

Cultural implications of biomimetics: changing the perception of living and non-living

Abstract

Living and non-living objects are usually considered two separate domains; however, the emergence of biomimetics has affected the perception of what is living and what is non-living. In this paper, I review how the problem of living vs. non-living was defined in different cultures throughout history, and how this problem evolved with the development of science. Biomimetics involves the step of abstraction and provides new ways of borrowing engineering solutions and models from the living nature to the domain of artificially designed objects thus bridging these two domains. The rising interest towards biomimetic technology is caused, on the one hand, by the realization that the power of the traditional technology is limited and, on the other hand, by the idea that nature provides almost ideal solutions to many problems. The cultural background and ideological implications of biomimetics and biomimicry are discussed.

Keywords: biomimicry, biomimetics, domains, cultures, engineering solutions

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Introduction

The definition of life and the difference between the living and nonliving nature have been among key issues of the philosophy of science for centuries; however, an exact and rigorous definition still remains elusive.¹ Most modern definitions of life are descriptive, and they imply that living objects are characterized by such features as homeostasis, reproduction, organization, metabolism, growth, adaptation, and response to stimuli.²⁻⁴ However, besides scientific definitions, there are also perceptions of what constitutes living and non-living objects. These perceptions are culture-specific. The emergence of biomimetics influences the perception of living and engineered objects being two separate realms, since biomimetic engineered objects are similar to living ones. A significant growth of interest towards biomimetics in materials science and in other areas of engineering occurred in the past decade. Biomimetic materials and devices mimic living nature including living organisms and plants, or at least these materials and devices are inspired by living objects or they borrow certain properties or design approaches from nature. There are significant differences between the traditional engineering design approaches and those inspired by nature. Engineers typically have blueprints of their final product, which often uses traditional engineering materials such as metals, which require high temperatures and pressures to produce, while nature utilizes composite materials and hierarchically organized structures. Organisms in nature are usually grown by self-organization while adapting to changing environmental conditions without having a blueprint of the final result, but using hierarchical organization and iterative DNA-coded algorithms. Biomimetic design should borrow some of these approaches from nature. For example, in material engineering this would mean more concentration on composite, nanostructured, materials with hierarchical architecture, metamaterials and similar, rather than on traditional engineering material choice.

The emergence and spread of biomimetics, i.e., mimicking of living nature for engineering applications, has affected how the difference between the natural and artificial is perceived. Although engineered biomimetic devices, materials and systems are certainly

not living objects, they can mimic some characteristics of the latter including self-assembly, self-repair, self-replication and adaptation.⁵ The growth of biomimetic research and engineering is a part of a more general paradigm shifting, and it should be viewed in the context of the social and ideological implications of the biomimicry regarding the human/nature relationship. Since the 19th century and until the mid- 20th century, the dominating human attitude toward nature was the belief that science and technology would eventually provide almost unlimited power to conquer and transform nature in a way comfortable to humans. Examples include plans to turn rivers (e.g., the Siberian rivers reversal) and move mountains (e.g., elimination of Mt. Vysokaya in the Middle Urals in Russia) effectively reformatting the natural environment. However, in the second half of the 20th century, it became obvious that it is impossible to solve many economic and social problems just by attempting to conquer nature. The human-nature relationship is much more complex, and humans can benefit by learning from living nature rather than trying to change it. As a result, new areas such as “ecology” and “holism,” which emphasize the harmony between humans and nature, became increasingly popular. The emergence of biomimicry is a part of this trend.⁶ An interesting aspect of biomimetics is that both technological progress and the protection of the environment are possible, at least in theory, although it needs to be proven by better practices.

In this paper, I analyze the aspects of biomimetics and biomimicry related to these ideological and social trends as well as to the perception of the difference between natural and artificial objects. In the following section, the history of views on how living objects are different from non-living ones in different cultures is reviewed.

Living vs. non-living in various cultures

I start with the discussion of how living and non-living was viewed in different cultures throughout history.

