

Nature-inspired Fashion Design through The Theory of Biomimicry

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Abstract: Nowadays, we can see the power of nature by its biodiversity. It is not only beneficial to mimic our nature, but also to create a human-friendly device. This study intends to present classroom lesson plans designed with the application of Biomimicry, and to further analyze the fascinating fashion design collection that originate from the concept and application of Biomimicry. As forms and patterns from Mother Nature may inspire creative thinking for fashion design, Biomimicry instruction may benefit students both in learning by observing the wonder of nature and getting inspired from interesting classroom activities. Therefore, the purpose of the study is to propose the design of Biomimicry instruction, with several topics included such as Phenomenography and Bricolage for the analysis of how Biomimicry transforms and contributes to the fashion design field. We presume the use of Biomimicry is a meaningful way to educate our students in Taiwan, especially in the Fashion Design education with its application and development. It is hoped that the Biomimicry approach would be widely applied in actual classroom practice and make improvement in traditional teaching methodologies in fashion design.

Key words: *Biomimicry, Fashion Design, Phenomenography, Bricolage*

1. Introduction

This study explores the feasibility of the ways to innovate design from the basic teaching methodology in fashion design. Through the cross-cultural viewing points, the application of design elements in both the Western and Eastern cultures are also investigated, along with how to create and present the unique style without losing the originality of the creative work. In addition, this study explores the sources of designing motivation, as well as the appropriate attitude and behaviors while learning how to design as students, before they qualify as experienced fashion designers. Nevertheless, “originality” could be acquired through the curiosity of things through learning and cultivation.

The first author in this study has successfully completed the course on fashion design and obtained the National Class A Certificate from the Taiwan government. We discovered that school education on fashion design has become market-oriented--the industrialization of ready-made clothes resulting in a traditional teaching method that focuses mainly on learning manufacturing techniques. Although learning manufacturing techniques has its own importance, what displays the best of the work is creative thinking. That is, the teaching of “design” technique must be a top priority over the teaching of manufacturing processes. In the process of fashion designing, the source of the inspiration is one of the most important elements for creative design. And both the work and creative thinking should be generated from deep within the students’ heart. In this way, students will aspire to the

possibility of a new style and learn more than merely the manufacturing techniques, eventually leading to a breakthrough.

2. Literature Review

2.1 Biomimicry

“Biomimicry” is a word combined with “bio” and “mimicry”. “Mimicry” is a proper noun that refers to animal behavior particularly with reference to their superior survival techniques such as imitating other living creatures’ behavior, physique, color and so on (Benyus , 1997) through camouflage. Janine M. Benyus indicates that Biomimicry has a higher level than Bionics for it is an ultimate way of how human beings imitate the living mechanism in order to adapt to the environmental changes for surviving. On the other hand, Bionics refers to the development of the engineering technology via the characteristics of the living creature. Both Biomimicry and Bionics intend to explore and use resources at hand to make most of the advantages for living under the condition of following the natural law without damage to the natural environment [6]. All in all, the purpose of this study is the adoption of the concept of Biomimicry as an alternative to fashion design teaching, seeking for the everlasting and prevailing elements in fashion design rather than blindly following the fashion trends.

Table 1. Terminology

Term	Definition
Bionics	Bionic proposed by the U.S. Air Force Maj. Dr. Jack E. Steele in 1960, and agreed with biomimeticists that bionics is a subject implements the biological theory and methods in engineering and technology. It is a science modeled or imitated on the coexistence systems whose characteristics have been presented by imitation and called bio-mimicry (Yeah, 1997). Bionic engineering referred to the biological model applies to the design of artificial systems. That is, from the basic principles of nature applied to the human need (Knight, Csa.com). Bionic Engineering is derived from a biological concept that has recently been promoted and assisted the human body organ or replaced body parts as a device by medical community national wide [18].
Biomimetics	Otto H. Schmitt (1969) indicated Bios means “unit of life”; mimesis refers to imitate, emulate, mimicry. Biomimetics, the synonym of Bionics, has been widely used in Science and Engineering [2].
Biomimicry	By the stimulated principle of biological mechanisms such as biological form, color, structure from nature solves the difficulties mankind encountered. Mimicry is the study of specific organisms whose behavior, shape, color or behavioral simulation leave the survival of humanity becomes more favorable [7].
Biodesign	Mike Jone mentioned in “Jocelyn De Noble”, Biodesign is to form or structure characteristics of biological shape, shown on inanimate objects [21].
Bio-inspired design	People back to nature seek for the answers while the technology has encountered a bottleneck in the design process. Most of biomimetic design cases inadvertently inspired by the behavioral characteristics of natural species that is known as bio-inspired design [4].
Bionical creativity engineering	Bionical Creativity Engineering is the scientific basis for the scientific technology development, particularly in nano-science and nano-technology. Bionical Creativity Engineering inspired by evolutionary of nature, looks for a solution to the problem from observed nature of the process, to find innovative ideas and design [8].
Biomorphology	The complex geometry of the biomorphic curves, as a source of inspiration for biomimetic converted to design the appearance of the object form [5].

