Review Article

Eco-design design strategy: Case study Biomimicry Approach in Design Product Materials

ABSTRACT

Ecodesign is an approach to design of a product with special consideration for the environmental impacts of the product during its whole lifecycle. This paper describes barriers and success factor to implement eco-design in functional textile design. The designing phase is critical for the integration of environment issue. Ecodesign is an early stage of a design. Through an intelligent utilization of the available resources, Ecodesign aims at a product and process design that ensures maximum benefit for all actors involved as well as consumer satisfaction, while causing only minimum environmental impacts.
In this survey, Biomimicry will be presented. It's the kind of inspiration is to create new and useful products for everyday life. This inspiration is always at the service of innovation and technology. That is why we consider the bio-mimicry, as a synergy between innovation, aesthetics and technology. We try in this paper to solve the toughest challenges in sustainability and train designer practicing biomimicry. "
The analysis of all examples of biomimetic fixtures shows that all of these products are a synergy once between innovation and functionality, once between ecology and technology, and again between the different notions.
Man was inspired, always, from nature to meet their needs. Nature was a primary source in a significant number of creations. This has led to biomimetic products that differ in the raw material, the way of manufacturing, techniques, ornamentation that show the synergy between nature on one hand, and on the other innovation, aesthetic and technology. Therefore, we could develop the concept of sustainable development while trying to meet the challenges of this approach.
In this paper, the main area of biomimicry in design will be presented and examples will be discussed.

Keywords: Eco-design, Biomimicry, design, nature, color, solar energy

1. INTRODUCTION

Product design and development has a fundamental role in designing and producing sustainable products. The decisions made during the product design and development process affect up to 80% of the environmental and social impacts of a product. The choices made in materials, forms, colours and production systems also affect the use and disposal of the product in the whole life cycle, and the designer thereby also influences patterns of sustainable consumption.
More and more people realize that the global economy in its current form is not sustainable. Therefore it is essential to find new solutions, especially in the area of product development. The question is how sustainable development and its idea of economic, environmental and social aspects can be linked to product development. This corresponds to our understanding of sustainable product design or Ecodesign.

Any search can be achieved only from a concept; that is to say, an idea proposed by the mind. A general concept can be adapted to many types of products. This category is often influenced by trends, changing lifestyles, modes of production and distribution [1].

Among the concepts that are needed in the design is that of biomimicry. Besides its importance in the field, this concept seems to be claimed in all aspects of daily life. To better understand the divergence of meaning of this concept, it should be addressed in different disciplines.
Examples of biomimicry in the field of sustainable design; and a comparative table in which we distinguish the criteria mentioned will be presented.
Our interest is mainly focused on the study of biomimicry in design to achieve finally analyze the biomimetic approach in different products that combine innovation, aesthetics and technology.
. This proposal leads us to question the possibility of studying biomimicry in design field based on the following questions:
- How to raise awareness and encourage consumers to consider the environmental factor in the design of biomimetic design product?
- How can the designer inspiration from nature to create products?
- What are the biomimetic criteria necessary that the designer must consider in his creations?

2. MATERIAL

Companies who wish to ensure their long-term success must implement multidisciplinary processes as well as new proactive approaches to solutions.
Environmental impacts are often related to resource consumption, which is, in turn, responsible for increased cash flow. If sustainable product design is combined with better resource management, cost-effectiveness is increased. The analysis of products as well as interdisciplinary working methods and the consideration of consumer needs can generate innovative product ideas, either by life cycle thinking or by searching for improvement strategies and successful Ecodesign measures. Furthermore, Ecodesign ensures the future success of the company as it defines responsibilities, motivates employees and thus gains stakeholders' confidence.
Ecodesign includes product lifecycle thinking. In designing for the environment the designer must consider not only aesthetical, trend and fashion issues, but also the production process, logistics, the use and maintenance of textile items and finally the recycling or disposal of the product.

2.1. Importance of Ecodesign in product life cycle

Ecodesign is a strategic management process that is concerned with minimising the impacts of the cycle of products and services (e.g energy, materials, distribution, packaging and end-of life treatments).
Through an intelligent utilization of the available resources, Ecodesign aims at a product and process design that ensures maximum benefit for all actors involved as well as consumer satisfaction, while causing only minimum environmental impacts.
The eco-design approach aims at bringing environmental criteria on board at the design phase as well as technical and economics ones. It is a question of finding the best compromise, from the development stage, during which nearly 80% of the harmful effects of a products throughout its lifecycle are generated by reducing the environmental impacts over the whole lifecycle of the products whilst preserving its suitabilty for the job it has to do. The design phase of a product is the right moment to bring in the environmental issues. The multidimensional approach of eco-design is represented in figure 1, it shows that the environment is one of dimension in product development.

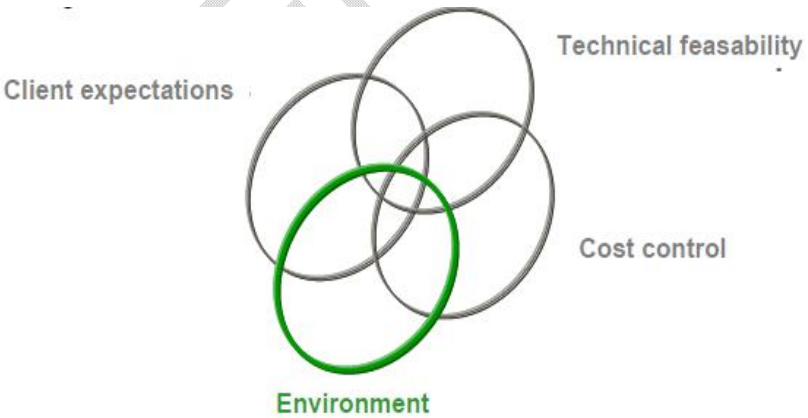

Fig. 1. Multidimensional aspect in the product constraint development [1]
The importance of environment in the product design is presented in the figure 2.

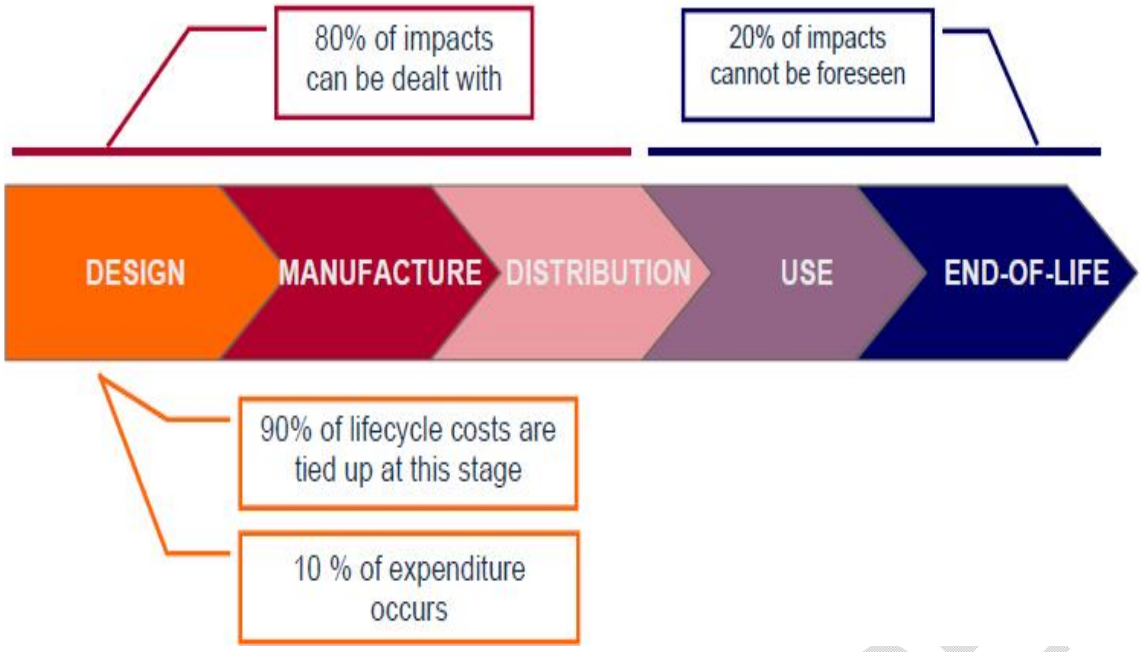

Fig. 2. Importance of design phase in the product life cycle

Different studies on eco-design exist, among them the Wimmer and Wüst studies representing the eco-design aspect in the different product life cycle (The figure 3 and the table 1).