Animism

The oldest and most archaic system of quasi-religious views is the so-called *animism* defined as the belief that all objects, places and

creatures possess a distinct spiritual essence or soul. The concept of *animism* was developed in 1871 by anthropologist Edward Tylor.⁷ According to animist views, all things including animals, plants, rocks, rivers, and products of human work, are animated and alive. Animist beliefs were typical for ancient pre-urban Paleolithic and Neolithic societies, as well as for many indigenous cultures of modern time.

According to animist beliefs, there is no difference between living and non-living, or, more accurately, all things are living. Therefore, the starting point for the analysis of the concept of living vs. non-living is the emergence of inanimate objects.

Egypt, Mesopotamia, and the ancient middle east

In the ancient science, since its emergence in Egypt, Mesopotamia, and other regions, the concept of life was related to the idea of the living or vital *force* which sustains life. The latter idea was related to the concept of force in general.

Ancient Egyptians did not have science in the modern sense of the word; however, they developed certain concepts which may be viewed as pre-scientific.

One of these concepts is the idea of “force” called NHT (Egyptian hieroglyphs are traditionally transliterated by consonants, since their vowel reading is not known), which, depending on the context, might mean a physical force, a divine force sent to the earth, or a living force sustaining order and life.⁸ The hieroglyph used for the word NHT had a form of an arm holding a knife (Figure 1). The same hieroglyph was also used for the name of the Pharaoh Djoser (27th century BCE) of the 3rd dynasty, famous for the Step Pyramid of Saqqara. One of the earliest and best known sources where the concept of NHT is used is in the story of Setne Khamwas:

“A Power of God (NHT) was sent down from heaven, saying, ‘Do not allow Nenefkerka- Ptah to go to Memphis, he prospering with every person belonging to him, all.’ At a moment, that which happened, Merab the child came out from under the shade of the pleasure-boat of Pharaoh. He fell into the river, he did the will of Ra. Every person that was on board uttered a cry, all. Nenefkerka-Ptah came out from under his tent, he spoke a writing to him, he made him leap up, there being power of god (NHT) as water resting upon him.”⁹



Figure 1 The Egyptian hieroglyph NHT meaning force.

A similar concept was developed in Mesopotamia, where force was personalized by Enlil, who represented not only force in the sense of brutality and might, but also as an ordering power. A similar concept was used in Biblical Hebrew, where several terms for force and might existed, including ליה *hayil*, זוע *'oz*, and חוכ *koah*, all meaning “strength” or “force.” The latter is used in Ps. 29:4: הכב ה לויק “The voice of the Lord is in power.”⁸

Dealing with ancient scientific knowledge it is often difficult to distinguish between science, technology, and ritual. Thus, the famous Egyptian painting upon the tomb of Djehutihotep in Dayr al-Barsha, which shows transportation of a giant structure, is often considered the earliest example (c. 1880 BCE) of water lubrication. This is because a man is shown pouring liquid in front of the statue (Figure 2). However, according to historians, the purpose of pouring water might be ceremonial rather than technical, given that pouring water is parallel to fanning the statue by burning incense.¹⁰

