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BİYOLOJİK YAPILARDAN İLHAM ALAN BİYOMİMETİK BİLİMİNİN TEKSTİL VE GİYSİ TASARIMINDAKİ GÖRÜNÜRLÜĞÜ

THE VISIBILITY OF BIOMIMETIC SCIENCE INSPIRED BY BIOLOGICAL STRUCTURES IN TEXTILE AND APPAREL DESIGN

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Özet

Doğa, insanoğlunun gereksinimleri sonucu ortaya çıkan sorunlarına yanıt bulmak için yaratıcılık ve teknolojik gelişmeler bağlamında, birçok fonksiyonel sistemlerle inşa edilen harikulade malzemeler sunmaktadır. Son zamanlarda, daha sürdürülebilir bir dünya yaratmak ve yaşamın dehasını korumak amacıyla doğayı taklit eden ve onun ekolojik standartlarını mühendislik, mimarlık ve tasarım alanlarında kullanan Biyomimetik kavramı karşımıza çıkmaktadır. Yeni bir bilim dalı olarak literatüre kazandırılan bu kavram, tasarım alanındaki eksiklikleri kapatma arayışında kusursuzluğu yakalamayı hedefleyen tasarımcılara geniş olanaklar sağlamaktadır. Bu araştırmada, tasarım problemlerine stratejik çözüm üretmede ve yeni prosesler geliştirmede yol gösteren Biyomimetik biliminin, tekstil ve giysi tasarımında nasıl ve ne amaçla kullanıldığı malzeme ve yapısal yönüne odaklanarak güncel örnekler üzerinden incelenmiştir. Tasarım olgusu ve doğadan esinlenmenin çok eskilere dayandığı bilinmekle birlikte, Biyomimetik biliminin tasarım alanına etkisinin günümüzde daha görünür hale geldiği açıkça görülmekte ve araştırılmaya değer bir konu olmaktadır. Bu nedenle, geliştirilen yöntemlerin ve ortaya konulan tasarım pratiklerini takip etmenin, konu üzerine yapılan teorik çalışmaları daha ileri seviyeye taşıyacağı düşünülmektedir. Çalışma, konuyla ilgili tartışmaların sürekliliğini sağlamak ve yeni yöntemler geliştirmeyi teşvik ederek söz konusu alana katkı sağlamayı amaçlamaktadır. Nitel tarama yöntemiyle gerçekleştirilen çalışma, teorik bilgilerin yanı sıra sınırlı sayıda seçilmiş görsel örneklerle desteklenmiştir. Sonuç olarak, bilimsel bir yaklaşım olarak karşımıza çıkan Biyomimetik sayesinde birçok problemimize sürdürülebilir yanıtlar bulabileceğimiz tekstil ve giysi tasarımı disiplinini baz aldığımız araştırmamızdaki örneklerde görülmüştür.

Anahtar Kelimeler: Biyomimetik tekstiller, Biyo-taklit, Biyo-tasarım, Tasarım odaklı düşünme, Yaratıcı tasarım, Tekstil ve giysi tasarım

Abstract

Nature offers us marvelous materials built with many functional systems within the context of creativity and technological developments in order to find answers to the problems that arise in the consequence of human necessities. Recently, the concept of Biomimetics, which impersonates the nature and uses the ecological standards of nature in the fields of engineering, architecture and design, confronts us for the purpose of creating a more sustainable world and of preserving the genius of life. This concept gained literature as a new branch of science provides wide range of facilities for designers aiming to achieve perfection in search of covering the lacking parts in the field of design. In this review study, how and for what reasons the science of Biomimetics, guiding to generate strategic solutions to design problems and to develop new processes, is used in textile and apparel design is analyzed over current visual patterns by focusing on materials and its structural aspect. Although it is known that the phenomenon of design and inspiration by nature dates back to very old times, it is clearly seen that the effect of biomimetic on design has become more visible today, becoming an issue worth researching. Aim of this study, to assure the sustainability of the discussions on the subject and to contribute to the mentioned field by encouraging developing new methods. This study is carried out by using qualitative research methods, is supported with theoretical historical as well as visual examples chosen in limited numbers. Consequently, the fact that sustainable answers can be found to many problems of ours thanks to Biomimetics confronting us as a scientific approach has been seen in the examples in our study in which we took textile and apparel design as the basis.

