing design was modelled after birds (Microsoft Encarta

2005). The development of planes wouldn't have been possible without the study of birds and copying them as was rightly done by the Wright brothers.

I. Inspirations from termites.
Living organisms such as termites have been a source of inspiration to some wonderful creations. Termites are found to be able to regulate and maintain the internal temperature within their mound. They do it by venting breezes in at the base of the mound, down into chambers cooled by wet mud carried up from water tables far below, and up through a flue to the peak (Abigail 2009)

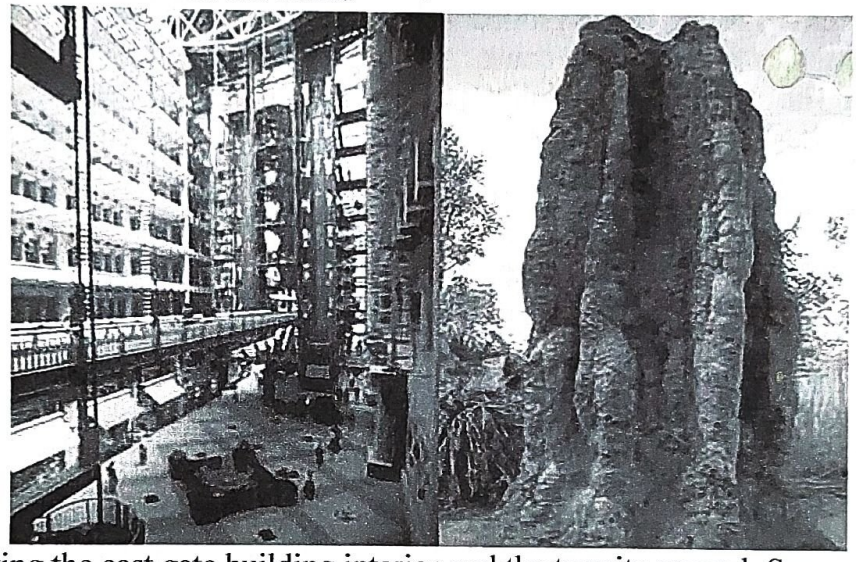

Plate 1: Showing the east gate building interior and the termite mound. Source: www.inhabitat.com/author/abigail

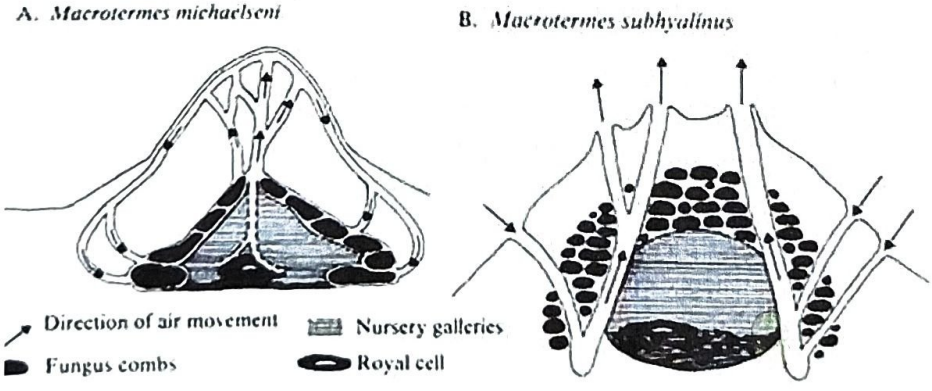

Plate 2. Air movement in a termite mound. Source www.inhabitat.com/author/abigail

This principle of temperature regulation was adopted by Architect Mick Pearce in the construction of the East gate Building in Harare, Zimbabwe (Scot and Rupert 2008). The energy consumption of the building was reduced to less than ten percent of a conventional building its size. Here the principle of bio mimicry applied here is that of a process copying. The average size of a termite is 12.7mm and they could construct their mound up to the height of 8.4meters which is 661 times their size, while on the other hand

the tallest building in the world the Khalif towers in Dubai commissioned in 2010 with a height of 800 meters is just 500 times taller than the average height of man (1.6meters). Even though throughout the world the Khalif tower is seen as an ultimate achievement, we still have a long way to go considering what has been achieved by ants.

