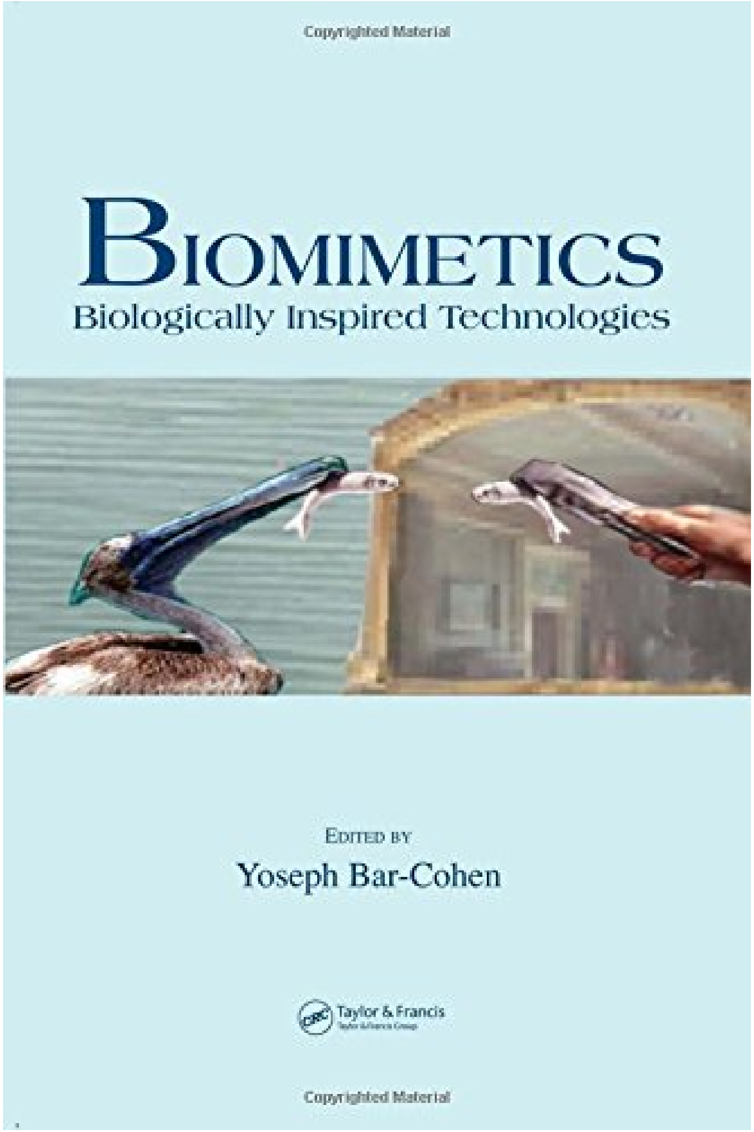
Biomimetics: Biologically Inspired Technologies

Yoseph Bar-Cohen
*DOC | *audiobook | ebooks | Download PDF | ePub*



#2715179 in Books CRC Press 2005-11-02Original language:EnglishPDF # 1 10.00 x 1.25 x 7.01l, 2.68
#File Name: 0849331633552 pages | File size: 19.Mb

Yoseph Bar-Cohen : Biomimetics: Biologically Inspired Technologies before purchasing it in order to gage whether or not it would be worth my time, and all praised Biomimetics: Biologically Inspired Technologies:

0 of 0 people found the following review helpful. Useful informationBy eva espunyVery interesting information about natural systems.The book was easy to understand, well structured, and did answer to my expectations. A very inspiring lecture.3 of 9 people found the following review helpful. Aspects of Emerging BiotechnologyBy P. NagyFeaturing extensive illustrations, including a 32-page full-color insert, Biomimetics: Biologically Inspired Technologies provides unmatched breadth of scope as well as lucid illumination of this promising field.Imagine a smart microchip that is