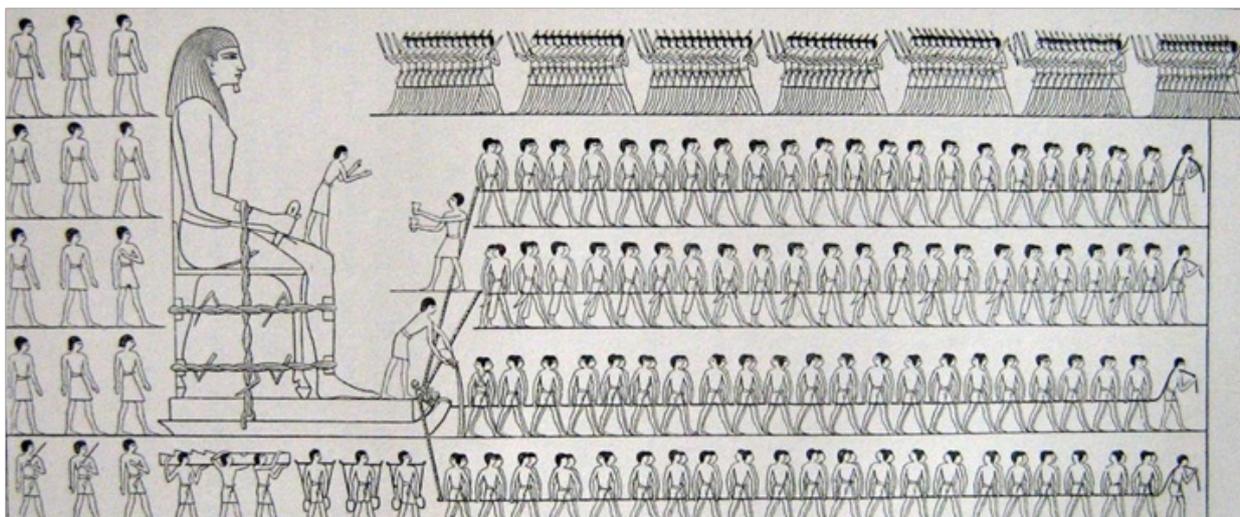


Figure 2 Painting from El-Bersheh, circa 1880 BC, showing transportation of a giant statue. Man in front of the statue pouring liquid from a jar. Some historians suggested that the liquid served ceremonial purposes, whereas some engineers suggested that this is one of the first recorded cases of lubrication. The figure entered many tribology textbooks.

While descriptions of actual biomimetic engineering are absent from Egyptian, Mesopotamian, or Hebrew ancient sources, there are literary motifs of artificial objects mimicking nature. Certainly, the human-like or animal-like artificial objects discussed in these sources should be viewed as literary or legendary characters rather than as real engineering objects. Thus, the Rabbinical homiletic commentary *Targum Sheni* (c. 7th–8th century CE) speaks about the mechanisms in the mythical King Solomon's Throne, which mimicked animals:

“When King Solomon stepped upon the throne, a mechanism was set in motion. As soon as he stepped upon the first step, the golden ox and the golden lion each stretched out one foot to support him and help him rise to the next step. On each side, the animals helped the King up until he was comfortably seated upon the throne. No sooner was he seated than a golden eagle brought the great crown and held it just above King Solomon's brow, so that it should not weigh heavily on his head. Thereupon the golden dove flew over the Holy Ark and brought out a tiny scroll of the Torah and placed it in King Solomon's lap, in accordance with the commandment of the Torah that the Torah shall always be with the king and should guide him in his reign over the Jewish People.¹¹

A somewhat similar account of King Solomon's Throne (نَامِ شَرَع) *arsh Suleyman* in Arabic) is also found in the 27th Surah of the Holy Koran.

Later Jewish tradition depicts an artificial servant (a robot) called the “Golem” (גִּלְגַּלִּים) mimicking a human. The legend originates in the Babylonian Talmud (Sanhedrin 38b, 65a), and the sages concluded that despite that the Golem was created from mud in a similar manner to the first man, Adam, the anthropogenic Golem is not fully human, since it is unable to speak. The Mishnah (2nd century CE) states that there are seven things in which a Golem (“an uncultivated person”) is different from a learned man, all related to speech, articulation, and eloquence: “There are seven things in a Golem and seven in a wise man. A wise man does not speak in front of someone who is greater than him in wisdom or in number, and he does not interrupt the words of his fellow, and is not impulsive in answering, and he asks to the point and answers as is proper, and he speaks to the first, and the last, and about that which he has not heard says, ‘I have not heard’ and he concedes to the truth. And their opposites are the Golem” (Pirkei Avot 5:6).¹²

The human-like or animal-like artificial objects in the ancient period should be viewed as literary or legendary characters rather than as real engineering objects.