Termites are observed for their ability to build magnificent nests out of the ground more skilfully than a human being could (Harun 2009). The skill of these tropical architects (termites) is undisputed in building cities that seem to appear out of nowhere. Their ease in finding building materials and technical skills are amazing. Every species of termite builds different kinds of nests suitable to their needs. These nests can be found inside trees, on or under the ground. Nests that are shaped like mountains are architecturally very complex. The construction of all the nests begins underground, where compartments become more spacious as they approach the surface.

Termites like man live on almost every continent, except in Polar Regions. Sudden rain storms and ensuing floods, high temperatures and other negative conditions make their life a struggle, no matter where they live. But despite all this, they live in these regions in perfect harmony with their environments in what can be called a cooperative comfort.

II. The spider web inspiration.

Biomimetics is explored towards the development of different biomaterial, most notably spider silk as well as robots based on animal models. Spider silk is one of the most sought after biomaterial, This material, produced by special glands in a spider's body, has the advantage of being both light and flexible, and has been found to be three times stronger than steel (Sean 2004). The incredible properties of spider silk are attributed to its unique molecular structure as shown in figure 1.

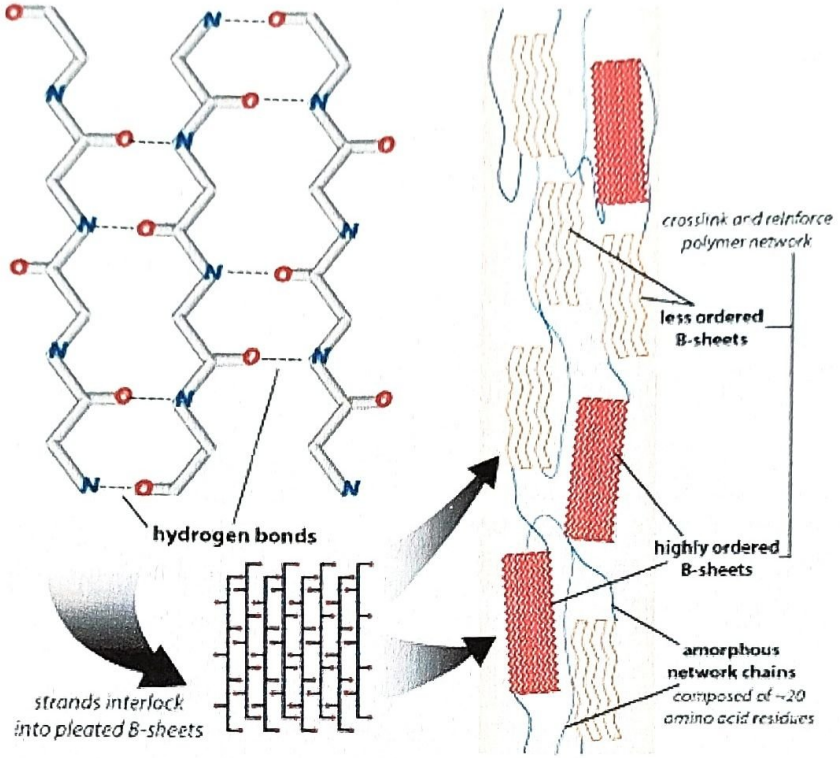

Figure 1. The structure of a strand of silk.
Source: science creative Journal 2004.

The study of the molecular structure of the spider web had inspired the generation of similar material for applications in the field of medicine, to create a new form of strong, tough artificial tendons, ligaments and limbs that are equally light weight. Spider silk could also be used to help tissue repair, wound healing and to create super-thin, biodegradable sutures for eye or neurosurgery, as well as being used as a substitute for Kevlar a material used for the production of bullet proof vests

III.The cockroach leg inspiration.