Keywords: Biomimetic textiles, Bio-mimesis, Bio-design, Design Thinking, Creative design, Textile and apparel design

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1. INTRODUCTION

Textile has been known since prehistoric period to be an indispensable part of human life (Das, et al, 2015:893). Textile, which humans formed with fiber-like materials they found around for the purpose of covering and protecting from harsh climatic conditions of nature, is understood to be us as woven fabrics at first. Humans, who colored these textile products with the paints they obtained from nature, demanded more in the course of time and converted their feelings and thoughts into the design movement. In the process of design movement, all designers encounter at least two main problems; creativity and finding new ideas (concepts). In this context, the main duty of the designers who are in search of creating differences in their production in the fields of textile and fashion is to follow the new developments and to assure sustainability in presenting innovations, as stated by Marta Kisfaludy (2008:59). Thus, there will be an increase in the usage fields of the design of textile and apparel, and the designs can get rid of ordinariness (Erbıyıklı, 2013:48).

> Fabrics were being produced long before the recorded history. Even 20,000 years ago, humans were twisted fibres together to make thread and string (the oldest preserved string is from Lascaux caves in France, aged circa 15, 000BC). The first garments made were probably string skirts, 'zostrast', used to advertise a woman's fertility. Egyptians made linen fabric around 5500 BC. Initially, humans started using textiles for protections purposes. Thereafter, textiles become fashion, art and design items (Das, et al, 2015:893).

Natural phenomenon can provide inspiration, knowledge, models and solutions for further developments in multiple design applications (Fratzl, 2007: 641). Nature provides limitless solutions for the above-mentioned design problems. For example; superhydrophobicity, self-repair, energy conservation, dry-adhesion, self-cleaning etc. (Eadie and Ghosh, 2011:761). These solutions undoubtedly act on the products of designers just as they contribute to the scientific studies of scientists as an inspirational source. Accordingly, it is possible to say that the approach of biomimetic, which is a new branch of science and which is based on impersonating the nature, is gradually gaining importance in textile and apparel design. In this approach, which basically necessitates an interdisciplinary study, it is pointed out that quite creative products have recently been manufactured in the consequence of the partnership of science and textile-apparel design. Although it is known that the phenomenon of design and inspiration by nature dates back to very old times, it is clearly seen that the effect of biomimetic on design has become more visible today, becoming an issue worth researching. This paper explores the form and materials of biomimetic textile and apparel design. The exploration begins with a general overview, followed by theoretical framework, and visual examples are provided, which stands out through the transformation of many objects that we trace in nature and daily life in textile and apparel design. In the conclusion part, the importance of biomimetic in the so-called field and the method that can be developed are mentioned, and suggestions are provided.

2. THE AIM of THE STUDY

The main purposes of this research is to clarify the concept of textile and apparel design from biomimetic perspective. In this study, the concept related to textile-apparel design and Biomimetic science are examined, design patterns based on biomimetic approach are analyzed and the methods of transmitting 'learning from nature' into design are presented in view of current developments. The study aims to assure the sustainability of the discussions on the subject and to contribute to the mentioned field by encouraging developing new methods.

3. METHODOLOGY

This paper is carried out by using qualitative research methods for historical review. The primary data for the articles consists of an academic publication, books, essays, newspaper, web site etc. Analyzing the data revealed similarities between the main categories including defining biomimetic. Study is classified into two groups: the form of textile structure and the form of apparel.

4. THEORETICAL FRAMEWORK: INTRODUCING BIOMIMETICS

"The terms bionics, bionik (German) and biomimetics, however, are of a much more recent date. They all designate a study involving copying, imitating and learning from nature" (Torben, Hyunmin and Shu, 2008:311). When the term Biomimetic is examined, the term bios means life in Greek, while mimesis means mimicking (Canpolat et al., 2014:92). Biomimetic is completely or partly mimicking a living being in the nature in terms of color, texture, function or form (Kuday, 2009:19). It has been called by different names such as 'intellectual structure' in Japan and 'smart material' in USA. At the same time, it includes bio-mechanics, bio-material and biological systems. Although the science of biomimetic has gained popularity relatively recently, the idea has been in existence for thousands of years (Eggermont, 2007). But, the term biomimetic, first put forward by Otto Herbert Schmitt in 1957, was first used in Schmitt's article named Some Interesting and Useful Biomimetic Transforms at his Third International Biophysics Congress in 1969. It was officially defined in Webster's dictionary in 1974 (Bhushan, 2009). Learning from nature is the main idea on the basis of all of the concepts such as bionics, biomimetics, biomimicry, bio-design, biomechanics, and organic design (Vincent, 2006).