Classical Greece and Europe

Ancient Greek philosophy developed a sophisticated system of concepts and ideas dealing with various aspects of the physical world, life, and human knowledge about the world. The three most important schools of Greek thought are Platonic, Aristotelian (peripatetic), and Stoic.

While Plato is viewed as a founder of the idealism, it was Aristotle who laid the foundations of ancient science. Aristotle is most famous for his theory of four interacting elements (water, soil, fire and air); however, his concept of life is related to his understanding of motion and causality. There are four types of causes in Aristotle's teaching: the material, formal, efficient, and final causes. Living objects have the cause of their motion within themselves, while inanimate objects are moved by external causes.

Aristotle has further suggested the concept of potential and actual. Actuality is called *energy* (ἐνέργεια) and *entelechy* (ἐντελέχεια) which denote anything that is currently happening. Just as energy is the activity which makes a thing what it is, entelechy is the end or perfection which has being only during activity. Potentiality or *dunamis* (δύναμις) is a Greek word for possibility or capability.

Aristotle is considered the founder of biology, who described five major biological processes: metabolism, temperature regulation, information processing, embryogenesis, and inheritance. Despite that, Aristotle and his followers, the Peripatetics and mediaeval Scholastics, apparently experienced difficulties in defining how the living is different from non-living. This issue was dependent on the relationship between the actuality and the causality and on the relationship of the four elements. Aristotle believed in the spontaneous generation of life: “Animals and plants come into being in earth and in liquid because there is water in earth, and air in water, and in all air is vital heat so that in a sense all things are full of soul. Therefore living things form quickly whenever this air and vital heat are enclosed in anything. When they are so enclosed, the corporeal liquids being heated, there arises as it were a frothy bubble.” (Aristotle, On the Generation of Animals, Book III, Part 11).¹³

Another attempt to understand how living matter is different from non-living matter was developed by the school of Stoic philosophers. According to them, the so-called “breath of life” or *pneuma* (πνεῦμα) was responsible for the vitality of humans and living creatures. The *pneuma* was viewed as a mixture of the moving element air and warm element fire. While *pneuma* existed even in inanimate objects, in its high form, the *pneuma* constituted the human soul being a fragment of the soul of a god.

According to Henry Dicks, the ancient Greeks understood both technology and art as imitation of Nature.¹⁴ The most famous example of the “biomimetic” design in Greek mythology was Daedalus who fashioned two pairs of wings out of wax and feathers for himself and his son Icarus.

India and Far East

In Asian cultures, breath was considered the force of life similarly to the Greek *pneuma*. In Hindu sources, so-called *prana* (प्राण, the Sanskrit word for “life force”) is responsible for all bodily functions in living beings, although, similarly to the *pneuma*, *prana* is also present in inanimate objects.

A very similar Chinese concept is *qi*, or Chi, which literally translates as “breath” or “gas,” and denotes the “life force” or “energy flow,” which is believed to be a vital force forming part of any living thing. Historically, the word *qi* was written as 气 until the Han dynasty (206BCE–220 CE). After that the 气 graph was used, which is clarified by 米 (‘‘rice’’) graph therefore indicating “steam rising from cooked rice.”¹⁵ The concept of *qi* was also used by the nations who experienced Chinese cultural influence including Vietnam, Korea, and Japan. The parallel concept in the Vajrayana traditions of Tibetan Buddhism is 氣 *Lung*.

Pre-modern and modern science

Various attempts to produce mechanical devices which rebuild plants, animals or humans, are known during the Middle Ages, the Renaissance, and the early modern era. A classical example is clocks

with various mechanical dolls, often animated. It was reported that Haroun al-Raschid's master, al-Jazari, built a clock in the form of an elephant bearing a mahout on its neck, a writer on its back, and a howdah with a third figure at a balcony in the front. At the half-hour, a bird on the top of the howdah turned and sang, and the man in the howdah pointed to an eagle which dropped a ball into the mouth of a dragon.¹⁶ Many European tower clocks had figures of carved "jacks" striking a bell at an hour.