The legs of the cockroach has also been an inspiration toward the creation of robotic legs

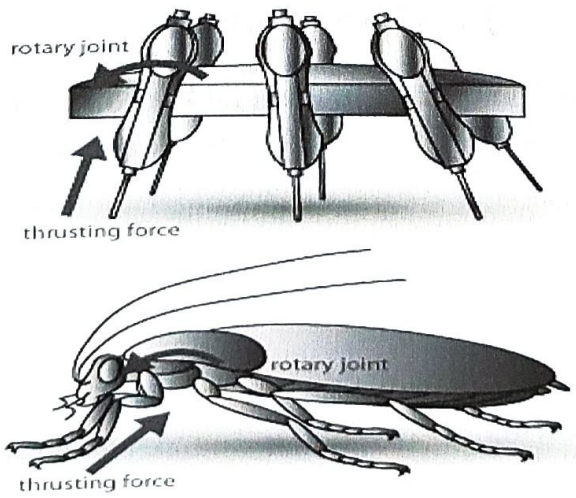

Figure 2. The cockroach leg as a prime candidate for biomimicry. Source :science creative journal 2004.

This was done by the mimicry of the leg and joint structure of the cockroach. The study of the ground reaction forces in cockroach locomotion, the direction of the forces relative to the hip joints, and the different movements of the individual legs was mimicked, to design and build sprawl legged robots that can move very quickly and also be able to manoeuvre in changing terrains.

IV. The Box Fish Inspiration.

When Mercedes-Benz engineers were trying to design a new aerodynamic concept car they focused on the obstruction cubicus, also known as the boxfish for inspiration (designboom 2009). This fish has a rather large body, but is able to swim very fast because of its low co-efficient of drag and rigid exoskeleton. By identifying the similarities between cars and the boxfish, the designers began modelling a new vehicle after the boxfish. Their final design had an unusual form that looked like a boxfish and after testing proved to have one of the lowest co-efficient of drag that had ever been tested. The plates 3 and 4 show the similarities of the physical structure of the fish and that of the Mercedes car. The concept of bio mimicry applied here is that of the physical appearance.

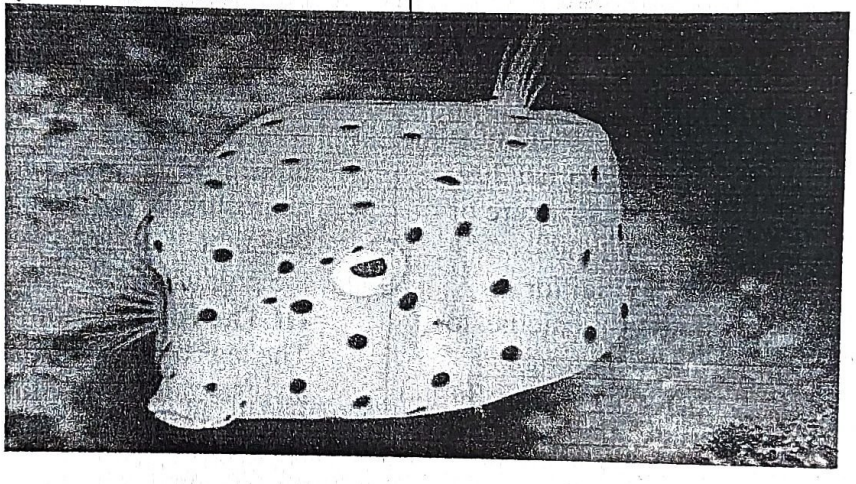

Plate 3: the box fish (ostracion cubicus) source: www//designboom.com (2009)