2.2 Biomimicry from Ancient Egyptian Culture

Wang (2008) cites that from the ancient times to the present, the ideas and materials of ornaments design from the great nature have been many. For example, the ancient Egyptian nobles carried certain ornaments to mean different things [30]. They blend the natural totem into their ornaments not only for the aesthetic sense but also indicating different intentions such as religion, power, hierarchy, protection against the evil spirit, the pursuit of luck and so on. Living beings that have been commonly borrowed for making ornaments by the ancient people include plants and animals like cobras, eagles, bird's wings, crocodiles, beetles, lotus flowers, etc. Also, Lee (2005) elaborates Bionics by the example of "The Block print of Queen Na Wei Da Mark" [19]. It uses visual images to analyze the Mother of the Earth, which is the embodiment of the goddess Mut. The posture looks similar to birds spreading their wings, which carries a meaning of protection. Moreover, wearing the ornaments with cobra icon is for the pursuit of luck and the avoidance of misfortune. And the linear decoration carved with the lotus flower represents its nobility and immortality. Capturing the symbolic significance from the natural elements gives a token or a code to the creation, also increasing the value of it.

2.3 Gustav Klimt's Art of Biomimicry

Gustav Klimt (1862~1918) was well-known as an Austrian symbolism painter. He established the Vienna Secession. Being influenced by Europe, Byzantine, and Japanese styles, Klimt's creation is based on lines and ornamentals and reveals the characteristics of special symbolic ornamental patterns. For artists of Art Nouveau, "water " has a very significant metaphoric quality for the flowing water lines and the winding whirlpool seem to be the body floating in the sky [1]. Subjects in his paintings are mainly women, and the themes of this work are mainly " Love " and "Sex ", as well as "Life and Death", the reincarnation and the destiny. It is obvious that in his paintings, there are embellishments made of plenty of lines transformed from the figure of cells when observing through the microscope. The invention of the microscope also made great progress in medical science. In Klimt's paintings, figures of the divided plant cells are commonly seen on women's clothes; while rectangles and figures that are repeatedly organized and permuted are used most often for the male clothes.

2.4 Decomposable Fiber (Bio Couture)

Bio Couture is a type of fiber that can be decomposed by living beings. Its rationale is using the microorganism to foster the growth of vegetable fiber. Suzanne Lee, a researcher and designer from the Central Saint Martins College of Art and Design, is the one who has researched into the raw material of this fiber. She worked with other biologists for the research on this fiber, and she figured and ascertained that might replace all synthetic fiber in the future. Since Bio Couture can be produced without creating the pollution environmental pollution, to the environment, it will not damage the environment. Therefore, it can become a kind of the an ecological design for the sustainable use [7]. Moreover, the way they apply the microorganism's survival mechanism to the design on the fiber is also a concept of Biomimicry, which is to transform the observations of the nature to the design of the clothing.

From this, one can see that the application of the Biomimicry is in truth world-wide. Nevertheless, the laws of nature must be explored in depth so as to widely apply to the fashion design, which makes the concept of Biomimicry worth further discussions.

3. Methodology and Theory Applying in this Research

3.1 Phenomenography

Phenomenography was developed 1970. Marton et al. indicate that Phenomenography is a qualitative research method which describes analysis by the observed phenomenon. The word Phenomenography, derived from phenomenon, is a combination of two Greek words, “Phainomenon” (appearance) and “Graphein” (description). Also, “Phenomenography” is derived from phenomenology, meaning to solve problems of thinking and learning via individual’s life experience. Peng et al. (2011) proposed that the word “Phenomenography” means essentially the research variation, and “variation” differs from “difference” on how the phenomenon is experienced and understood [23]. This study is based on this method, the Phenomenography, to proceed with the preliminary research. From the perspective of a natural observer, we collect fashion design that relates to Biomimicry and analyze the elements. Works collected are classified into two categories, “Intention” and “Coincidence”. The way that Phenomenography explores the unsurpassed secrets of nature as a natural observer enables students to discover interesting natural formations of the living beings and learn wisdom from the Mother Earth. It could also be another option for fashion designers in the field to inspire their creativity. To sum up, this study applies Phenomenography into school teaching and designing in the field, comparing two different phenomena—intention and coincidence for analysis.

3.2 Bricolage

Through the concept of Phenomenography, it could be perceived that most Biomimicry design is the application of collage or mixture to create the heterogeneity in fashion style. In many different ways, Bricolage reserves the original construct and pieces up what the designer intends to express. Bricolage originates from a French word “Bricoler”, meaning to paste. This study adopts the concept of Bricolage to discover the wisdom of nature and analyze the principles of the living being’s formation, characters and living mechanism in order to apply them into classroom activities. Peng (2008), mentioned that Bricolage theory is commonly made use of the cultural research when a new cultural phenomenon is created due to the cultural integration, the function essentially being to trace back the history and complete the historical record for the process of cultural changes over time [22]. Apart from the cultural research, Hatton (2005) suggested teachers use Bricolage for class demonstration in terms of design and techniques [15].