There are some sources that the above-mentioned terms are synonymous with. However, their fields of usage have become different in the course of time although their basic meanings and appearance aims are similar. Professor Orhan Küçüker, on the other hand, defines biomimetic and biomimicry as a new branch of science which examines the models in the nature and aims to find solutions to people's problems by getting inspired by these models. Küçüker, who says that the concept of biomimicry is as old as history of humanity, stated that the main source of the inspirations, is the feature found in plants and animals and described it as mimicry in biological education (Yıldız, 2012:61). In addition to

Küçüker's explanation, it is necessary to state that there exist the sciences of zoology, botanic, chemistry, physics, engineering and materials as well as biology in the basis of biomimetic science (Senosian, 2003). Although there are long-lasting studies on the term biomimetic, American naturalist and author Janine Benyus made the issue a current agenda with her book Biomimicry: Innovation Inspired by Nature (1997) (Vierra, 2011:1). According to Benyus, biomimicry's three approaches are;

1. Using nature as an inspiration to solve human problems
2. Using nature as a judge or measure of the 'rightness' of our innovations
3. Using nature as a mentor, looking metaphorically at us designing with values and perspectives present in the natural world.

In her book Benyus, summarized biomimicry as best learning and comprehending the possible solutions in the nature and the solution potentials. She also stated that the systematics and methods of these interactions bringing many different fields together should be revealed in each discipline. She added that if this learning process spreads and continues in different disciplines, there will be a biomimetic revolution in the coming years (Selçuk and Sorguç, 2007:456). Benyus, sets out that there are nine basic laws underpinning the concept of biomimetics;

> In his book 'In the Bubble', John Thackara highlights Benyus' perception about nature offering us endless examples to design. According to Benyus it is possible to benefit from these design examples and create more efficient solutions to even our basic needs such as keeping warm finding shelter and getting food. Benyus continues how nature is able to craft materials in a complex and functional way humans can only dream of (2005:187).

Humans have not been indifferent to their environment, have observed all living beings from past to present, and the change in the opinions about nature have affected the design as well in the course of time. "Modern biomimetic is a systematic approach for researchers who know that new developments and insights can only be achieved in transdisciplinary collaborations." (Milwich, et al. 2006: 1455). Discussing the concept of biomimetic within the context of textile design is important in terms of the reformation of the concept as in other disciplines. Therefore, it is thought that the developed methods and following the revealed design practices will uplift the theoretical studies on the subject to a further level.

5. BIOMIMETIC EFFECTS in DESIGN PRACTICE

In the periods in which the phenomenon of design did not emerge, humans used any object in the nature in accordance with a purpose. In this case, humans continued their lives pragmatically by using the method of logic (Bayazıt, 1994: 41). Later, they observed the nature while living in harmony with it, and produced objects that they could use in daily life by mimicking what they had learnt from the nature in order to ease their lives. In textile designation, there are several opinions and ongoing

discussions concerning the process of getting inspired by/learning/modelling and adjusting or applying the nature, which is a process increasing and being discussed day by day and frequently seen in applications (Selçuk and Sorguç, 2007:455). In this approach, an important development that reveals the relationship between textile design and science is the fact that Textile Futures Research Group (TFRG) researchers/designers worked with the candidates for Nobel Prize in the project 'The Nobel Textile' in 2008 (Şimal and Yıldırım, 2012:12). Textile, which is used in many different fields and which is a growing branch of industry, leaves behind massive and non-recyclable wastes while consuming the sources. The environment facing such kind of negative problems has forced us to develop strategies thereon and to think again (Theodorescu, 2014:1). Chiu and Shu (2007) suggested that designers and engineers concluded with their observations about getting inspired by biology in order to find solutions to the problems of design but this method reduced the great potential of biology. Therefore, they pointed out that there are some methods by which designers can reach biological sources and obtain more detailed biological sources with correct key words, achieving more comprehensive results in biomimetic design. With a direct approach, how a design problem is solved in the nature is researched and how it is applied in designation is found out. Designers do not need to have a profound knowledge of biology so that they will find solutions to their problems of design with the help of biomimetics. Here the duty of the designers is to define the problem correctly and to determine what is needed. It is not difficult for a designer to mimic the mechanical features of a form or organism inspired by the nature, yet, it seems appropriate for biologists to be involved in the design process in mimicking scientific issues such as chemical processes (Panchuk, 2006).