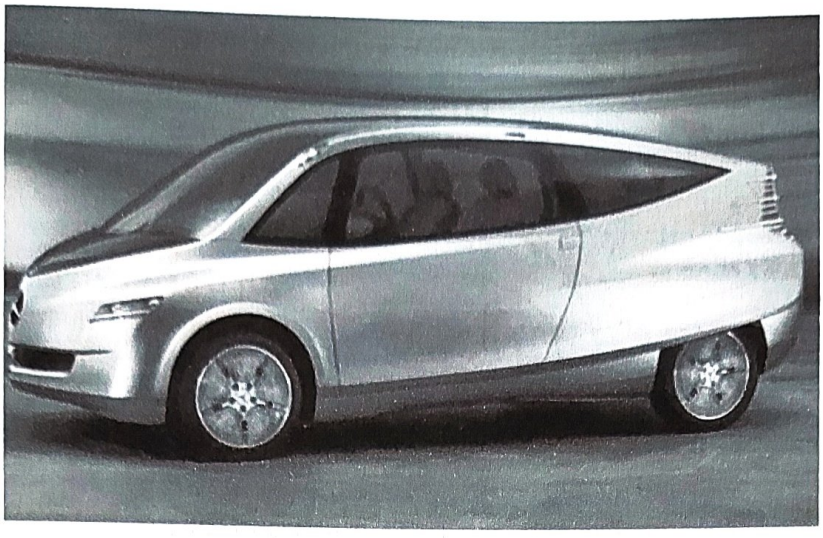

Plate 4: Mercedes-Benz bionic concept vehicle. Source: www//designboom.com (2009)

V.The dragons fly inspiration. The Munich Olympic Stadium.

Dragonfly wings are one three-thousandth of a millimetre thick. Despite being so thin, however, they are very strong since they consist of up to 1,000 sections (Harun 2008). This is as a result of the compartmental structure of the wings which do not tear, and are able to withstand the pressure that forms during flight. The roof of the Munich Olympic Stadium was designed along the same principle of compartmentalisation

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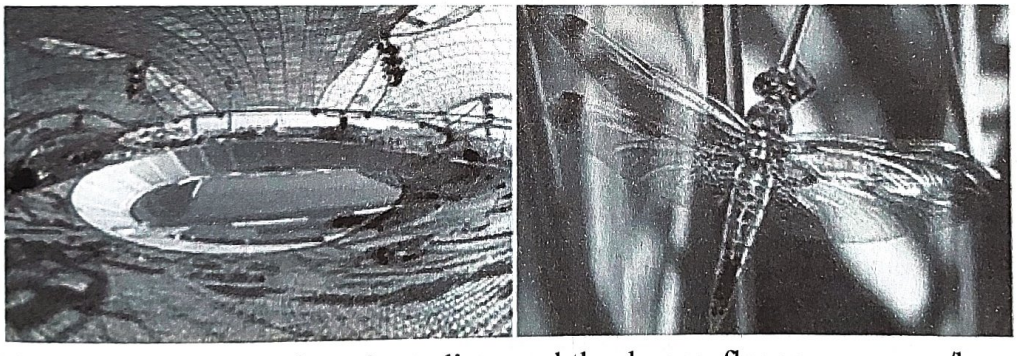

Plate 5.The Munich Olympic stadium and the dragon fly: source www/harunayaha.com:

APPLICATION OF BIOMIMICRY.

The application of bio mimicry using Carl Hastrich, design spiral as explained by bio mimicry institute's website (2009) gave the following illustration (fig3)

