



**Biomimicry between  
technological innovation and sustainable development**



## Abstract

No one can deny that modern life is invaded by technology which is in continuous evolution. This technological evolution has a detrimental effect on the ecological system, which consequently harms our physical and moral health. Faced with this ecological problem, it is necessary to resort to nature, which has always been a source of inspiration for mankind, both in solving his problems and in satisfying his needs. This return is done through biomimicry considered as an approach guided by the need to meet a technological or organizational need. It pushes the Man to be inspired by the living, the biological, known by its diversity and its wealth, to lead to the stakes of the sustainable development (social, environmental and economic) by bringing him advantageous solutions in terms of technology, comfort, economy and aesthetics. In fact, in recent years, and because of the ecological crisis, many works and researches of innovation on biomimicry have been carried out on a global scale. These works show a remarkable rapprochement in the approach of some physicists and chemists with the modes of functioning of the living.

All these researches are explained by the fact that biomimicry is currently considered as the advantageous solution that ensures sustainability. The biomimetic approach starts from the imitation of the living because the nature offers enough materials and functions. But to be able to copy a system, we must already understand how it works. This shows that in biomimicry, we note an approach of three steps: Imitation of the form, imitation of the process and imitation of the strategy of ecosystems and their interrelations.

We aim then to analyze the complex properties of materials and biological processes of the living and to divert them to industrial purposes. It is important to say that in nature, there is no waste, everything is to be recycled. Every living species is a library that inspires Man to produce an object. Moreover, the analysis of living materials shows that these materials have particular qualities.

**Keywords :** Biomimicry, bio-inspiration, innovation, eco-innovation, swarm intelligence, artificial intelligence, collective intelligence, complex systems, algorithms, robotics

## **Introduction**

Following the technological development which does not cease evolving day after day, the current world knew an economic and ecological crisis caused by the overexploitation of the natural resources, which pushes certain Western societies to seek solutions to the ecological problems. Specialists in the field, many researchers, architects, industrialists, and futurists think of integrating technical productions in the life cycles, which gives birth to the biomimicry approach.

It is a process of innovation that took its scientific aspect in the 1990s with the American biologist Janine Benyus. This pioneer in this field was able to show the essential role of biomimicry in sustainable development. Thanks to this approach, it was possible to make industrial development and economic growth cohabit with natural ecosystems.

The word biomimicry, etymologically, is of Greek origin. It is formed by the words: Bios which means life, and mimesis which means to imitate. The combination of these two terms gives: imitate life, that is to say nature.

Biomimicry is a scientific approach that consists in creating technological products, useful for everyday life, by imitating nature or by being inspired by biological systems. The Economic, Social and Environmental Council (CESE) determines that biomimicry is "Imitating nature to innovate in a sustainable way, an idea that makes sense at a time when France is committed to a transition both energy and ecological,

A pioneer in this field, the American naturalist Janine M. Benyus, believes that biomimicry "is not based on what we can take from nature, but on what we can learn from it by taking it as a model.

This means that nature is a source of inspiration for humans, who often look to nature for solutions to the problems they face in their daily lives.

The notion of biomimicry has found an echo in the scientific work of various specialties: agronomy, material science, energy, robotics, medicine, or even cosmetics....

For all these virtues, we can ask ourselves the question: can we establish an interdependence between biomimicry and sustainable development?

Can biomimicry, which is inspired by nature, lead to the creation of artificial intelligence?

Let's start by showing how the inspiration of nature manifests itself in biomimicry.

### **Biomimicry: the inspiration of nature**

Biomimicry is an approach that proposes to draw inspiration from the genius of living beings as a source of sustainable innovation. It consists in observing and reproducing the essential properties of one or more biological systems to develop innovative and sustainable forms, materials and processes. If the imitation of nature by Man is present since the beginning of our civilizations, biomimicry has a requirement of sustainability that is quite recent. And to imitate nature, man is invited by biomimicry to draw from three sources of inspiration. The first approach focuses on the forms present in nature, the second on the processes used by living organisms to best respond to a need dictated by their environment, and the third on ecosystems, with regard to their performance in terms of sustainability, productivity and adaptability.

Since ancient times, Man has been inspired by nature to satisfy all his needs. In all sectors, nature has been a primary source in a significant number of creations. This has given rise to biomimetic products that are differentiated by the raw material, the method of manufacture, the techniques used, the ornaments that show the synergy between nature on the one hand, and innovation, aesthetics and technology on the other. Thus, we were able to put

forward the notion of sustainable development while trying to respect the stakes of this approach.

Innovation is above all a state of mind. It is a living process that leads management to seek, at all levels, the most innovative way to offer the best. According to the OECD and its Oslo Manual, innovation is "the implementation of a new or significantly improved product (good or service) or process, a new marketing method or a new organizational method in business practices, work organization or external relations. In this framework of ideas, this process must be continuous, structured and organized at all stages: from the idea to the marketing of the product.