In this context, textile designers not only used the materials they got from the nature as a solution to the increasing problems but also obtained positive results based on the sustainability of the design through the help of carrying out the solutions from the shortest way by spending the least energy and of adjusting them to the designs. There are a great many reasons in the designers' mimicking of the nature such as resistance, fixing itself, getting the raw material from the nature, high productivity, aesthetics, and recyclability (Gök and Gürcüm, 2014: 1919). Generally speaking, there is a perception that biomimetic designs should resemble the forms in the nature. Although there are designs inspired formalistically, the aim in biomimetic design is not analogy but it is to use the genius of the nature. That is to say, it can be not only formalistic but also in material, structural and functional dimensions. "It is important to understand the difference between a material and a structure. A material is homogeneous, right down to the atomic level. A structure, on the other hand, is inhomogeneous and may even be anisotropic" (Johnson et all, 2009:1559).

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6. DESIGNS MIMICKING the NATURE in TERMS of TEXTILE MATERIALS

For a designer, material is extremely important in the process of design. Therefore, the science of biomimetic has an important role in the development of materials. German researcher and biomimetic expert Wilhelm Barthlott, during the research on lotus leaf, discovered that it has sticky crystals with small bubbles and resisting water. The dirty molecules on the surface of the lotus leaf rise thanks to the bulges on the leaf and can be easily collected with water droplets. By developing this feature, it contributed to the production of clothes that can clean itself and resists to dirt on the surface in textile as well as in many fields (image 1). “On the other hand, electrospinning has become one of the most popular methods for the fabrication of micro and nano-fibrous materials with controllable compositions and structures in recent years, and therefore offers excellent prospects for construction of biomimetic superhydrophobic surfaces” (Wang et al, 2011:511). “Experimental investigations have shown that the fabrics with such new structure have clearly faster liquid water transport and better moisture management property” (Fan, Sarkar and Chen, 2010:221).

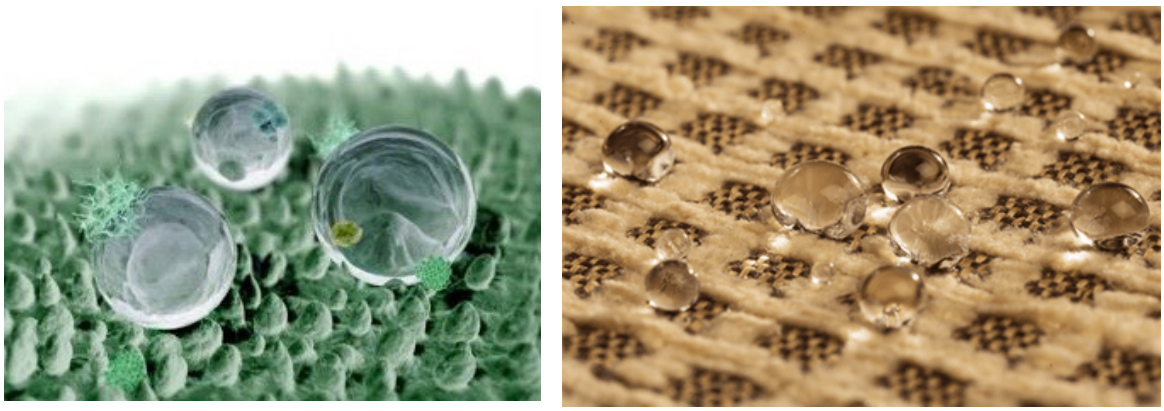

Image 1: Water Drop on Lotus Effect Textiles

While walking on the Jura mountain in 1948 with his dog, Swedish electrical engineer Georges de Mestral (1907-1990) realized that the fruit of Xanthium Spinosum was attached to the wool of his hunting pants and to the fur of his dog. When looked under magnifying glass, there are hundreds of observed small hooks on the fruit of Xanthium Spinosum. Depending on these findings, Mestral invented the bond named Velcro, made generally of small flexible nylon hooks (Deyoung and Hobbs, 2009: 150). This idea of design which flourished with the observation of Georges de Mestral is one of the most known and the best examples of biomimetic design (image 2).