One of the driving forces for the Scientific Revolution of the 17th century was the need to explain the so-called non-manifested forces, which could not be explained by the interaction of Aristotle's four elements. These mysterious forces included gravity, inertia, magnetism, fermentation, and similar phenomena. While gravity and inertia were successfully explained by the revolutionary works of Galileo, Newton and others, the nature of biological phenomena remained to be understood.¹⁷

Most of the early modern and modern (up to the 20th century) science involved the concept of *vitalism*, the belief that living organisms are fundamentally different from non-living entities because they contain some non-physical element or are governed by different principles than are inanimate things.

The concept of the "living force" was deeply connected to the ideas of the physical force and energy in general. In physics, *vis viva* ("living force" in Latin) was a term for kinetic energy in an early formulation of the principle of the conservation of energy proposed by Gottfried Leibniz between 1676 and 1689. The term is still used in astrodynamics for the equation of the orbital-energy-invariance law.¹⁸

In chemistry, it was considered impossible to synthesize an organic material from inorganic compounds until 1828 when Friedrich Wöhler synthesized urea from inorganic components. This experiment is traditionally considered the birth of modern organic chemistry.¹⁹ Louis Pasteur argued in 1857 that fermentation is the process catalyzed by living organisms and thus rebutted the spontaneous generation theory.²⁰

Despite all these advances, vitalist concepts remained popular well into the 20th century. These included bizarre pseudo-scientific theories, such as the "Odic force" (from the name of the Norse god Odin or Óðr) suggested in 1845 by Baron Carl von Reichenbach. "Élan vital" was a term coined by French philosopher Henri Bergson in 1907 for a hypothetical force responsible for the evolution and development of organisms.

Until the discovery of DNA in 1953, various vitalist theories occasionally emerged in biology. Thus, the concept of the "vital substance" presumably responsible for the spontaneous generation of life was developed by Soviet biologist O. Lepeshinskaya, and officially supported in 1950 by the Soviet Academy of Sciences as a "materialistic" theory of inheritance as opposed to "bourgeois idealistic" genetics. Lepeshinskaya's theory was refuted several years later.²¹

Later discussions of the possible "vital force" and its nature were related to the concept of evolution and whether evolution has any objective. One example of this is Orthogenesis, the biological hypothesis that organisms have an innate tendency to evolve towards some goal (teleology) due to an internal driving force, such as increasing biological complexity.²² Another theory, Emergentism, claims that the properties of a system cannot be fully described in

terms of the properties of its parts. Emergentism is sometimes considered a modern form of vitalism.²³

Current general consensus by biologists is that there is no life force other than the genes. However, what constitutes life remains a matter of controversy in the case of viruses and RNA-based life forms.²⁴ It is not unlikely that with the advances of molecular biology and genetic engineering, synthetic DNA and artificial organisms will be synthesized,²⁵ making the definition of natural vs. artificial even more complex.

From modern to post-modern

Besides the scientific definitions of living vs. non-living, there are also cultural perceptions of what life is. Since the 1970s, new post-modern approaches became increasingly popular in literature, art, culture and scholarship. A typical feature of the post-modernist attitude is the conviction that truth is relative and context-dependent. The concept of the "vital force" is often exploited by those who advocate non-traditional medicine, healing, and "New Age" type of esoteric concepts. Many adepts of such teachings consider scientific truth as only one possible opinion among many alternatives to the Western science.

It is typical for these post-modern and post-scientific attitudes to stress cultural diversity and universality of the concept of living force. Thus, many adepts of modern day vitalism would state that the Chinese concept of Chi is similar to the Polynesians *mana*, to the Iroquois *orenda*, and to the Algonquian *manitou*, as the spiritual and fundamental life force. Furthermore, *chi* is the personal spirit of a person *mmúó*, in the Igbo culture where it is the spirit which determines destiny. In Western philosophy, notions of *energeia*, *élan vital*, or vitalism are assumed to be similar.²⁶

Although these "post-scientific" perceptions of living vs. non-living may seem irrelevant to the scientific discourse, they likely played a role in the rise of the biomimicry. Another related trend is the change of the so-called structuralist paradigm in humanities for the post-structuralist paradigm (e.g. the Chomskyan generativist linguistics). While in the humanities and the arts the post-structuralist approach is usually considered "progressive", the case is much more complex in the natural sciences, as will be discussed below.

