Biomimicry

Subjects: Others

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Biomimicry can be defined as the branch of science for developing technology by mimicking nature, where forms and structures of creatures are the basic sources of inspiration to come up with optimized design solutions.

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1. Introduction

Wildlife species need efficiency in their processes: a simple mistake in the hunt of a prey or defending against a predator can draw the line between life and death. The mechanisms that enable organisms to thrive in their ecosystems can be imitated or adapted for different purposes[1]. These efficient processes occur at different levels, including molecular ones. Biomolecules have the potential to interact with each other and to self-organize in a functional way. In this sense, several products explore this self-organization process at the molecular level, creating new solutions[2].

2. Application

The application of such concepts to industrial projects may begin from one of two starting points[3]: (a) solution-to-problem, where a known biological solution is applied to suitable problems; or (b) problem-to-solution, where a particular problem is tackled by searching for biological solutions to analogous natural challenges.

In 1960, Steele[4] defined the word “bionic” as the science of systems that have some functions copied from nature. The use of this method draws attention to what one can learn from nature instead of what can be extracted from it[5]. The basic concept is that engineers and designers should pay attention mainly to the details and designs of natural systems, using them as a source of inspiration for effective, self-sustainable, renewable and definitive solutions to the problems that compete with environmental sustainability[6]. According to Zhang[7], biomimicry can be achieved at different levels, including, (1) imitating the form or function of nature, (2) imitating natural processes and (3) imitating natural systems; where the first is seen as the most common approach.

When we carefully analyze nature’s projects and systems, we understand why these are considered the best example of eco-friendly design and why they deserve great attention from those who seek to solve problems related to sustainable technologies in energy, medical engineering, materials and technological innovation. Among its specifications, there is the operation with sunlight, restricted use of the necessary energy, recycling, containment of excesses and adjustment of form to function[6]. Bionics is a systematic research tool that relates to biological mechanisms, which are systems and subsystems that allow the interaction of the design parameters with the natural characteristics of the analyzed elements[8]. The main objective of biomimetics is to provide a better understanding of the solutions and strategies used by nature in 3.8 billion years of evolution and their possible implementation in current technological practices[8][9].

Nature provides resources and conditions for all organisms to grow and reproduce. Those that take better advantage of these factors, in a process that may take thousands or millions of years to happen, can be considered as more adapted. For an organism to adapt, it is necessary that its morphology, physiology and ecology are modified creating new structures that allow this living being to succeed in its habitats and niche[1]. For example, it is common knowledge that marine mammals such as whales and pinnipeds, which have their ancestors common in terrestrial mammals, had their forelimbs modified for swimming, thus adapting to the new needs that the aquatic environment demanded[10][11].

The adaptations developed often have functions that are not obvious to the observer; for instance, even though cactus spines are efficient tools for defense, there are more functions for these structures[1][12]. Since the thorn is a modified leaf, it took this form to reduce water loss once cacti had their habitat mostly in arid regions. In addition, the proximity of the spines makes the cactus shaded, and with this, its internal water distribution becomes more efficient[13].

Another process that we can mention is the convergent evolution, where organisms that are not phylogenetically related develop similar characteristics and for the same purpose[1]. As an example, we can observe the wings of birds and the wings of bats. While the two groups had different terrestrial ancestors, they evolved independently into animals with flying ability. The bat's wing is an extension of the interdigital epithelial membrane connected between its fingers, which are more elongated than those of other mammals, while the wings of birds are a feather-covered structure attached to its arm that has been fused to its forearm[10][11].

Thus, it is extremely important in biomimicry projects to understand the actual origin of structures, that is, how organisms have adapted to the most different challenges and environments, and the most varied functions of the same structure, including the least obvious ones[14]. This wide comprehension allows designers to create more efficient products, guaranteeing that their success is not accidental[15].

Nowadays, it is possible to find biomimetics applied in several areas, mainly in materials with different functions, ranging from anti-repellant surfaces, adhesive stamps, anti-abrasive coating, glue and rubber to medical applications, ceramics, color changing materials, light-weight strong materials, thermo isolation materials, and so on[16].

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