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Biomimetics: An Overview

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Abstract

Biophysics is an interdisciplinary science that explores relation between Biology and Engineering. Biomimetics or Biomimicry is a science of bioengineering that is immensely popular and attempts to synthesize materials that imitate bio inspired structures. This article relates the introduction, principles of Biomimetics. It also explores the challenges and applications of Biomimetics.

Keywords: Biomimetics; Engineering; Nature; Materials; Nanotechnology

The relation between Physics and Biology is very interesting. Biophysics explores the relationship between Physics and Biology by elucidating Biology with help of Physical principles. Biophysics explains principle behind the living organisms like cells. The requirements in near future demand the understanding of biophysical principles of various living organisms. Recent understanding of principles prompted a new field of science – Biomimetics. Historically, the term 'biomimetics' was first used by Otto Schmitt during the 1950s, when he made a distinction between an engineering/physics approach to the biological sciences, which was termed 'biophysics', and a biological approach to engineering, which he termed biomimetics [1]. Biomimetics is a research field that is achieving immense prominence through a wide variety of new discoveries in biology and engineering.

Biomimetics or biomimicry, as it is called, is a method for creating solutions to human challenges by emulating designs and ideas found in nature. Biomimetics is the field of scientific trial, which attempts to design systems and synthesize materials by using biomimicry [2]. Bio inspired structures are very robust and highly functional. Human kind had a constant fascination to copy nature. From times immemorial, man has tried to imitate nature and understand the principles behind the natural findings. First known imitation of nature – desire to fly like birds. Leonardo Da Vinci observed the flight of birds and made numerous sketches of the perception. The first known successful imitation of nature is Velcro. Some other examples of biomimetics are Shinkansen bullet train, harvesting desert fog like beetles, shark skin covered boats, spider web glass, gecko feet adhesives, firefly light bulbs, humanoid robots, etc. Multifunctional materials and high strength materials form a section of bio mimicking.

Exclusive studies have been dedicated to studying the principles behind various living organism in nature. Natural selection often shapes the surfaces of organisms in interesting ways to adapt them to the environment where they reside. Designers have picked up on these adaptations and are finding new uses for them. Nextgeneration biomimetics combines biology with other technology in solving problems. In particular, nanotechnology is becoming a key discipline that will be utilized to help understand the material and its structures. The greatest challenge faced by biomimetics is to determine how nano- and microstructures function in their relationship with the organism and the environment. Nanotechnology refers to the design and creation of objects on an atomic or molecular scale. As humans don't operate in these scales, we have often looked to nature for guidance on how to build things in this tiny world. Understanding phenomenon at nano scale is very complicated. Nanoscience is the study of ability to manipulate atoms at the atomic level ranging from one to several nanometers in order to understand, create and use material structures, devices and systems with fundamentally new properties and functions resulting from their small structure. The damage caused by humankind to the nature may be minimized by biomimetics as nature can help in avoiding this pattern. Biomimetic structures made of multiple cells would allow for the design of devices and mechanisms that are impossible with today's capabilities. Emerging nano-technologies are increasingly enabling the potential of such capabilities.

Usage of biomimetics in Engineering involves: a) search of relevant technologies, b) analysis of solutions, c) identification of underlying principles, d) final product. During the implementation of functional principles and manufacturing processes found in biological solutions into technical developments ('biomimetics'), new findings arise that, in turn, contribute to a deeper insight into the functioning of the biological concept generators ('reverse biomimetics') [3]. Commonly used approaches to biomimetics are either problem driven or solution based. Both of them have different starting points and different stages of development.

The solution-based approach describes the biomimetics development process in which the knowledge about a biological system of interest is the starting point for the technical design. The biological system of interest performs a function that shall be emulated in technology. This biological system must be understood in depth in order to extract underlying principles and to define design problems which could be addressed using these principles. The knowledge concerning these principles is primarily gained from fundamental research. After their abstraction the biological principles may be applied in technology. The solution-based approach is therefore closely connected to the steps of the technology knowledge transfer process from scientific to industrial organizations.

On the other hand, the problem-driven approach is the biomimetic development process that seeks to solve a practical problem, with an identified problem to be the starting point for the process. New or improved functions may be applied via identifying biological systems, which perform a certain function or mechanism, and by abstracting and transferring these principles to technology. The problem-driven approach is closely connected to the problem-solving process.

The main challenges involved in successful biomimetic prototyping are lack of technology to support manufacturing at scale, and uncertainty about relevant models. The greatest challenge faced by biomimetics is to determine how nano- and microstructures function in their relationship with the organism and the environment. In promoting the coexistence of nature and humans, the economic, environmental, and social aspects of biomimicry are increasingly in demand and greater is the scope of application [4]. The integration of biomimetics in biomedical engineering is advancing technology in many ways. Biomimicry has the best potential to be harmonious with nature while resulting in better outcomes than any artificial means of development. Advancement in Biomimetics has a potential for technical development with nature friendly evolution.

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