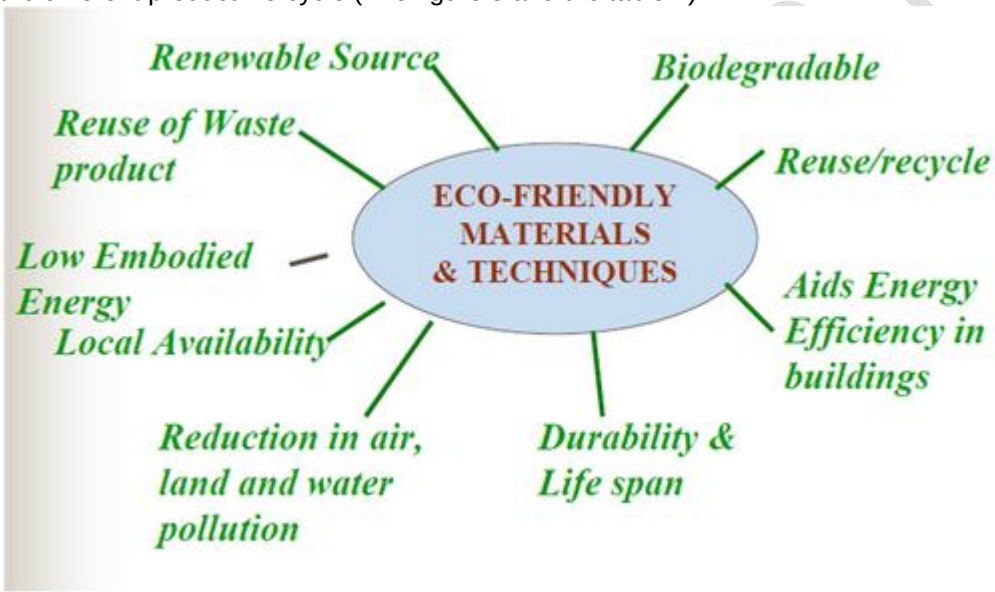

Fig. 3. Ecofriendly material and techniques concepts [3]

Table 1. List of ecodesign aspects [8].

Life cycle	Ecodesign aspects
Raw Material	Type of material Amount of material Origin of material
Manufacture	Production technology Energy demand for production Auxiliary and process materials for production Production waste and emissions External parts and components Assembly
Distribution	Packaging of product Transportation of product
Use	Functionality of product Service life User behaviour at use stage Product ergonomics Environmental safety at use stage Energy demand during operation Auxiliary and process materials during operation General conditions of use Waste/emissions during use Maintenance of the product Repair of the product
End of life	Product return Disassembly Refurbishing of the product Reuse of parts Recycling of material Disposal of unusable parts of the product

The four levels of environmental actions are represented in the following figure.

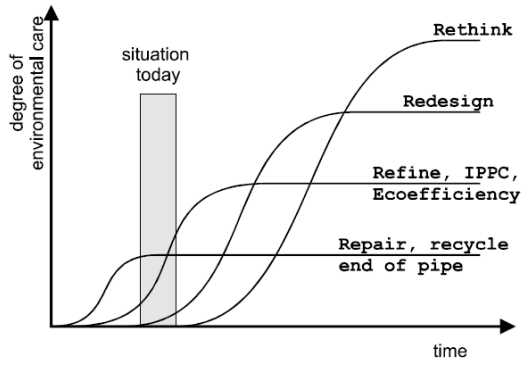

Fig. 4. The four levels of environmental actions [9].

There are various reasons why a company should introduce Ecodesign. One important incentive is the improved environmental performance of the company's products. This can be achieved, for instance, by avoiding or reducing adverse environmental impacts, by reducing material and energy intensity during the life cycle of a product as well as by fulfilling health and safety standards within a company.

We can classify the different environmental approaches according Millet and al. into:

- Partial eco-design representing a low company transformation and flourishing from 1980 to 1990,
- Classic ecodesign representing a medium company transformation and flourishing from 1990 to 2000
- Innovating eco-design representing a high company transformation and flourishing since 2000.

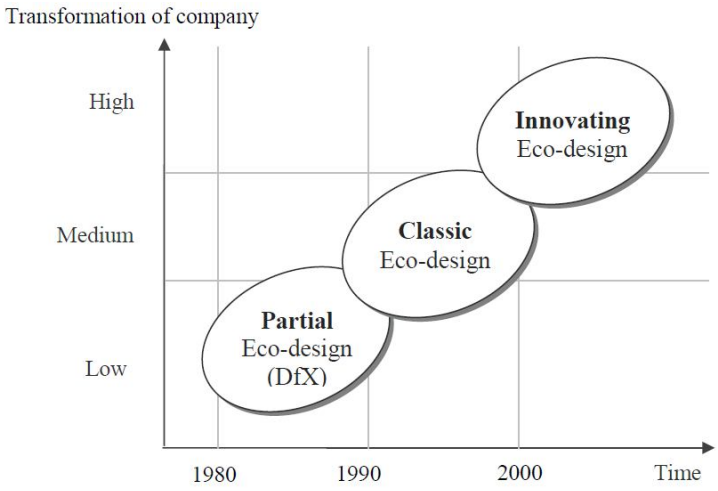

Fig. 5. Classification of different environmental approaches [10].

"In the textile and apparel sector, eco-design above all addresses the environmental impacts throughout the value chain of fibre production and textile manufacturing" [11]. "There are various ecolabelling schemes as well as fair-trade labels each indicating different aspects of sustainability" [12]. Textile industry has undertaken efforts to prevent environmental pollution of manufacturing processes, mainly in terms of environmental management. Foremost attention has been paid to the reduction of chemicals (e.g. dyes, bleach etc.), using water more efficiently as well as purifying wastewater. Apparel industry has increasingly been responding to consumer demand for 'Green Textiles'. Design for green textiles has been focusing on greening the supply chain (elimination of production steps that utilize harmful substances) and raw-material selection.

The classification of Eco Friendly Textiles Fibers is presented in the following figure.