As we have already mentioned, drawing inspiration from nature to satisfy needs or find solutions is not a new practice. It is a practice as old as humanity. But biomimicry is not about faithfully or blindly imitating nature. It is currently defined as new engineering inspired by the natural and the living. It is also considered as the art of sustainable innovation that starts from the observation of the living world, and leads to innovation in the field of technology, aesthetics, architecture, design .... This return to nature is explained by the fact that it is very rich in forms and materials that offer a favorable framework for innovation.

In this sense, it is important to quote the American scientist and naturalist Janine Benyus who considers bio-mimicry as an approach to produce innovative goods and services, while being inspired by nature. She describes biomimicry as a way "to help innovators design sustainable products and processes that create conditions that support all life forms."

It is clear, then, that biomimicry represents a gushing source of progress and innovation. It can only be meaningful if it is the bearer of a sustainable creation that represents a sustainable solution useful to humanity.

We can consider this approach as a correlation between the real world presented by nature, the laws that govern it and the imagination of Man. Indeed, thanks to

bio-mimicry, we can draw from the genius of the living world a source of sustainable innovation as it has been done in the solar collector which imitates the leaf of the plant. The approach starts from the observation of the essential properties of one or several biological systems, and finally leads to the development of forms, materials and processes that are both innovative and sustainable.

Innovation through biomimicry affects almost all areas of humanity. In all the fields where Man has put his hand, we find innovations inspired by nature. In what follows, we will mention some fields marked by biomimetic innovations.

It is undeniable that biomimicry is considered as an art of observation. And like any art, it is based on aesthetics. Indeed, since the dawn of humanity, Man has always tried to reproduce the aesthetic aspect of living organisms.

In ancient times, he was inspired by the structure of a skeleton to build his primitive huts. But nowadays, he has built monuments inspired by the curves and patterns present in organic forms.

He has always had a strong relationship with nature, which was a source of reference and inspiration for him. At times, he even competed with it to demonstrate his ability to create ingenious forms by means other than those of nature. This is where bio-mimicry comes in, which becomes a favorable field where human intelligence is reinforced by the intelligence of nature. This is how the ingenuity and creative value of man is manifested.

Technology is ubiquitous in the man-made world, whether it is his personal or professional environment. "Technology is the application of knowledge for the purposes of human life, or to change and manipulate man's environment. Technology also brings knowledge and skills related to the design and realization of product. As far as our sector is concerned, it is specific to each design of a lighting product where the use of tools and materials from the application of technology such as techniques, methods, procedures and skills are used to increase productivity, creativity and innovation. From this idea, we can

conclude that the purpose of devoting technology in lighting using the combination of practical experience, procedures and the use of tools is to make man more capable of controlling and mastering the product according to his need.

Technology dominates our lives day after day, and it is becoming more and more modern. It is in this technology that human intelligence is manifested, which, in order to perfect its inventions, is reinforced by the intelligence of nature. The combination between the two types of intelligence has given birth to bio-mimicry, thanks to which, many technological inventions have been created, especially through biomimicry. But the most famous is perhaps the Japanese TGV created in the XXth century. In this technological creation, the engineers were inspired by the feathers of the average owl and the beak of the kingfisher to increase its speed and reduce its noise and power consumption.

We can conclude, then, that thanks to bio-mimicry, man has been able to master new manufacturing tools. Thus, he knew to answer technically to numerous needs. In this way, he realized technological progress which was impressive thanks to the industrial revolution.

### **Biomimicry: a Symbiosis between techno-sphere and biosphere**

The "biosphere" designates the whole of the elements of the living world, including the human kind, which exist on the Earth. It also includes the inorganic and organic supports and everything that conditions its existence. The "technosphere" is the set of all technical actions carried out by humanity. Both are based on a principle of unity because they form a system.

At the present time there is a strong tendency towards a reconciliation between the technosphere and the biosphere. Indeed, although the human being is a fairly powerful brain capable of producing enormous creations, he remains a biological being linked to an ecosystem that is also biological. So any damage to this ecosystem is also a damage to the human being. Consequently, to protect the human species, we must protect the ecosystem.



The essayist Emmanuel Delannoy, who has worked extensively on the themes of biodiversity and the economy, sums up the mission of this reconciliation by saying "Reconciling the techno-sphere with our biosphere means going to look for knowledge in the living".

This can only be achieved by using biomimicry, which consists of drawing inspiration from nature, which is considered not only as a material, but also as an enormous source of information, since it is an immense reservoir containing hundreds of millions of species and models that can be a source of inspiration if we manage to understand the living system beforehand through our thoughts.