buried in the ground for a long time. Upon certain triggering conditions this chip begins to grow and consume materials from its surroundings, converting them into energy and structural cells. As the chip grows further, it reconfigures its shape to become a mobile robot. Using its recently created mobility, the chip becomes capable of searching and locating critical resources consuming them to grow even more. The type and function of the specific cells that are formed depend on each cell's role within the growing structure. This science-fiction scenario is inspired by true-life biology such as the growth of chicks from an egg or plants from a seed. Yet given all our technological advances, it is still impossible to engineer such a reality.Bionics as the term for the field of study involving copying, imitating, and learning from biology was coined by Jack Steele of the US Air Force in 1960 at a meeting at Wright-Patterson Air Force Base in Dayton, Ohio (Vincent, 2001). Otto H. Schmitt coined the term Biominietics in 1969 (Schmitt, 1969) and this field is increasingly involved with emerging subjects of science and engineering. The term itself is derived from bios, meaning life, and mimesis, meaning to imitate. This new science represents the study and imitation of nature's methods, designs, and processes. While some of its basic configurations and designs can be copied, many ideas from nature arc best adapted when they serve as inspiration for human-made capabilities. In this book, both biologically inspired and biologically mimicked technologies are discussed, and the terms biology, creatures, and nature are used synonymously.Nature has always served as a model for mimicking and inspiration for humans in their desire to improve their life. By adapting mechanisms and capabilities from nature, scientific approaches have helped humans understand related phenomena and associated principles in order to engineer novel devices and improve their capability. The cell-based structure, which makes up the majority of biological creatures, offers the ability to grow with fault-tolerance and self-repair, while doingall of the things that characterize biological systems. Biomimetic structures that are 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.The beak of birds may have served as an inspiring model for the development of the tweezers and the tong. While it is difficult to find evidence that it had inspired early humans, one can argue that since nature invented this device first it was a widely known concept way before humans began making tweezers and tongs. The mimicking of the beak is illustrated graphically on the cover page, of this book, where a virtual mirror is drawn to represent the inspiration of adapting nature's capabilities. Although enormous advances have been made in the field of biomimetics, nature is still far superior to what we are capable of making or adapting. Given the limitation of today's technology, copying nature may not be the most effective approach. Many examples exist where humans using nature as inspiration have used its principles to invent far more effective solutions; flying is one such example. This book focuses on the technologies that resulted from both mimicking and being inspired by biology.Nature evolves by responding to its needs and finding solutions that work, and most importantly, that last through innumerable generations while passing the test of survival to reach its next generation. Geological studies suggest the presence of life on Earth as early as 3.8 billion years ago (Lowman, 2002). Specifically, in Greenland, a series of ancient metamorphosed sediments were found with carbon isotope signatures that appear to have been produced by organisms that lived when the sediments were deposited. Furthermore, fossil evidence indicates that ancient bacteria, Archea (Archaebacteria), have existed on the Earth for at least 3.5 billion years (Schopf, 1993; Petr, 1996). After billions of years of trial and error experiments, which turn failures to fossils, nature has created an enormous pool of effective solutions. It is important to note however that the extinction of a species is not necessarily the result of a failed solution; it can be the result of outside influences, such as significant changes in climate, the impact of asteroids, volcanic activity, and other conditions that seriously affect the ability of specific creatures to survive. The adaptations of nature have led to the evolution of millions of species each with its own way of meeting its needs in harmony with the environment (Research Report, 1992).Through evolution, nature has "experimented" with various solutions to challenges and has improved upon successful solutions. Organisms that nature created, which are capable of surviving, are not necessarily optimal for their technical performance. Effectively, all they need to do is to survive long enough to reproduce. Living systems archive the evolved and accumulated information by coding it into the species' genes and passing the information from generation to generation through self-replication. Thus, through evolution, nature or biology has experimented with the principles of physics, chemistry, mechanical engineering, materials science, mobility, control, sensors, and many other fields that we recognize as science and engineering. The process has also involved scaling from nano and macro, as in the case of bacteria and virus, to the macro and mega, including our life scale and the dinosaurs, respectively. Although there is still doubt regarding the reason for the extinction of creatures such as the mammoth, it may be argued that the experiment in the evolution of mega-scale terrestrial biology failed. While marine creatures such as the whales survived, nature's experiment with large size terrestrial biology ended with the extinction of the prehistoric mega-creatures (e.g., dinosaurs and mammoths). Such creatures can now he found only in excavation sites and natural history museums.As the evolution process continues, biology has created and continues to create effective solutions that offer great models for copying or as inspiration for novel engineering methods, processes, materials, algorithms, etc. Adapting biology can involve copying the complete appearance and function of specific creatures like the many toys found in toy stores, which are increasingly full of simplistic imitations of electro-mechanized toys such as dogs that walk and bark, frogs that swim, and such others. However, while we have copied or adapted many of nature's solutionsan enormous number of mysteries remain unravelled. Humans have learned a lot from nature and the results help surviving generations and continue to secure a sustainable future.Biology offers a great model for imitation, copying and learning, and also as inspiration for new technologies. Flying was inspired by birds using human developed capabilities, whereas the design and function of fins, which divers use, was copied from the legs of water creatures such as the seal, goose, and frog. But the distinction between technologies resulting from the various adaptive approaches is not always clear. For instance, studying photosynthesis in a leaf may lead some to argue that the invention of the solar cell is an imitation, while others may see it as a biologically inspired technology. While both photosynthesis and solar cell use sunlight as a source of energy, they neither perform the same process nor create the same output.Biologically inspired terms such as male and female connectors, as well as teeth of a saw are common, and it is very clear to us what they mean. Other terms derived from biology the usage of which are clearly understood include the heart to suggest the center, the head to indicate the beginning, the tot or tail to imply the end, the brain to describe a computing system. Likewise, the use of the terms intelligent or smart suggests the emulation of biological capabilities with a certain degree of feedback and decision making. Other terms include aging, fatigue, death, digestion, life cycle, and even "high on the food chain" (referring to a high management level). In the world of computers and software many biological terms are used to describe aspects of technology including virus, worm, infection, quarantine, replicate, and hibernate. Other forms of imitating nature comprise virtual reality, simulations and copying of structures and materials. Shapes are also used as recognizable terms where the dog-bone provides a clear description of the shape of test coupons that are used to measure the tensile module and strength of materials. Structures are also widely copied, for example the honeycomb. Used for its efficient packing structure by bees (which is different from its use in aerospace - for low weight and high strength), the honeycomb has the same overall shape in both biological and aerospace structures. It could be reasoned that the honeycomb structures, which are used in many of the aircraft structures of today's airplanes, were not copied from the bees (Gordon, 1976). However, since it is a commonly known structure invented by nature many years before humans arrived, no patent can be granted in the "patent court" of nature to the first human who produced this configuration. Generally, biological materials (Chapter 14), including silk and wool that are widely used in clothing, have capabilities that surpass those made by humans. This superb capability of biological materials, structures, and processes has been the subject of imitation in artificial versions of materials.Plants can also offer a model for imitation (Chapter 19). Besides their familiar characteristics, some plants exhibit actuation capabilities that are expected of biological creatures. Such plants include the mimosa and the Sensitive Fern (Onoclea sensibilis) that fold or close their leaves when touched. There are also bug-eating plants with a leaf derived trap "door" that closes and traps unsuspecting bugs that enter to become prey. Examples of such plants include the Venus Flytrap (Dionaea muscipula) and the Pitcher plant (Sarracenia purpurea). The sunflower tracks the sun's direction throughout the day to maximize exposure to its light. Plants have evolved in various ways, and some have produced uncommon solutions to their special needs. For example, some desert plants have flowers that produce the malodor of rotten meat, and some even have a brown color that appears very much like decomposing meat. Such characteristics are critical for these plants to attract flies, rather than bees, to pollinate their flowers.This book reviews the various aspects of biomimetics from modeling to applications as well as various scales of the field from cell to macro-structures. Chapter 1 provides an overview of the field of biomimetics addressing technologies that mimic biology versus those that adapt its principles using biology as an inspiring model. Chapter 2 describes biological mechanisms as models for mimicking. Chapter 3 examines the mechanization of cognition and the creation of knowledge, and the various aspects of processing by the brain as a basis for autonomous operation. Another angle of this issue is covered in Chapter 4, where evolutionary robotics and open-ended design automation are described. One of the widely used biologically inspired algorithms, the genetic algorithm, is described in Chapter 5 using a mathematical imitation of evolution and natural selection. Robotics is increasingly inspired by biology and robots that are close imitation of animals and humans are emerging with incredible capability as described in Chapter 6. The details of making a biological system as a model are discussed in the following chapters where biologically inspired molecular machines are described in Chapter 7 and molecular design of biological and nano-materials in Chapter 8. The next two chapters deal with biological and artificial muscles with Chapter 9 describing engineered muscle actuators and Chapter 10 covering the topic of artificial muscles using electroactive polymers (EAP). An important aspect of biology and systems is the use of sensors and Chapter 11 covers the topic of vision as an example of bio-sensors. One of the unique characteristics of biological materials and structures is their multifunctionality and these materials are covered in Chapter 12. Other aspects of biological systems that offer important models for imitation are described in the chapters that follow. Chapter 13 covers defense and attack strategies and mechanisms in biology; Chapter 14 covers biological materials in engineering mechanisms: Chapter 15 describes mechanisms and applications of functional surfaces in biology. One of the critical issues of operating systems is that of control and Chapter 16 examines the issue of biomimetic and biologically inspired control. Interfacing the body with artificial devices is covered in the next two chapters with Chapter 17 describing interfacing microelectronics and the human body and Chapter 18 covering artificial support and replacement of human organs. Plants also serve as a model for inspiration and Chapter 19 describes the topic of nastic structures, which are active materials that enact and mimic plant movements. Chapter 20 of this hook includes an overview, description, challenges, and outlook for the field of biomimetics.This chapter provides an overview of some of the key biology areas that inspired humans to produce an imitation. This includes making artificial, synthesized, inspired, and copied mechanisms, as well as processes, techniques, and other biomimetic aspects.