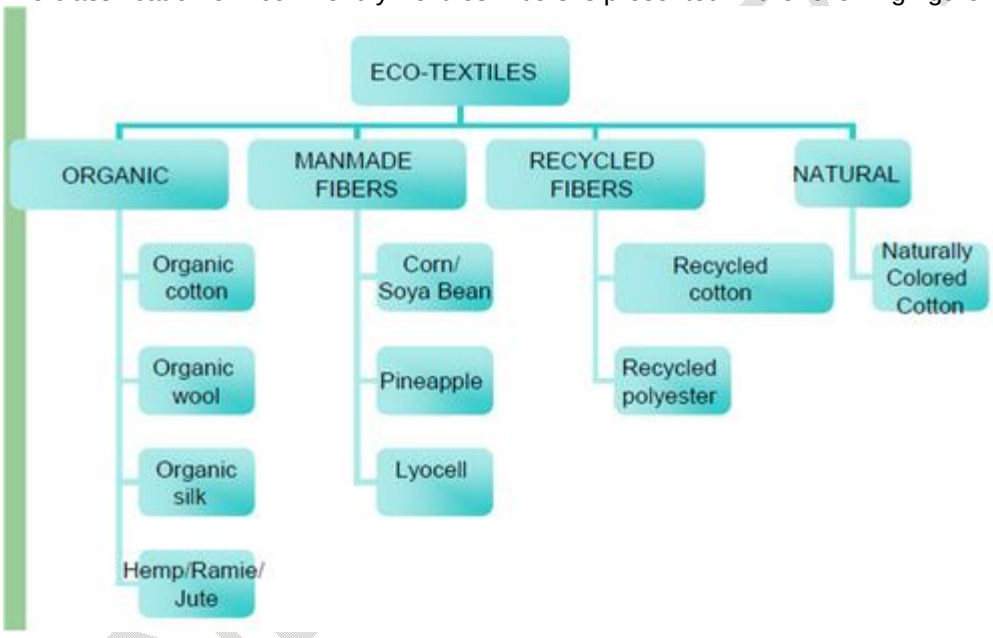

Fig. 6. Classification of Eco Friendly Textiles Fibers [10]

2.2. Implementation of eco-design in the innovation process of functional textile

"Eco-design typically addresses a variety of aspects that can have a large influence on a product's environmental impacts. These aspects include the selection of materials (e.g. using non-toxic substances, recyclable materials), the choice of production processes (e.g. in regard to waste and emissions), the determination of the products' energy demand during the use-phase, as well as its end-of-life treatment (i.e. repair and recycling)" [16]. Ljungberg presents "models for the selection of materials with regard to their sustainability characterisation and reviews strategies for more efficient use of materials (including dematerialisation and recycling)" [17]. "Recently, the increasing scarcity of certain critical raw materials that are indispensable for the production of modern high-tech products has also moved into the consideration of sustainable design" [12-13]. . "More holistic eco-design strategies centre around the function of products and their

influences on the environmentally relevant behaviour of their users. For one thing, the functions of modern products can help their users to save energy or avoid unnecessary travel. Moreover, the functions of modern information and communication technologies (ICT) offer opportunities to substitute virtual services for physical products (dematerialisation)" [14].

2.3 Role of eco-designer

The main tools used by companies involved in eco-design concern for environmental impact assessments of the products at each stage of the product life cycle, from design to recycling or recovery of its components.
We can summarize the role of eco-designer in the following points:

- Consider all impacts on the environment from the very beginning of a project (before the development of the product) and all technical aspects, markets and uses (research benefits for the consumer: sources of savings or changes in behavior).
- Responding to changing consumer behavior :
    - Today consumers and users are not buying only products or functions, they look for "old products".
    - Consumers expect lasting values, products and new uses, new codes, different and significant; visible and legible difference compared to conventional products.
    - He expects an authentic relationship with brands, including advertising, something that goes well beyond a "green washing."
- The design should revive interest, provoke a new look Consumer Product by other uses, it facilitate a more respectful behavior of the environment, and communicate the expected values.
- Develops a new approach to design
- Combines an interest in sustainability with a recognition of the relentless pace of the trend cycle by creating new fabrics made entirely of edible materials.
- Embraces new processes such as biomimicry.
- Uses of natural dyes and pigments who frequently experiments with new ways to color and design fabric use of ecoprint methods, which transfers colors from plants and plant materials directly to cloth without the use of synthetics.

2.4 Future trends of ECo-design in textile

The main trends in eco-textile are summarized in the following points:

- Slow fashion would be designed according to an ethical consumer's values. The clothes would be designed to be durable, high quality and in sustainable materials. The production lines would be ethical and perhaps even local production. The style would be more classical and longer lasting in design, color and print.
- The clothes would be longlife products made from durable materials. The material choices would be optimized so that the clothes need very little maintenance, especially washing and ironing. And materials and clothes could also be reused and even recycled into a new textile material. Multifunctionality and a modular structure is important, and producers can also offer new service concepts, such as repairing, recycling, changing, renting and leasing clothes.
- Fast fashion would be directed towards the younger generation, and it would be based upon their need to consume and build identity with fashionable items. This might mean new sustainable clothing materials which are optimized for the real lifetime of the product

2.5. Some issues, challenges and opportunities of eco-design approches

Some issues, challenges and opportunities for the different aspects of functional textile development are summarized in the following points:

- **Recommendations materials that have less impact on the environment**
  - Choice of materials with low toxic potential (low emissivity Pollutant glues without chemical solvent, water-based paints ...).
  - Preference for materials with low "energy content" ie did not require large amounts of energy in their production cycle and transport.
  - Weight reductions to reduce the energy impact of transportation for deliveries.
  - Use of easily recyclable materials or that the recycling is well established. Preference for materials with low impact on CO2 emissions.
- **Reduced quantities of raw materials used**
  - Use of materials with higher performance at equal volume.
  - Optimization profiles and shapes to reduce the volume of materials used.
  - Decrease in the volume of non-reusable falls through better design of parts to be made depending on the areas and volumes of basic materials.
- **Optimization of production techniques**
  - Selection methods saving energy, reducing transfers, requiring no additional treatment surface.
  - Reducing the volume of waste by sizing to delete the non-reusable falls.
  - Reduction or elimination of pollution caused for employees and the environment
- **Optimized packaging and logistics**
  - Removing overpack.
  - Reduced packaging, mono-choice packaging material to facilitate recycling.
  - Use of shared transportation, containers recovered.
  - Optimization of the content / container to reduce the costs of transport and storage.
- **Reduced impact during the lifetime of a product**
  - Reducing the impact of the product on the environment, upstream of its life cycle (development) or downstream of manufacture (use and recycling).
  - Reducing energy consumption, reduced maintenance by longer periods of use, choice of consumables respectful of the environment.
- **Optimizing the life of the product**
  - Strengthening the users / products link.
  - Align sustainability, product liability and commercial life.
  - Harmonization lifetimes of the various components of the product.
  - Orientation towards a modular design to anticipate technological change.
- **Optimizing the end of product life**

- Designing a reusable product, entirely or in part.
- Adoption of solutions to easily recycle the product by anticipating its disassembly by dissociation of its components and sorting.

⦿ **Development of new concepts**

- Dematerialization by the sale of a service rather than a product.
- Integration from the functional analysis of environmental aspects.
- Optimization functions within the product or integration of new features to guide usage or ecological understanding of the product.

3. APPROCH

3.1 Biomimetic approach

“Etymologically, the word biomimicry is of Greek origin. It consists of the words: Bios meaning life, and mimesis meaning imitate. The combination of these two terms gives: imitate the life that is to say nature” [7].

Biomimicry is a scientific approach aims to create technology products, useful in everyday life by imitating nature or on the basis of biological systems. The Economic, social and environmental (EESC) sees biomimicry is "Imitating nature to innovate sustainably, is an idea that makes sense at a time when France is committed to a transition to both energy and environmental ". This means that nature is an inspiration for the man who often seeks to find solutions to problems he encounters in his daily life while referring to nature. Moreover, it is a multidisciplinary approach that starts from the study of nature's models to reproduce the essential properties (forms, materials or processes) of biological systems to finally get to create objects for solving technological problems as this is confirmed by Hermine Durand sees the term biomimicry means "imitation by humans in their activities of some remarkable properties of biological systems."