Ideological perceptions of biomimetics and biomimicry

While biomimetic approaches are embraced by engineers and applied scientists, the fundamental philosophical and societal implications of biomimetics remain much less understood, thus limiting the transformative potential of the biomimetic design paradigm for society at large.

The emergence of bionics, biomimicry, and biomimetics

The word "biomimetics" was coined in the 1950s by the biophysicist Otto Schmitt and it became popular in the 1970s. An alternative term, "bionics," was coined by a medical doctor Jack E. Steele in 1958, originating from the technical term *bion* (βίος, meaning "unit of life") and the suffix *-ic*, meaning "like."²⁷ The term was popularized in the 1970s, and today the word bionics is common in popular culture, whereas the term biomimetics is used in scientific and engineering literature.

The modern definitions of these terms was accepted by the ISO Standard 18458 in 2015, and it states that *biomimetics* is “interdisciplinary cooperation of biology and technology or other fields of innovation with the goal of solving practical problems through the function analysis of biological systems, their abstraction into models, and the transfer into and application of these models to the solution,” while *bionics* is a “technical discipline that seeks to replicate, increase, or replace biological functions by their electronic and/or mechanical equivalents.” Furthermore, *biomimicry* and *biomimetism* are defined as “philosophy and interdisciplinary design approaches taking nature as a model to meet the challenges of sustainable development (social, environmental, and economic)” and *boinspiration* is a “creative approach based on the observation of biological systems (The relation to the biological system may only be loose).”²⁸ Biomimetics involves the step of abstraction and provides new ways of borrowing engineering solutions and models from the living nature to the domain of artificially designed objects thus bridging these two domains.

Although the concepts of biomimetics and bionics emerged in the 1950s, the idea of mimicking nature for artificial devices has existed since antiquity. Examples of this include the idea of mimicking bird wings for men to fly, in the myth of Icarus, and the “robot”-like heroes such as the Golem. A reason why biomimetics has remained popular since the 1970s is related to the increasing popularity of various “holistic” concepts.⁶ Although the connection between biomimetics and holism is not straight forward, it is well documented in the literature including such different areas as the computer-aided biomimetic tools,²⁹ holistic biomimetic batteries,³⁰ and even holistic biomimetic dentistry.³¹

As it has already been discussed, the dominant attitude of humans towards nature since the 19th century and until the mid-20th century was the belief that science and technology would eventually provide almost unlimited power to conquer and transform nature in a way comfortable to humans. The cause of this perception of the nature/human relationship is in the tremendous successes of empirical science and technology since the scientific and technological revolution in the 17th century and especially since the dawn of the 20th century. However, in the second half of the 20th century, it became obvious that it is not possible to solve many economic and social problems just by attempting to conquer nature. The human-nature relationship is much more complex, and humans can benefit by learning from living nature rather than trying to change it. As a result, new areas such as “ecology” and “holism,” which emphasize the harmony between humans and nature, became increasingly popular. The emergence of biomimetics is a part of this trend. Henry Dicks argues that the epistemological principle of biomimicry, “Nature as mentor,” affirms that Nature is the ultimate source of truth, wisdom, and freedom from error. The biomimetics and biomimicry involve a new philosophical paradigm of “enlightened naturalism.”³² He further notes that, while the Ancient Greeks understood both art and technology as imitation of Nature, Biomimetics makes it possible to leave behind the goal of “mastering and possessing” Nature and instead to rediscover the initial vocation the technology shared with art: imitating Nature.¹⁴