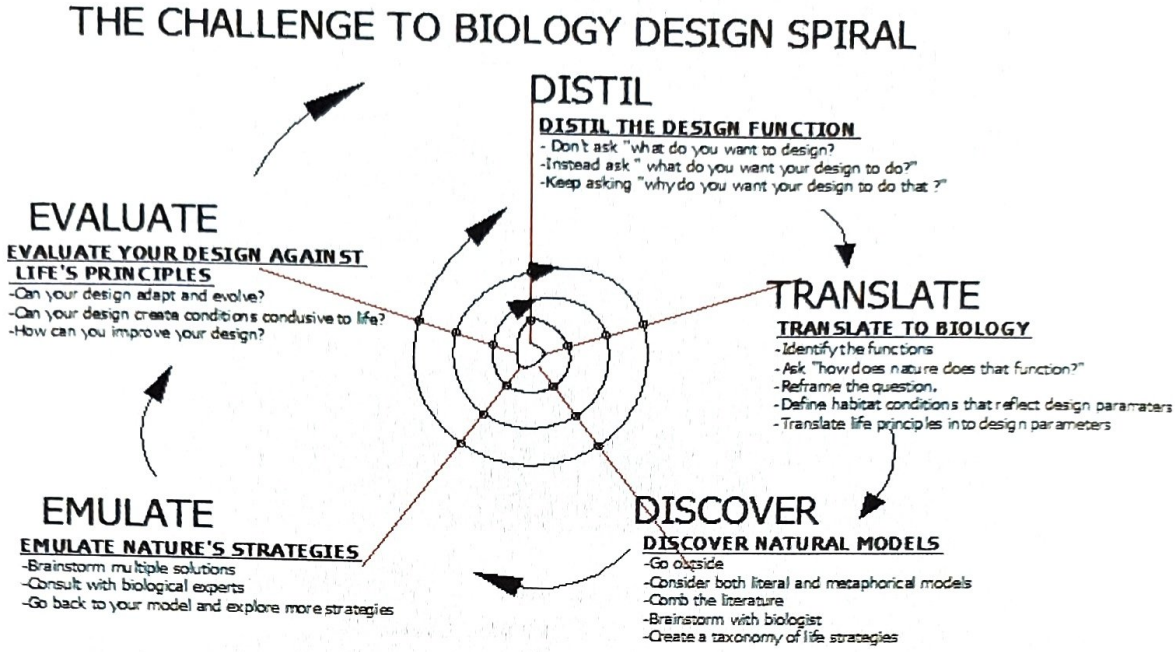

Fig 3. Carl Hastrich design spiral. source: www//biomimicryinstitute.org (2009)

The design spiral explains how the science of bio mimicry can be applied to solve any design problem. This is distinctively divided into six steps.

1. Identification of problems.
2. Translation of problems.
3. Observation from nature.
4. Abstract.
5. Application
6. Evaluation.

1. Identification of problems.

This involves the development of a design brief of the human need, and it constitutes the following steps

i. Development of a design brief with specifications about the problem to be resolved

ii. Breaking down of the design brief to identify the core of the problems and the design specifications

iii. Identification of the function that the design wants to accomplish.

iv. Definition of the specifics of the problem:

2.Translation of problems

This involves looking at nature to solve the problem raised by the design brief, here the problems are interpreted to see how nature carries out such functions and the following conditions are also taken into consideration, location of the subject, the Climate conditions, Nutrient conditions, the Social conditions and the Temporal conditions

3.Observation.
This involves looking at nature for answer to resolve the challenges and finding organisms that are most challenged by the problem at hand and are unfazed by it.

4.Abstract
This involves the uncovering of repeated patterns and processes within nature that had achieved success. This is further broken down into:-

i. The creation of nomenclature of life's strategies

ii. The selection of the champions with the most relevant strategies particular to the design challenge.

iii. Collation from the lists of repeating successes and principles that achieved success.

5.Application
This stage involves the use of ideas and solutions based on the natural models. This is enumerated as follows.

a) **Mimicking Form**: This principle can be seen to have been applied by the manufacturer of Mercedes Benz manufacturers that mimicked the box fish to achieve an aerodynamic shaped vehicle.

b) **Mimicking Function:** This principle can be seen to have been applied in the construction of the east gate building in Zimbabwe where the principle of venting the termite mound was applied in ventilating the structure naturally.

c) **Mimicking Ecosystem**: This concept involves the study of the eco system as a whole and how the various individual units relate with each other in perfect harmony.

6. Evaluation
This is the stage at which the ideas generated are compared to life's principles. It also involves an assessment of the design in comparism with life principles. It is at this stage that the design can be judge to be good or not and whether it will require going through another circle of design spiral.

CONCLUSION

Biomimicry aims at revolutionizing the process which natural system employs to accomplish a perfect co existence. The mimicry of a biological system in all its totality is neither feasible nor attainable, but the selective application of a process can lead to a lot of innovative solutions to a long standing problems. As noted earlier, the design by Architect Piearce who designed the East gate building using the ventilation principles found in termite mound, helped in reducing the energy consumption that would have been required in ventilating the structure. On the other hand a deep study of the possibility of mimicking the secretion generated from the termites may lead to the improvement of mud as a local building material which is found to be readily available. There are a lot of such natural models out there to be explored. Biomimicry holds the natural models for the sustainable and eco-friendly

developments of the future. All that is required is the study of the natural models in the environment. The paper hopes to be a window for present and future designers into looking at the modern approach of imitating nature to tackle environmental challenges.

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