Nature is the world's foremost designer. With billions of years of experience and boasting the most extensive laboratory available, it conducts research in every branch of engineering and science. Nature's designs and capabilities have always inspired technology, from the use of tongs and tweezers to genetic algorithms and autonomous legged robots. Taking a systems perspective rather than focusing narrowly on materials or chemistry aspects, Biomimetics: Biologically Inspired Technologies examines the field from every angle.The book contains pioneering approaches to biomimetics including a new perspective on the mechanization of cognition and intelligence, as well as defense and attack strategies in nature, their applications, and potential. It surveys the field from modeling to applications and from nano- to macro-scales, beginning with an introduction to principles of using biology to inspire designs as well as biological mechanisms as models for technology.This innovative guide discusses evolutionary robotics; genetic algorithms; molecular machines; multifunctional, biological-, and nano- materials; nastic structures inspired by plants; and functional surfaces in biology. Looking inward at biological systems, the book covers the topics of biomimetic materials, structures, control, cognition, artificial muscles, biosensors that mimic senses, artificial organs, and interfaces between engineered and biological systems. The final chapter contemplates the future of the field and outlines the challenges ahead.Featuring extensive illustrations, including a 32-page full-color insert, Biomimetics: Biologically Inspired Technologies provides unmatched breadth of scope as well as lucid illumination of this promising field.