The new way of thinking about engineering problems, which biomimetics brings, encourages better harmony between humans and nature. The perception that if an engineering solution mimics nature, it is ecological. Biomimetic surface engineering was identified as one of the three areas of ecotribology (or “Green Tribology”, tribology is the study of friction).^{33,34}

At an even more fundamental philosophical level, one can view the transformative scientific revolution of the 17th century, which resulted in the development of the modern empirical scientific method, as the abandonment of Aristotle’s approach towards nature as expressed within his physics and metaphysics.⁶ The new empirical method, as developed by Francis Bacon, Newton, Descartes, Leibnitz and other great minds of the 17th century has led to the establishment of modern science, which has resulted over the subsequent 300 years in an amazing number of discoveries and transformative technologies of modernity. However, it became evident by the second half of the 20th Century that such a “technocratic” approach also has its own limitations, leading to post-modern views on nature and humankind. Consequently, a change of paradigm (the departure of the classical views developed in the 17th-19th centuries), which is similar to the change of paradigm related to the emergence of biomimicry, has occurred in many areas of science. Thus, in physics and mechanics new concepts, such as fractals, were suggested to study phenomena which are not described by continuous functions and traditional calculus.

Biomimetics and progressive ideology

One of the reasons why holistic science and biomimetics attracts supporters is that it seems to offer a progressive, “socio-ecological” view of the world, although this has been disputed by some scholars, who consider the trend reactionary.³⁵ Biomimetic research also supports multicultural or even “orientalist” perceptions. When the superhydrophobicity was discovered, one of the first and most cited articles was titled “Purity of the sacred Lotus” stressing the role of the lotus flower in Asian cultures as a symbol of purity and coining the term “Lotus-effect”.³⁶

Indeed, the Lotus plant emerges clean from dirty or muddy water and serves as a symbol of purity in India and the Far East (Figure 3). The Hindu sacred text Bhagavad Gita 5:10 says



Figure 3 Painting of Hindu god Vishnu sitting on a Lotus as a symbol of purity (left) and lotus leaves emerging from water (right).

(ब्रह्मण्यथाधाय कर्माणि सिद्धिं त्यक्तत्वा करोति यः लप्स्यति न स पापेन पद्मपत्रलम्बाम्भसा) “Those who dedicate their actions to God, abandoning all attachment, remain untouched by sin, just as a lotus leaf is untouched by water,” which is often quoted in the literature about the biomimetic lotus effect.³⁷ There is a parallel place in the Buddhist “Lotus Sutra” 14:46 (also known as the “Dharma Flower Sutra”): “These, who are untainted as the lotus is by water; who

to-day have flocked hither after rending the earth, and are standing all with joined hands, respectful and strong in memory.³⁸ Or, in a different version: “They have learned the bodhisattva way well, And are untainted by worldly things, Just as the lotus flower in the water Emerges from the Earth.³⁹”

Following the success of the lotus-effect, many other effects with similar names have been introduced, including the gecko-effect,⁴⁰ rose-petal effect,⁴¹ rice-leaf effect,⁴² butterfly-wing effect,⁴² etc. The shark skin effect is the reduction of hydrodynamic drag due to the special microstructure and orientation of riblets found in shark skin;⁴³ biomimetic swimsuits using the shark skin effect have already been produced for swimming competitions and various water applications from ships and submarines to water pipes. Furthermore, underwater surface microstructuring similar to the shark-skin effect is also used for environmentally-benign antifouling which can substitute or complement for chemical surface treatment.⁴⁴ Biomimetic materials mimicking thermogenic plants can be used for the deicing of surfaces without applying chemical coatings.⁴⁵ Biomimetic membranes are used for desalination and water-oil separation with the lotus effect. A mesh formed by a material which is hydrophilic but superoleophobic (repelling oil and organic liquids) or, vice versa, super hydrophobic but oleophilic would let water, but not oil, through and can be used for water-oil separation. A similar type of membrane involving reverse osmosis can be used for desalination.⁴⁶ Super hydrophobic corrosion-resistant coatings are being developed.⁴⁷

Biomimetics is often viewed as a technology which will bring sustainable progress and resolve many problems of humankind. Note that biomimetic solutions mimic nature and thus are environmentally friendly. For example, traditional antifouling coatings for ship hulls involve paints which are toxic and thus kill microorganisms, while biomimetic coatings are environmentally benign and thus meet environmental standards for ports. It is therefore very important to integrate biomimetics with ecology.