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Image 2: Xanthium Spinosum and Velcro, and Microscopic Image of Tiny Hooks Found in Cockleburs Clinging to a Fabric

One of the last examples of the biomimetic effects is seen in textile designer Jane Scott's Hierarchy in Knitted Forms project inspired by biomimetic model of the hygromorp, pine cone and the hierarchical nature of plant materials (image 3). This textile design explores the potential design using natural sustainable materials. She explains the project as (2013:365);

> *Three moisture responsive pieces are described which use the inherent properties of wood veneer as an actuator incorporated into complex knitted forms constructed from linen and wool. These textile/veneer assemblies are environmentally responsive, transformable and constructed from natural, sustainable materials. This represents a new interpretation of shape changing textiles for architecture. The work illustrates the potential of designing hierarchically organized structures where functionalities are incorporated at different levels of material fabrication.*

It can be said that this textile project is located at the intersection of biomimicry and responsive material systems. These textile and veneer assemblies are environmentally responsive, transformable and made of natural and sustainable materials (Uuttu, 2015:26).

Image 3: Hierarchy in Knitted Forms

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7. THE CONCEPTS OF MIMESIS FROM NATURE TO APPAREL DESIGN

Biomaterials have structure-functional capabilities that are beyond the reach of manmade materials like silk, leather and wool which are widely used to make apparel. Humans have always made efforts to imitate nature and reach high level of development in biomimetic design. For example, fashion designer Stefanie Nieuwenhuyse made an apparel design by being inspired by reptile skins, in her Biomimetic project carried out within her master's program (image 4). By combining modern techniques such as hand sewn and laser cutting, she formalized plywood pieces and applied them on cloth without leaving any waste in the nature. With this projects of hers, in which she used natural materials, she both gained sustainability and resistance and made a balanced contribution to design aesthetically.

Image 4: Biomimicry Garments Inspired by Reptiles and its Detail

All designers have a great responsibility for developing new products and defining the materials, production methods and necessary finishing during their manufacture. Textile designer Veronica Kapsali is one of the first practitioners to research biomimetic textiles with a view to heightening the performance of apparels. She developed an adaptive textile, inspired by the way in which moisture can induce shape changes in many types of plant structures (image 5). *The textile works the opposite way that conventional natural fibres do.* Kapsali expresses that the process of the method in biomimetic is

utilized by mimicking the pinecone which opens to release its seed during dry conditions to allow the wind to disseminate the seed far away;

> *Fibres such as wool and cotton swell as they absorb moisture, which reduces the porosity of the textiles they comprise. The system i created becomes more porous as it absorbs moisture, and adaptive to perform so efficiently that it regulates the temperature around the wearer to the degree that they may not need several layers of clothing in winter"* (02.17.2015).

Image 5: Adaptive Apparel Design Inspired by Pinecone

Texture is another element for designers try to capture usually through embellishment but it can also be shown through structure and shaping of garments. "Several authors have attempted to qualitatively define texture. Pickett states that "texture is used to describe two dimensional arrays of variations. The elements and rules of spacing or arrangement may be arbitrarily manipulated, provided a characteristic repetitiveness remains" (Kandi, 2011:53). Textile samples usually consist of several types of textures, in this sense, another example of biomimetic effects can be observed in Alexander McQueen's apparel designs which are inspired by insects (image 6).

Image 6: Moth Apparel Inspired by Insects

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Some companies have taken inspiration from the South American blue Morpho butterfly (genus Morpho) and are creating structurally colored fibres with no dyes or pigments. Scientists have created the effect of Morphotex product which changes color as it moves by using nanotechnology. Japanese textile firm Teijin, having obtained structural color by mimicking the wings of a Morpho butterfly, has created Morphotex fiber by using 61 very thin polyester layers and nylon (image 7). 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. "The technology's proponents claim that these colors will never fade, and that the manufacturing is environmentally friendly because no chemical coloring is involved" (Dolgin, 2015:2).

Image 7: Morpho Apparel Inspired by Morpho Butterfly's Wing

Sharks have a mechanism that minimizes their resistance in water thanks to the structure of their skins. By this means, sharks can move faster. Having observed that the skin of the fish is composed of stripes when examined under microscope, and these stripes reduces the resistance of water by creating water swirls and spirals, scientist utilized this on the swimming suits of professional swimmers (Oeffner and Lauder, 2012:789). (image 8).