This approach is summarized by the American biologist Janine Benyus, author of the book "Biomimicry" which asserts that biomimicry is "The concept, which now has an international reputation, refers to the practice that we observe, we learn and reproduces the genius of nature. " The figure below summarizes well the biomimetic approach of following steps .

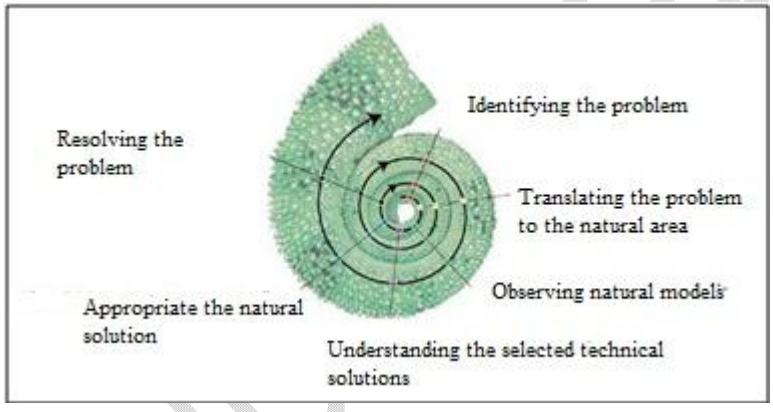

Fig. 7. Biomimetic Approach [2]

Biomimicry as a simple practice, appeared in antiquity, since nearly 3.8 billion years, as nature has always been for man a source of inspiration and inexhaustible creativity [2].

The approach of biomimicry is a multitude of steps: identify the problem, remove the problematic nature area, observe the natural patterns, understand the technical solution, appropriating the natural solution and finally solve the problem.

Then Hezafen Ahmed Celebi (1609-1649), which was inspired by da Vinci also studied the flight of birds and developed a flying apparatus with which he managed to take off. A few centuries later, precisely in the nineteenth century, the French engineer Clement Ader constructed an airplane (a Aeolus) drawing on bats India. For his part, Otto Lilienthal, who played an important role in biomimicry, created the first successful flight equipment, having studied the flight of storks.

This approach is then carefully observing natural phenomena in order to understand their functioning to finally get to reproduce useful artificial objects in our daily lives.

We can also draw on the ecosystem organization or more generally the functioning of living beings to better integrate the organization and human technologies. Thus, man can reproduce animals mechanisms for use in technologies such as bionics and biophysics. It is therefore a science based on the notion of transfer from biology to technology. It is based on

the application of materials, forms, processes and remarkable properties among natural beings to human activities in the production of technical products (Figure 2). Incidentally, Benyus says that biomimicry fact "call transfer and adaptation principles and strategies developed by living organisms and ecosystems to produce goods and services more sustainably, and finally to make human societies compatible with the biosphere. "

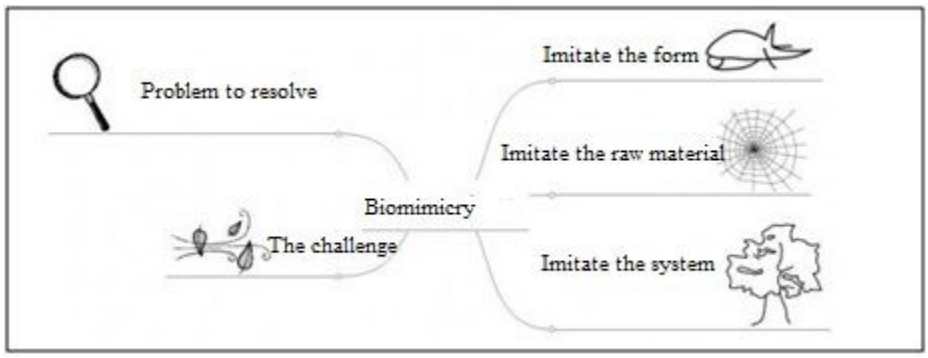

Fig. 8. Inspiration area [14]

This approach is not to blindly imitate nature, but it aims to innovate what is natural by using all the tricks of the world living in different human applications, whether in technical, technology and even in modes of organization.
It is then clear that biomimicry, although it is based on nature, it is also a source of progress and innovation because we always try to renew what is observed in nature. In this sense, Jean-Marie Lehn, the chemist who won the Nobel Prize in Chemistry in 1987, defines the biomimicry saying he is to repeat what life has done, but in our own way.
It is clear that many researchers and scholars consider biomimicry as a very important area to mankind since it from the imitation of living (shape, process or set of interactions) eventually leading to the development of new technologies, new agricultural practices or new organizational schemes which provide original and interesting solutions, useful to man in his daily life.
It is in this sense that biomimicry, besides being a science; it is also an art as it is based on observation of what is natural. It is therefore to observe, understand and inspire the living to finally get to create products and artificial systems.
Biomimicry is a concept created by Benyus to express the idea that nature is an inspiration to humans. So we could infer that the bio-mimicry, for this biologist is "ingenious inventions inspired by nature [3].
She added that she considers nature as the greatest creative center. This is a great reservoir of materials, forms and products that can present solutions to problems that humans encounter every day.
It is for this reason that during all his lectures, it transmits a message for inventors, saying, "when looking to solve an engineering problem, turn first towards nature. You will find the inspiration to design sealing, aerodynamics, solar energy, etc " [3].
Life on earth has already begun for over 3.8 billion years, but 99% of all species that have existed on Earth disappeared. Species that exist there today are certainly those that work best. If these species still exist is because they create conditions for a better life because for this biologist: "If a thing does not exist in nature, it's probably for a reason." Therefore, we must take in order to live better. That means it is necessary to form "this adaptation portfolio biological intelligence because there is wisdom embodied in these designs."
We can explain this by the fact that we must draw inspiration from nature to ensure a better life. This idea is illustrated by quotes from Janine Benyus which says: "Our planet is like a laboratory for research and development: the best ideas have triumphed at the expense of toxic or too greedy concepts in energy or raw material. Organizations that remain are effective" [3].
It is obvious that the bio-mimicry today represents the solution that will ensure sustainable development on earth since it ensures to man a more durable and more comfortable life. In this context, Benyus says: "As our world moves closer to nature, the more likely we are to live long on this earth we must never forget that we're not the only inhabitant" [3].
We can deduce that the bio-mimicry also ensures the survival of the human species on long-term land. We experience all kinds of things, because we can. But today we must ask the question of our long-term survival as a species. In this context, any approach inspired by nature can contribute to innovation and creating the name of Bio-mimicry. She says at first she found only silence. Then gradually we start to grant an interest in this area. The first people who were really interested were the architects.

Nature provides answers to very current issues. Indeed, it always optimizes its responses, with maximum efficiency and minimal energy cost [4].
Biomimicry is then an approach of continuing to produce wealth without destroying ecosystems while referring to nature.
There is a need to establish a sort of symbiosis between man and nature. This symbiosis can not do that if Man admires and respects nature. So it can be inspired and find solutions to its problems.

The bio-inspired approach brings us to a level of correspondence with nature more consistent with what we must do to solve our problems.