An American scientist named Otto Schmitt considers the inspiration of the living which is the principle of biomimicry as a real scientific process and not as a pleasure activity. This inspiration concerns the different aspects of nature: the forms, the materials, the properties, the processes and even the functions of the living in order to innovate.

This reconciliation between the techno-sphere and the biosphere requires the convergence of our economies with our activities within the living system on which we are dependent. It must concern skills, knowledge and interactions, towards the oceans, the climate and biodiversity, which represent the three major points of protection that we must integrate in each of our actions.

Biomimicry is therefore the effective method to reconcile the techno-sphere with the biosphere. This approach remains the excellent channel and fertile source of innovation and sustainable development, it is the toolbox, generating eco-innovation that can lead to a probable industrial revolution.

The many assets of biomimicry allow to combine and enhance both skills and companies by a very rich biodiversity and international work also rich in economic terms and which affect the various fields of electronics and / or mechanics, robotics, biomechanics, bio-inspired sensors without forgetting a rather interesting field namely the fields of medicine.



It is enough to cite the examples of medicinal plants which are innumerable in nature and which have enriched the pharmaceutical library. We also cite the example of bees which are extraordinary insects capable of treating and curing us of the most serious diseases, even cancer, by their honey or royal jelly. Beyond that, American researchers have succeeded in stopping the multiplication of cancerous cells by injecting bee venom into cancerous cells. This group of researchers have discovered that bee venom contains a protein capable of stopping the evolution of diseased cells by attaching itself to their membranes: melittin.

Other research in the medicinal field has also shown that animal venoms have enormous medicinal properties against pain, they have almost the same functions as morphine, to suppress pain.

In addition to the medicinal field, other fields have been enriched by biomimicry, thanks to which nature appears to be an inexhaustible source of inspiration for engineers who find in it a reservoir of biological solutions for technological problems, which is why biomimicry is considered to be a tool for sustainable innovation.

-Bio-assistance or biotechnology: using living organisms or molecules of biological origin for agroecology and the chemical industry.

Indeed, in biomimicry, it is plants and animals that are mainly observed in order to discover their functioning and imitate them. It is in this sense that nature is considered the best laboratory that exists and the most perfectionist factory. An example of this is the bio-plastic of the bee. American researchers at the Franklin W. Olin School of Engineering have discovered that bees protect their eggs from the cold with a kind of cellophane that they make naturally. Being as strong and more impermeable than industrial plastic, this natural plastic could be used in the future to create non-polluting packaging, thus promoting sustainable development.

This is just one example among millions of others with which nature abounds as a generous source of genius and inspiration to implement almost perfect processes regarding energy management and production, materials manufacturing, recycling or ergonomics.

In the search for new materials, researchers have been using biomimicry for many decades. They start by identifying a biological material with interesting characteristics such as spider silk, then they study its microstructure to understand how these characteristics are created and then they try to reproduce them by creating artificial materials similar to natural materials. One example is the group of researchers who used the adhesive properties of gecko legs to produce "GeckSkin," the tape with extraordinary adhesive power.

It is undeniable that the field of textile has been well enriched by natural materials such as spider's thread and worm's silk. By imitating both of them, we obtain synthetic materials that are very resistant and that are used to produce a wide range of textiles combining both beauty and good quality, which explains why the most expensive clothes are made from textiles made from natural cotton bolt silk.

Another important example is the role of the lotus leaf, known for its ability not to retain water in the realization of super hydrophobic, self-cleaning and waterproof materials used to manufacture self-cleaning or waterproof fabrics.

It is therefore clear that through biomimicry we have managed to show that nature is a valuable gold mine in terms of ecological resilience and ecosystem optimization.

Indeed, by taking inspiration from nature we learn to satisfy our needs by obtaining more and polluting less. By this approach, Man must interact with nature like any other living being, that is to say in the respect of the ecosystems and their balance. This can only be done through the use of biomimicry, which can provide methods and tools representing resolutions of problems through

bio-inspiration, which is done through natural selection, thus offering sustainable and innovative technological solutions in many areas.

Nature abounds in resources that no technology can match, these resources are associated with optimization strategies which leads to the fact that living organisms are able to gain technological solutions that are both biomimetic solutions, interesting, not only for their ingenuity, but also for their ability of ecological resilience.

It is therefore undeniable that biomimicry is the sustainable development tool par excellence in the sense that it is structured on the fundamental concepts of ecological resilience, systemic approach, eco-design, sustainable innovation. It is an approach that takes nature as a model and source of inspiration in order to respond to the challenges of sustainable development (social, environmental and economic). To achieve this objective, and especially to ensure the sustainability of the approach, it is necessary to complete the biomimetic design with a life cycle analysis, while taking into consideration economic factors and ethical, social and moral criteria.