Biomimetics and conservative ideology

Interestingly, the area of biomimetic engineering has also caused some enthusiasm among the conservative activists interested in promoting such religious or quasi-religious concepts as Intelligent Design (ID) and Creationism. The perception of biomimetics among this group is that nature possesses presumably “ideal” solutions of engineering problems, which can be used in engineering design. Therefore, according to this view, the natural design is parallel to the engineering design paradigm.

Thus, for example, biomimetics occupies a significant place among the interests of the fellows of the major ID institution, the Discovery Institute.⁴⁸ A typical reaction of ID proponents on biomimetic research is presented below: “Of course, the fact that biological structures are inspiring intelligently designed technology supports the notion that those structures are the result of unguided and random natural evolutionary processes, right? Bhushan would probably say “yes,” but his description of the general nature of biological systems sounds very much like the general nature of human-designed technology... These encoded biological structures prove useful in human-designed technology precisely because they themselves are a form of intelligently designed technology.⁴⁹”

While Intelligent Design is often considered a pseudoscientific principle and ostracized as such, the difference between ID and the concepts of irreducible complexity, emergentism, orthogenesis, and teleology is often quite subtle. It is even more striking that the

same ideas, which are viewed as pseudoscientific in the biological community, can be considered progressive among linguists and anthropologists. A bold example of that is the Chomskyan idea that language emerges instantly. This implies that all languages and races are similar (and equal), and that the anthropological binary oppositions are constructed, in line with the tenets of post-structuralism. However, it is interesting that in support of his ideas Chomsky would quote a paper by a religious biologist⁵⁰ hypothesizing that a universal genome of all multicellular organisms was created instantly: “...it is now possible to contemplate seriously the proposal that there must be a ‘Universal Genome that encodes all major developmental programs essential for various phyla of Metazoa’ that emerged at the time of the Cambrian explosion half a billion years ago (Sherman, 2007). From this perspective there is only a single multicellular animal from an appropriately abstract point of view. Observed variety would be superficial.⁵¹”

All this indicates that the ideological implications of biomimetics and related definitions of life, evolution and design are controversial or, at least, non-linear.

Conclusion

Below are the conclusions from the present study.

- A. The rise of interest towards biomimetics is in line with general post-industrial developments. Roughly speaking, in the second half of the 20th century, mankind has realized the limit of extensive development based on the industrial revolution and numerous ecological hazards associated with it. The search for new approaches which would bring humans in harmony with the environment became a priority. Biomimetics was among these new attempts to look for engineering solutions in line with nature.
- B. Biomimetics plays well with the entire spectrum of ideologies. For progressives, it offers a socio-ecologically responsible view of the world in harmony with the sustainable environment. For conservatives, biomimetics is consistent with the idea that a natural “intelligent designer,” who is much wiser than a human designer, may be behind the ideal solutions of engineering problems found in nature. Biomimetics also fits well with multiculturalism since it brings attention to Asian and indigenous traditional concepts. At the same time, this does not mean that there is ideological connection in everyday biomimetic research and development. At this point there are no biomimetic devices which would not be distinguishable from living objects. However, those devices which emerge are becoming more similar to living organism. Examples are FESTO’s Smart Bird⁵² and Boston Dynamics’ humanoid robots.⁵³ It is likely that the boundary between living and artificial will become more transparent in the future. Therefore, biomimetics will affect the perception of living and non-living in the direction of making the boundary between living and artificial will become more transparent.

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Conflict of interest

Authors declare that there is no conflict of interest.

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