3.1 Concepts related to biomimetic approach

It was not until the twentieth century that biomimicry had its true meaning as a science and art especially with Benyus, she is inviting designers to see nature as a model, measure and mentor in emphasizing the importance of combining sustainability with the use of biomimicry. It is therefore obvious that biomimicry is hardly an art or a modern science. But it is a very old practice. It is practiced in various areas [3].

3.1.1 Biomimicry between innovation, design and technology

Currently, we define biomimicry as a new engineering inspired by the natural and living. It provides a framework for innovation. Indeed, although it is based on the inspiration of the living, biomimicry is not to copy nature faithfully. It is the art of sustainable innovation which is why we can place it in the field of aesthetics. It is an art that is based on the observation of living organisms to transpose human creations, robotics, aeronautics through artificial intelligence. As defined Benyus, biomimicry "appealed to the transfer and adaptation principles and strategies developed by living organisms and ecosystems to produce goods and services more sustainably, and ultimately make human societies compatible with the biosphere [3].

We can conclude, then, that through biomimicry, the man could master new manufacturing tools. Thus, he has technically meet many needs. In this way, it has made technological advances that have been impressive thanks to the industrial revolution.

Innovation is primarily a state of mind. It is a living process that requires management to look at all levels, how to be more innovative to offer the best. According to the OECD and the Oslo Manual innovation is "the implementation (implementation) of a product (good or service) or a new or significantly improved process, a new marketing method or a new organizational method in business practices of the organization of the workplace or external relations. " Within this framework of thought, this process must be continuous, structured and organized at all stages: from idea to product marketing.

As we mentioned before, learn from nature to satisfy needs or find solutions is not a new practice. “It is a practice which is quite old as man. But biomimicry is not to imitate faithfully or indiscriminate nature. It is currently defined as a new engineering inspired by the natural and living. It is also considered as the art of sustainable innovation that starts from the observation of the living world, and leading to innovation in technology, aesthetics, architecture, design ... This return to nature is explained by the fact that it is very rich in forms and materials which provides a favorable framework for innovation” [3].

“In this sense, it is important to mention that considers Benyus biomimicry as a process to produce goods and innovative services, while drawing inspiration from nature. It is obvious that the bio-mimicry is a gushing source of progress and innovation. It can take real sense if it carries sustainable creation that represents a sustainable solution useful to humanity” [3].

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, through biomimicry, we can tap into the genius of living a sustainable source of innovation as was done in the solar cell that mimics the plant leaf. The process starts with an observation of the essential properties of one or more biological systems, eventually leading to the development of forms, materials and processes that are both innovative and sustainable.

Innovation through biomimicry affects almost all areas of humanity. In any area where Man has hand we find innovations inspired by nature. In what follows we will mention a few areas marked by biomimetic innovations.

a. Biomimicry and aesthetic innovation

“It is undeniable that the bio-mimicry is considered an art of observation. And like any art, it relies on aesthetics. In fact, since the dawn of humanity, man has always tried to reproduce the aesthetics of living organisms. In antiquity, it was inspired by the structure of a skeleton to build its primitive huts. But now, he built monuments on the basis of curves and patterns present in organic forms.

He was always in strong relationship with nature, which for him was a source of reference and inspiration. This is where the bio-mimicry becomes a favorable field where human intelligence is strengthened by the intelligence of nature arises. Thus manifests the ingenuity of man and its creative value” [3].

b. Biomimicry and technological innovation

Technology is everywhere in the world built by man, it is his personal environment or the working environment "Technology is the application of knowledge to the goals of human life, or to change and manipulate the human environment. " The technology also provides knowledge and skills for the design and implementation of product. Concerning our industry, it is specific to each design a luminaire product whose use of tools and materials resulting from the application of technology as the techniques, methods, procedures and skills are used to increase productivity, creativity and innovation.

Technology dominates our lives day by day becoming more and more modern. It is with this technology that manifests human intelligence, which, in order to perfect his inventions, it is reinforced by the intelligence of nature. The combination

of the two types of intelligence gave birth to the bio-mimicry whereby, technological inventions have been created especially after man began to master new manufacturing tools.
Technological inventions created by biomimicry are quite numerous. But the most famous is perhaps the Japanese TGV created in the twentieth century. In this technological creation, the engineers were inspired feathers owl and the average beak kingfisher to increase speed and reduce noise and power consumption.
We can conclude, then, that through biomimicry, the man could master new manufacturing tools. Thus, he has technically meet many needs. In this way, it has made technological advances that have been impressive thanks to the industrial revolution.

3.1.2 Biomimicry and Sustainable Development

Nobody can deny that modern life is invaded by technology that is constantly evolving. This technological development has an adverse effect on the ecological system that night so our physical and mental health.
Faced with this environmental problem, it is necessary to resort to nature that has always been human inspiration whatsoever in solving its problems to meet its needs. This return is through biomimicry considered a philosophy or approach guided by the need to respond to technological or organizational need.
It grows Man to learn from the living, organic, known for its diversity and wealth, leading to issues of sustainable development (social, environmental and economic) by providing attractive solutions in terms of technology, comfort, economy and aesthetics.
Indeed, in recent years, and because of the ecological crisis, many studies and innovative research on biomimicry has been made globally. These works demonstrate a remarkable rapprochement in the approach of some physicists and chemists with the life of the operation modes. All this research is explained by the fact that biomimicry is currently considered the preferred solution that ensures durability since it changes the modes of production in different fields. In 2002, Benyus says "Companies must operate as a living system ... they must find a way to create conditions conductive to life, non-toxic to life." This approach is evolving more and more and in 2007, the Senate showed that biomimicry is: "One of the toolboxes of the fourth industrial revolution."

The biomimetic approach from the imitation of living because nature provides materials and quite many functions. But to copy a system, we must already understand how it works. This shows that biomimicry, we note a three-step approach: Imitation of form, imitation imitation of the process and the strategy of ecosystems and their interrelationships. We aim then to analyze complex material properties and biological processes of living and divert industrial purposes.
In nature there is no waste, everything is recycled. Every living species is a library that inspires the human production of an object. Moreover, analysis of living materials shows that these materials have unique qualities. They usually produce at low thermal insulation which creates a great energy saving. From this we can say that biomimicry can cause the reduction of energy consumption and natural resources. Figure 3 illustrates the innovation strategy of Biomimetic structural materials.

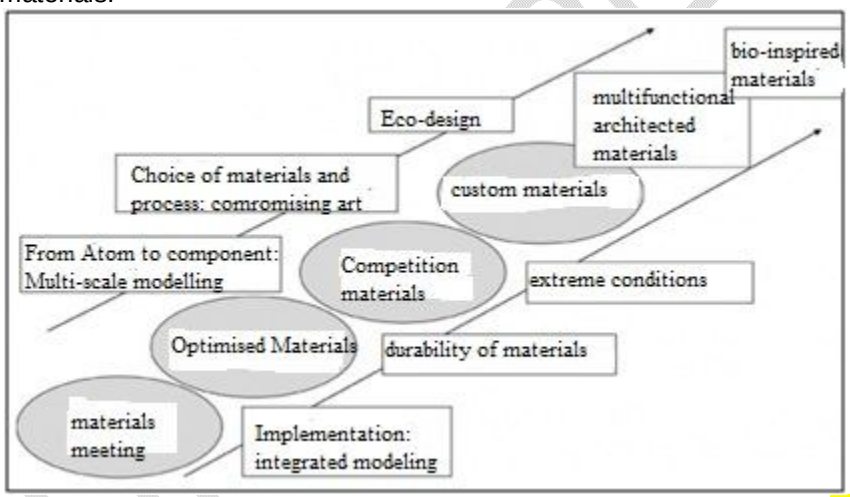

Fig. 9. The innovation strategy of Biomimetic structural materials [15]