Considering the importance of the biomimetic approach and its primordial role in sustainable development, the number of researchers and industrialists related to bio-inspiration is growing day after day and almost in all countries of the world despite the complexity of the transfer of knowledge from biology to technology. This leads to the simplification of the biomimetic approach in order to improve it while preserving the three levels of inspiration of the living being :

- The processes and materials,
- The forms and structures
- The organization and functioning of systems.

To close this part, it is important to affirm that the circular economy, towards which humanity tends at the present time, is based on the principles of

biomimicry which is currently in full expansion. It is summarized by the fact of being inspired by the living to think, innovate and act differently.

### **Biomimicry: a creation of artificial intelligence**

Artificial intelligence (AI) is defined as "the set of theories and techniques used to create machines capable of simulating human intelligence".

It is a set of concepts and technologies and not an autonomous discipline.

According to the TLF (Trésor de la Langue Française), artificial intelligence is defined as follows: "the ability to apprehend and organize the data of the situation, to relate the processes to be used to the goal to be reached, to choose the means or to discover the original solutions that allow adaptation to the requirements of the action".

According to Franck Bulinge and Serge Agostinelli (2005) the notion of artificial intelligence is: "an individual and collective ability to understand and solve the problems of data acquisition and transformation of information into operational knowledge, that is to say, oriented towards decision and action" (quoted by Bulinge, 2014 ).

This means that artificial intelligence, which manifests itself in a large number of fields of application, is very close to informational intelligence in the sense that it contains the set of concepts of relating and adapting, particularly relevant, designated for problem solving and successful action and for making a decision, it tries to imitate the functioning of the human brain in its logic.

The notion of artificial intelligence, which was born in the 1950s thanks to the mathematician Alan Turing who proposed, in his book "Computing Machinery and Intelligence", to bring to machines another form of intelligence, is well and truly applied in the world of computer science, where all the big companies (Google, Microsoft, Apple, Facebook...) are trying to set up artificial neural networks allowing them to process heavy calculations within databases.

After all this definition, one wonders then what relation can be established between biomimicry and artificial intelligence? Is biomimicry able to lead to the creation of an artificial intelligence?

To be able to answer this question, we are faced with another question: can we think that the human brain can be equalled?

It is obvious that biomimicry, which starts from the inspiration of the living to reach excellence in the various fields of industry and urbanism, can also have the same feat in the field of information and artificial intelligence.

For example, the chips that were created by taking inspiration from nature and especially by imitating the neurons of the human brain whose synapses were also a model in the creation of a microprocessor capable of "rewiring" its connections when it encounters new information.

One such chip is the silicon chip called TrueNorth, which was created in August 2014. This one is made up of 256 million synapses and one million artificial neurons. It can perform complex tasks without consuming much energy. This chip was invented, thanks to biomimicry as it is designed by imitating the human brain. It represents a big step in the evolution of artificial intelligence thanks to these impressive results the human imagination.

We also mention the "Deep learning" or deep learning which is a learning system formed by a set of automatic methods based on "digital artificial neural networks" inspired by the human brain. This system, which is used in the recognition of voices, sounds, characters, languages, is designed thanks to biomimicry.

The idea of biomimicry is to draw inspiration from the functioning of the human brain to design increasingly intelligent machines. This principle is implemented in the field of computer science through algorithms that play a role in the realization of certain tasks such as voice and image recognition.

On the other hand, researchers in artificial intelligence and robotics are working with biologists to use the concepts of biomimicry to develop algorithms to solve

complex optimization problems based on the analysis of the properties of swarms of social insects or schools of fish.

Thanks to swarm intelligence, which concerns a wide range of application domains such as robotics, transportation, environment, space, health, defense, telecommunications, etc., scientific progress has undergone a considerable evolution as technical inventions, made by imitating nature, reach a very high degree of sophistication and technicality.

- Bio-inspiration: drawing inspiration from the living for architecture and materials, etc.
- Eco-mimicry: studying the functioning of ecosystems, engineering and urban planning
- Bionics (drawing inspiration from living organisms to improve biological functions through equivalents).

### **Conclusion**

By way of conclusion, it is worth noting that the biomimetic approach consists of taking inspiration from nature and imitating it in the search for new materials, as well as in the forms and structures and in the organization and functioning of systems.

Thanks to this approach, we have managed to establish a close link and even a symbiosis between the techno-sphere and the biosphere, which allows us to deduce that biomimicry is a factor of sustainable development.

This approach, which has invaded all areas of human activity, has also concerned the field of computer science through the creation of artificial intelligence, by which human thought has succeeded in creating algorithms to solve problem situations.

The virtues of biomimicry are innumerable, the most important of which is that it is an approach of innovation and essential mutation allowing to pass from a polluting economy to a "green economy" based on simple, clean, safe and sober technologies.

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