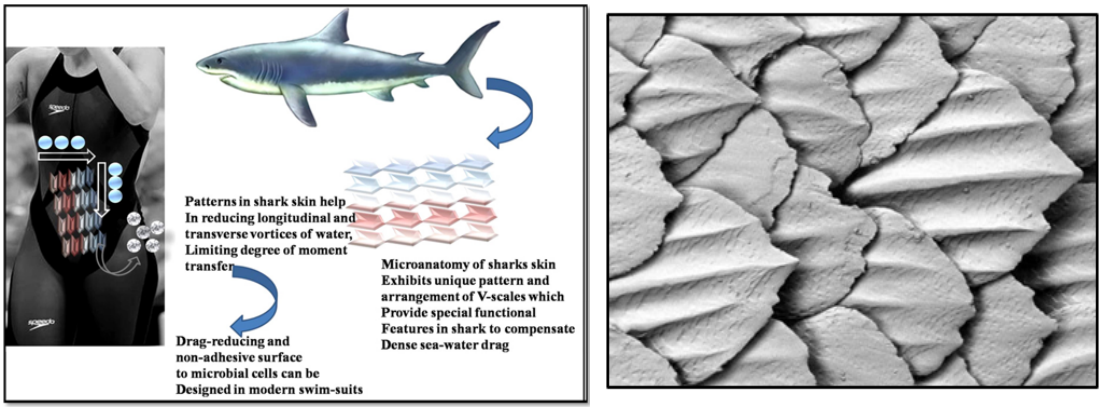

Image 8: Speedo's Swimsuit Design Based on the Structure of Sharkskin and its Detail Under the Microscope

Another example is interactive biomimetic apparel created by Birce Özkan. In this design, she wanted to mimic the leaves that every autumn trees shed to conserve energy for winter season (image 9). Her apparel design, named Fall, sheds small pieces of fabric when the light fades, just like trees do, except with the help of wearable technology (Quinn, 2010). She explains;

> *The apparel that I created a piece of wearable technology that is inspired by nature and changes in response to its environment, and i used mimicry to capture the beauty of falling leaves and I believe that the piece will make audiences appreciate the natural world. Fall is meant as an expressive garment that interacts with its environment and draws people's attention (06.10.2015).*

Image 9: Interactive Biomimetic Apparel Inspired by Leaves

8. DISCUSSION

As it is above mentioned, biomimetic science presents a challenge in several fields such as medical, artistic communities, sport, military and aerospace. The use of biomimetic model in textile and apparel design is rapidly increasing. Biomimetic textile and apparel design is an exciting and emerging field within the high-performance and functional textiles category, and as an interdisciplinary field, it deserves due to attention from the smart fabrics sector, as well. But, major problems of biomimetic design are high cost production, manufacturing limitations and service. In the future work, all these challenges can be reduced by increasing the volume of usage, the combination of newly discovered materials with biomimetic research will be a key to understanding their applications and limitations. Also, technological developments can help in reducing the cost, and using high-tech fibers and textiles nowadays are used for environmental pollution control or lifesaving implants. If scientist and designers are trying biomimetic approach to smart fabric design, they might be able to create intelligent apparel design with high performance.

9. CONCLUSION

This article focuses on the current research topics in biomimetic, and discusses the potential of biomimetic textile and apparel design. The interdisciplinary collaboration of designers with biological, chemical, physical, and engineering backgrounds and a systematic biomimetic approach will bring new insights for the development of new technical solutions in textile and apparel design. The fact that sustainable answers can be found to many problems of ours thanks to biomimetic confronting us as a scientific approach has been seen in the examples in this study in which textile design was taken as the basis. In addition, like many natural functional surfaces, the textile surfaces also offer excellent opportunities for developing new functionality. All these allow an easier way to borrow the biomimetic principles of nature in textile field than in other industrial areas. In the meanwhile, it is also possible to say that there is no limit for learning from nature and this is proven by biomimetic science. At this point, designers are undoubtedly among the people who will help make positive contributions to forming a more humane world. The role of the designer in creating sustainable society is not only creating sustainable products but also fictionalizing products, processes and services to encourage wide-spread sustainable behavior. It is necessary to implement the action of design, a vital development, to spread it, to create examples, methods and traditions in this direction and to encourage this action in each discipline. As Veronika Kapsali noted (2012), “in the future further advances in technology will enable the clothing industry to transfer even more paradigms for sustainable manufacture.” To sum up, this scientific approach will be able to present creativity and novelty only with a collective study and make advancement with the obtained data. This study will be a good resource for those interested in biomimetic research, including academicians, designers, and will provide guideline to stimulate further interest in this area. In short, from the above discussions, it is clear that biomimetic science has a very bright future in the textile and apparel design.

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