In addition, these materials are autonomous; they self-organize, reconfigure and self-regenerate. They have a very high degree of optimization of composite structures. With all these features biomimicry aims to create environmentally friendly innovations and not consuming fossil resources with a product life cycle without waste.
These natural materials have been used even in the field of design to create products that combine aesthetics and natural.
In addition, biomimicry, in its strictest interpretation, is the process of emulating nature's way of finding a solution including designing and making with the least environmental impact. In fact, biological systems should be seen more as concept generators in terms of transfer of principles and mechanisms rather than something to copy, literally. Modern technologies

have made it possible to design and manufacture products/systems that are based on nature. However, the process or the technology to do so has not always been purely eco-friendly. It is primarily because nature's implementation of a concept into a system is far different than that developed by humans. In nature, growth is the primary means of manufacture rather than fabrication.
The design strategies of biological materials are not immediately applicable to the design of new engineering materials, since there are some remarkable differences between the strategies common in engineering and those used by nature. The first major difference is in the range of choice of elements, which is far greater for the engineer. Elements such as iron, chromium and nickel are very rare in biological tissues and certainly not used in metallic form, as would be the case for steel. Iron is found in red blood cells, for instance, as an ion bound to the protein haemoglobin and its function is certainly not mechanical but rather to bind oxygen. Most of the structural materials used by nature are polymers or composites of polymers and ceramic particles. Such materials would generally not be the first choice of an engineer to build strong and long-lasting mechanical structures. Nevertheless, nature uses them to build trees and skeletons. The second major difference is the way in which materials are made. While the engineer selects a material to fabricate a part according to an exact design, nature goes the opposite way and grows both the material and the whole organism (a plant or an animal) using the principles of (biologically controlled) self-assembly. This provides control over the structure of the material at all levels of hierarchy and is certainly a key to the successful use of polymers and composites as structural materials.
Bio-inspiration is not just a consequence of an observation of naturally occurring structures. The reason is that nature has a multitude of boundary conditions which we do not know and which might all be important for the development of the structure observed. Therefore, we need to keep our eyes open and must be able to solve a particular problem set. Both the biological structure and the set of problems the structure is designed to solve can bio-inspire us.

3.1.4. Biomimicry and industrialization

Design is a creative activity whose aim is to determine the qualities of objects produced by industry is that "all companies subject to the transformation of raw materials and the exploitation of energy sources (...) All commercial activities contributing to artistic representation of production. ".
In the years after the war, all industrialized countries are showing interest in the product design to new means of production, new material. Within this framework of thought, industrial ensures, in the design of a light object, the consistency between the technical requirements of manufacturing, the internal structure of the object, its value in use and appearance. So industrial objects tend to embrace all aspects of the human environment which are conditioned by industrial production. In the field of industry, for example, the biomimetic innovations implemented in some companies allow cost reductions and waste. Thus, biomimetics is a research guide, applied to the industry, because the nature adapts maintaining and replicating the most successful innovations.
Applying biomimicry to the industry is: enter the era of low-carbon society have an interest for Humanity, bring interest to the industry. So this biomimetic approach helps preserve the planet and biodiversity as it stimulates innovations that bring sustainable value in the markets, saving in economic and environmental efficiency (reducing costs and waste).

3.2. Biomimicry in Design

Design is a practice of adapting its methodology on extremely complex and varied forms, to find a solution to every problem. Design is everywhere, beyond material things around us, and all his wealth stems from its multidisciplinary approach. We treat both product space, communication, technology, humanities, semiotics, economics, ...
Nature, imaginative by necessity, has always been for designers, architects and artists inspired. It gives them the idea to imitate the beauty of its forms, processes and behaviors. They then use biomimicry, which now seeks to draw from nature to invent solutions to environmental problems and to develop new interaction between man and his surroundings. Within this framework of thought, we can cite the following examples: painting that mimics the lotus leaf; carpet reminiscent of the forest floor, ... [5].
Domestic life can also benefit from the expertise and specific qualities of the fauna, flora and natural phenomena. For once, the design copy is appreciated.

3.2.1 Biomimicry in architecture design

The architecture is a field that has benefited a lot of biomimicry saw that architects have always turned to nature for inspiration.
Buckminster Fuller, an architect known for the use of forms of nature in the structures he realizes, said that "natural concepts represented wonderful models." According to him, most of the natural technology, dynamic, functional and light is its optimum efficiency.
Similarly the architect Eugene Tsui is deemed to be inspired by natural concepts in her designs. It does not use the right angles and straight lines which we are accustomed, he prefers the soft lines that we find in nature. The structures designed according to these principles are able to withstand the destructive effects of earthquakes, wind and water.
In the field of architecture, examples of buildings constructed on the basis of nature abound. First, we include the Eiffel Tower, the structure is similar to that of the proximal femur. This structure, although it is lightweight, it is very resistant to

wind and all natural phenomena. Similarly several architects and building engineers are inspired by the internal structure of bone in the roof construction.
In addition, we have the Olympic Stadium in Munich, it was built by its designer Frei Otto at the minimum surface notion observed in the structures of cobwebs. Besides those mentioned previously, we can mention the roof of Canada's Royan Market was designed based on the model of the oyster shell with irregular shapes allow them to withstand enormous pressure despite their light weight.
We studied until now, the biomimetic approach in various ways, in the architectural dimension, sustainability, innovative, aesthetic and technological.

3.2.2 Biomimicry in textile design

From the dawn of time, nature was to man the first shop that offers her clothes. Certainly it was not the clothes themselves but objects that cover his body. This process still continues to the present time but only as a source of inspiration or source materials [6].
Nobody can deny the value of textile materials manufactured by taken from nature such as spider silk and silk worm. These two totally natural materials are known for their strength and elasticity. Their ability to twist and deform without breaking is very remarkable. Spiders like silkworms stack the proteins that make them as patties, which by hydrogen bonding, somewhat weak, become extremely strong.
It is therefore obvious that the imitation of the silkworm and the spider's web, gives rise to well-resistant synthetic materials used to produce a broad textile combining both beauty and quality.
In the field of textile, materials inspired by nature is not only limited to spider silk or silk worm, but the bio-mimicry of the library in this area is very rich. Quote of example, the role of the lotus leaf in the manufacture of self-cleaning or waterproof fabrics. It is undeniable that the lotus leaf is not known its ability to not retain water. Indeed, the surface of the lotus leaf is covered with bumps provided with hair in the wax crystals that make ultrahydrophobicity which prevents water droplets from entering the surface of the sheet. This lotus effect was an inspiration to many researchers and industry in achieving super hydrophobic materials, self-cleaning and waterproof for the manufacture of waterproof fabric.
The examples in the field of biomimetic textile are still numerous. But we limit ourselves to name a few such as coatings inspired skin of the shark. This kind of coating developed by US company Sharklet, is antibacterial and non-toxic. We also include dry swimsuit right out of the water while keeping the feel of cotton, which is a natural material used in the manufacture of various textiles.
We can not begin the study of all textiles inspired by nature. But we try to mention the most known. Nobody can deny that the most expensive clothes are made from textiles made of natural cotton or silk worm.
The large array of polymeric fibres and other materials available to us often lead to blending or mixing of these fibres to develop a new product or improve an existing one. This makes it immensely difficult, at times, to eventually recycle the product. Use of limited variety of materials in nature makes it easier to recycle. With only two polymers (proteins and polysaccharides) in use, it is much easier for nature to separate and recycle. Biomimicry in textiles must also consider recyclability and aim at reducing the number of polymer types we tend to use in a product. Natural systems are inherently energy-efficient and adaptable. To be sustainable, textile fibres and products must emulate this feature as well.
The combination of biofibres, such as kenaf, hemp, flax, jute, henequen, pineapple leaf fibre and sisal, with polymer matrices from both non-renewable and renewable resources to produce composite materials that are competitive with synthetic composites requires special attention, i.e. biofiber–matrix interface and novel processing.
The hook and loop fastener, Velcro, has been traditionally manufactured using nylon. The key ingredients are petroleum derivatives, with the usual environmental consequences of petroleum processing. If biomimicry is to be used as a new principle in designing fibres(e.g. textiles), sustainability must be part of it. Biomimetics can help us rethink our approach to material development and processing thereby help to reduce our ecological footprint. The history of textiles is full of continuous search for invention of new fibre-forming polymers with unique and improved properties. The increase in world population coupled with increased standards of living has driven per capita consumption of fibre to levels that may not be sustainable. The increasing demand for fibres is also driven by their new and innovative use in new and innovative products. Ideally, the increasing demand should be met largely by using renewable resources and through efficient recycling. Plants and animals in nature hold the key to this route.

3.2.3 Biomimicry in products design

Products inspired by nature and created by biomimicry are countless. They are so numerous and divided into different areas that you cannot study them all. But it prevents cite some of these products.
Besides those mentioned previously, such as the Japanese T.G.V and the Eiffel Tower, we can speak of Airbus aircraft. Engineers and aircraft manufacturers of this company are in the nature of an unlimited source of inspiration. The return to nature allows them aerodynamics, energy saving and new materials. Moreover, the researchers started from the study of gecko. They discovered that this big lizard has an extremely complex force by which one of his fingers can support its entire weight as indicated Duncan Irschick, who studied the lizard for over twenty years. "The foot of a gecko is composed of several elements that interact, including tendons, bones and skin in addition setae, working together to produce this

fantastic easily reversible adhesion." The following figure shows the hierarchical structure of the gecko's paw to the nanometer scale.

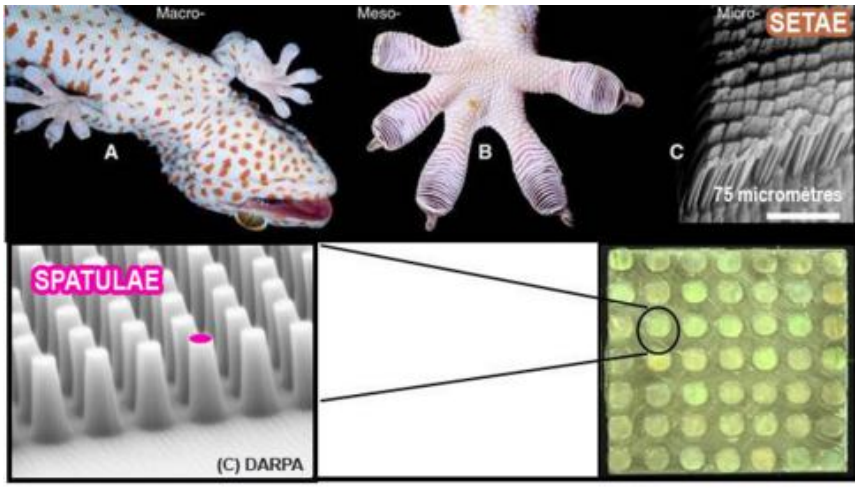

Fig. 10. Hierarchical structure of gecko's paw [17]

In 2011, the researchers copied this invention to produce a strong adhesive, dry and colorless: the geckskin able to easily carry a 40-inch flat screen.

Biomimicry has also invaded the medical field. In addition to the drugs produced by medicinal plants, we find medical tools inspired by nature. In this context include the painless medical needles, made by two Japanese companies. To achieve these needles, the two companies have copied the wrong mosquito that inspired their conical shape. Thus, especially in 2005, researchers have managed to create conical needles. Currently, Nanopass33 syringes are widespread throughout the world and in large numbers. In the same context, we must mention the new method to store vaccines at room temperature. This method was discovered on the basis of the plant "resurrection". Also as part of the research done in the service of medicine, we cite the example of the adhesive inspired by mussels. This is an adhesive which can be used in medicine since it is inspired from a natural material which is the ability of the mold to synthesize tights filaments in sea water. Thus, it was found that this glue works wet , so it can be used in medicine. Within this framework of thought, hundreds of projects are done as part of biomimicry gave birth to many useful biomimetic products in various fields. For example, in commercial use, we have created the tire tread, which is inspired by the cat's paws. These tires provide exceptional braking.

In the field of energy, bio-mimicry played a key role. He is also involved in energy production, inspired by photosynthesis. It was a project presented in 2010 and of producing a clean and inexhaustible energy that only throw water. Also as part of energy and to solve problems of LED lamps which light capacity is very limited field of researchers use change these lamps by drawing on the abdomen of the firefly is covered Photuris scales sawtooth allowing the insect to shine very strong. In this way, the brightness of the light source of the lamp becomes more increased.

Nature was also a good source of materials for the manufacture of glass. In this context include the nanostructured glass used in the manufacture of windshields seen that it is very solid. This type of glass developed by Saint Gobain, was inspired by the lotus leaf. Similarly, self-cleaning glass is inspired by the hydrophobic surface of the Nymhéa leaves. Glass microspheres encapsulating therapeutic molecules are inspired shells of diatoms.

In addition to these products inspired by nature, another product should be mentioned given its usefulness for mankind, it is the new anti-counterfeiting technology that was created by the Canadian company Nanotech Security Corp drawing on butterfly wings.

Talking biomimetic products can never have an end, but to finish this part, we quote the production of plastic inspired bees. This natural plastic can be used in packaging. It can therefore participate in the protection of our planet artificial plastic is petroleum based.

We can deduce that this approach is seen as a sustainability tool that is to say that it makes sense only when it has, sustainable creation tool, innovation and technology. This is an area that continues to be in continuous evolution. Its evolution has allowed many advances.

3.3. Studied examples of biomimicking in product design

3.3.1 Applying color without dyes

Nature has unique abilities to manipulate light. Most surfaces in nature are not just functional; they often produce brilliant, vivid and iridescent colours. Colour, of course, is an essential part of most textiles. Natural colours are often produced by a diversity of photonic structures that have evolved over millions of years to generate effects known as structural colours (in contrast to colour from pigments). Structural colours result from interference or diffraction, or selective reflectance of incident light owing to the physical nature of a structure. If these submicrometre structural variations are periodic with a periodicity of the order of the wavelength of light, they are often called biological photonic crystal structures. These biological structures suggest a new perspective on fine structure of fibres as well as higher level assemblies of fibres used in textiles. Examples of structural colours have been reported in a large number of species, including butterflies, bird and beetles. There is a vast body of literature on the structural colour in plants and animals. Srinivasarao, Parker, Tayeb et al. provide excellent reviews of mechanisms of structural colour.

Excellent examples of biological optical systems and clues to their potential applications in textiles can be found in studies involving anatomical basis of photonic crystals in nature. Photonic crystals (also known as photonic band-gap materials) are periodic structures that have a band gap that forbids the propagation of a certain frequency range of light. As a result, photonic crystals always reflect only that specific band width (colour) of visible light. Such structures are found in nature in butterfly wings, some plant species (bracts of edelweiss), marine creatures (e.g. brittlestar, Ophiocoma wendtii), opals, etc.

Butterflies probably exhibit the most interesting varieties of optical microstructures and have been studied extensively. In general, the butterfly wing consists of two or more layers of small scales formed over a membrane. Typically, there are two to three types of scales of about 200 μm long and 50 μm wide, arranged with an overlap much like roof shingles. The density of the scales varies from 200 to 500 mm−2. The various colours produced are mainly owing to both pigmentary and structural colour production mechanisms. Most of the colours are produced by either thin film interference or diffraction. The membrane of the wing usually contains the pigments melanin or pterins that accentuate the colour effects because of structural variations. In the case of Morpho butterflies, the metallic blue is produced by the elaborate structural features on the wings. The dark melanin present in the membrane absorbs the light that is not reflected to make the reflected colours appear bright.

A native of the South America rainforest, the Morpho is one of the largest butterflies in the world, with wings that span five to eight inches. The vivid color on the upper surface of their wings is the result of microscopic, overlapping scales that amplify certain wavelengths of light while canceling out others.

Similarly, Morphotex relies on fiber structure and physical phenomena such as light reflection, interference, refraction, and scattering to produce its opalescence. The fabric comprises roughly 60 polyester and nylon fibers, arranged in alternating layers that can be varied in thickness to produce four basic colors: red, green, blue, and violet.

This dress's iridescent hue is purely a trick of the light. Fashioned from Morphotex, the frock uses structurally colored to mimic the microscopic structure of the Morpho butterfly's wings, which appear shimmery cobalt despite its lack of pigment. Manufactured by Teijin in Japan, Morphotex requires no dyes or pigments, nor the prodigious amount of water and energy used in conventional dyeing.

Fig. 11. Morphotex dress [12]

By mimicking the way colour is produced in the Morpho butterfly's wing, the fibre appears coloured but does not use any dyes. Iridescence in the butterfly's wing is formed through structural or physical colour, rather than chemical colour.

3.3.2 Bright sunflower

This is a PV panel (Fig 11) created by designer Andy Florkowski which has always sought space innovation and perfection. He has always worked closely with "Architecture for Humanity" to deliver community architectural projects at the service of humanity. In his work he was inspired by nature and he took care to ensure sustainable development.
He presents his work, saying, "I consider myself very fortuitous because my job as it is, is simply to do what I love. I am an ambitious designer, multidisciplinary with a talent for spatial innovation and improved output; or in other words, I want to challenge the agreements also tend to push the car above the expectations of the high tide line. "

Andy Florkowski is a designer but also talented architect. Thanks to its expertise in the field of architecture, he tried to innovate and create in the context of sustainable development. He says in this direction: "My skills affect many aspects of design and architecture, although my specific expertise includes retail design, design of brand identity, retail analysis, architectural visualization, regeneration and spatial sustainability. " Among its innovative work, a photovoltaic panel, created as part of sustainable development. This is a biomimetic panel as it is inspired by nature. It has the shape of the flower sunflower and works with solar energy.
It is a light panel used for night street lighting. It is formed of a composite head leaves similar to those of the sunflower flower, placed on a support. The whole forms a photovoltaic panel exactly like natural sunflower. This panel can be regarded as a biomimetic creation. First, because its shape is inspired by nature and secondly because it emulates the process of photosynthesis using solar energy that ensures its functionality.
The upper part of the panel which represents the head has a dual role. This is both a solar sensor on the day, and at night it becomes a light distributor. It moves according to the appearance or disappearance of the sun. Throughout the day, the head of the panel turned to the sky to capture solar energy and store it indoors. When the sun disappears, the head rotates mechanically to cope with the earth. This phenomenon is similar to movement of a sunflower following the path of the sun above. During the day, the solar energy stored in the sensor is transformed into a changing light which is reflected in its positioning. The shape of the light is taken from that of a "moonflower", just as for protective.
When the sun disappears, and at night, the head of the panel turns to face the ground. So his role is changing. At a solar sensor in the presence of the sun, it turns into an administrator and light light reflector. Thanks to the shape of the leaves whose edges are irregular, biomimetic panel to disperse and reflect light through the streets.

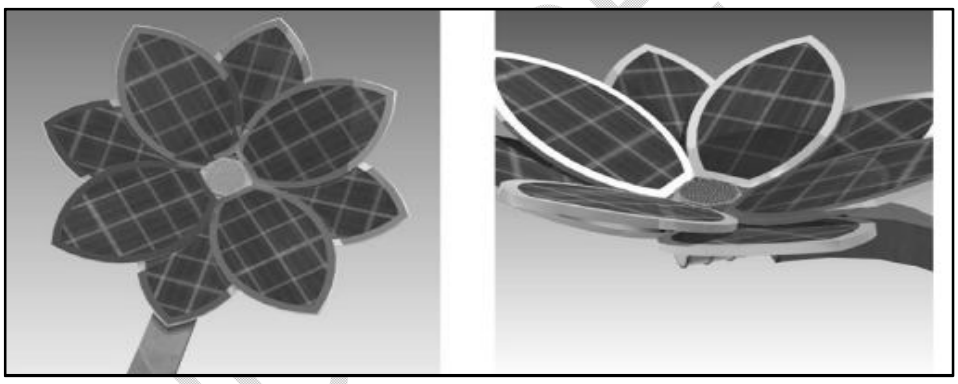

Fig. 12. The operation of the head bright sunflower [11]

It is obvious that the bio-mimicry, we could create a photovoltaic panel in the shape of a natural plant and operated by solar energy. Inspired by the natural concerning the shape and material, we can produce electricity and light. It is a synergy between the natural and technology.

4. CONCLUSION

New ecodesign tools and methods should be developed to be usable in early design stages of functional textile, so that real innovation and environmental benefits can be achieved. One particular area of concern is the disposal of functional textiles after the end of their useful product life.
New ecoconcepts, material choices, designs, aesthetical concepts, and maintenance habits depend on the consumer’s acceptance and willingness to change his/her preconceptions and routines.

This ecodesign in functional textile seems to be not as easy to accept among consumers. Consumers do not want apparel to be different in design or appearance. Few consumers want clothes to declare ecoaesthetics.
At last but not least, new ecodesign tools and methods should be developed to be usable in early design stages, so that real innovation and environmental benefits can be achieved. Ecodesign will only be robust and fully efficient when these challenges will be taken up.
It appears important to show that biomimicry is an approach that has always been at the service of man. He proposed to tap into the genius of living a sustainable source of innovation. It is to observe and reproduce the essential properties of one or more biological systems to develop shapes, materials and processes that are both innovative and sustainable.
While nature was to man a source of unlimited inspiration, it is because it presents models of inventions and abundant materials giving rise to non-polluting innovations and not consuming fossil fuels. Even if the imitation of nature by man is present from the beginning of our civilization, bio-mimicry, which gives a sustainability requirement in creating a product's life cycle without waste is itself very recent.
And to imitate nature, man is invited by biomimicry to draw on three sources of inspiration. The first approach focuses on forms found in nature; the second to the processes used by the living to best respond to a necessity dictated by its environment; third ecosystem saw the performance of these sustainability, productivity and adaptability.
We want to imitate nature simply because it has already solved most problems that concern us. This is why it is possible to apply efficient strategies of nature in all fields, including the following: Design, engineering (civil, materials, surfaces, chemical, mechanical, electrical), architecture, management (management, operations, networking), urban planning, social, chemistry, and even in our daily lives.
Finally, we can summarize that the bio-mimicry is the transfer and application of materials, forms, processes and remarkable properties observed at different levels of life, to human activities giving rise to biomimetic products.

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