For the instruction in schools of fashion design, Bricolage could also help analyze and recombine the elements of the Biomimicry fashion design.

4. Analysis

To make the work of the analysis proceed smoothly, this study divides the research methods of Phenomenography into two parts—“Intention” and “Coincidence”, described as below.





4.1 The Phenomenography Analysis: “Intention” Textile Design

“Intention” is the concept of a determination to act in a certain way, in this study regards to designers who use the concept of Biomimicry as a foundation of their work [4]. Therefore, in their design, elements such as natural objects, color and formation can be obviously seen. This study analyzes the design of “Intention” by two aspects: (1.) from the "the patterns of textile", and (2.) from “the appareling”. The inspiration of these two aspects should extract from natural elements. After transmitting and transforming, designers skillfully mix textiles and appareling

into a special visual fusion, and avant-garde hybridity.




The Art of Embroidery is a book expressing how to mimic the texture of the plants as a source and transform these natural elements into embroidery materials. Embroidery techniques capture color, texture, material, shape of natural objects fused with a variety of mixtures such as wire, fabric, beads for special and original creations. Furthermore, she emulates plants individualized and symbiotic, and the texture of chrysanthemum petals, the blossoming solid touch of broccoli, and the texture of a stone converses them into embroidery material. The author believes nature with its regularities and irregularities should be applied in design. "The regularities" as patterns or motif are the repetitive embroidery such as the tone and shape of leaf in fabric. "Irregularities" are with irregular patterns or motif that combines with the repetitive embroidery techniques to render the special texture of the design.


Table 2. Intentional Biomimicry embroidery and analysis

	Lichens	Cabbages				
Biomimicry object						
Embroidery patterns / motif						
Outlook Description	Imitating the texture of the symbiotic cluster relation of lichens.	Imitating the texture of cabbages vein that has been eaten by a snail.				
Biomimicry element						
Shapes	Irregular shape of the coils			Irregular round		
Color	Orange	Golden Brown	Gray	Gray Blue		
	C	C	C	C	C	C
	0	20	50	50	40	35
	M	M	M	M	M	M
	70	50	40	40	40	40
	Y	Y	Y	Y	Y	Y
	70	68	35	35	35	35
	K	K	K	K	K	K
	0	0	0	0	0	0
Materials	With gray cloth as base, and sewn wool and beads onto a crowded coarse cluster as lichens.			Wool as the base fabric as a thick texture of cabbage.		
Embroidery Techniques	Double French Knot creates the effect of rosette as moss special texture and a crowded coarse cluster			In the base of the wool fabric, dig holes and saw blanket stitch at the edge of the holes.		

4.2 Analyzing The Apparel Design Belongs to “Intention” in The Classification of Phenomenography

Table 3. The analysis of the Biomimicry fashion design-- under the category of intention

The object of Biomimicry element	The creation of apparel design
	
<p>Chlamydosaurus kingie</p>	<p>The analysis of the features</p>
<p>Chlamydosaurus kingie is distributed in Australia. As it is threatened, the umbrella film and mouth will open in attempt to scare away the enemy. They usual crow with four legs but when they escape with the rear. (Australian-animals.net, 2011)</p>	<p>Reversal of the evolution of life, the re-transformation of the natural elements presents in clothing creation. By the hybridity, and collage approaches, clothes has again been deconstructed and reorganized. The umbrella-shape cloak transforms from Chlamydosaurus kingie; Armadillo-like boots covered by tens of thousands of mini flashing Blue Morpho. The combination of clothes: dress and wedge ankle boots [2].</p>
	
<p>Blue Morpho</p>	
<p>This is a male Blue Morpho, a kind of tropical butterflies, living in Central and South America with brilliant blue is to scare away the enemy. (Butterflyutopia.com, 2011)</p>	

Biomimicry element	Features of Biomimicry design							
<p>Form</p>	<p>Mimicing an umbrella-shape cloak from Chlamydosaurus kingie, combined with sleeves to form a unique and original style.</p>							
<p>Main color</p>	Brown		Brownish gold				Olive yellow	
	C	50	C	8	C	15		
	M	68	M	46	M	24		
	Y	92	Y	76	Y	58		
	K	8	K	0	K	0		
<p>Color image</p>	Energetic, perseverant, bitter		Bright, cheerful, straightforward				Quiet, lonely, stained	
<p>Color analysis</p>	<p>The fabric like the texture of the umbrella lizard, including similar hue, lightness and saturation changes slightly.</p>							

Material	Silk jacquard with the patterns of Chlamydosaurus kingie
Analysis of the formation	Biomimicry emphasizes on the cloak combined with the sleeves and wedge ankle boots. It mimics an angry lizard opened its film as it attempts to scare its enemies which the designer converted to the sleeves of the dress. The Biomimicry design of the wedge ankle boots collages Armadillo and groups of Blue Morpho clustering in the outer layer of the boots. This innovation structure must be combined with dimensional cut in order to overthrow the original prototype.
Idea of design (In designer's Word)	<p>Year / Title 2010 spring & summer collection: Plato's Atlantis</p> <p>This series of creation displays the concept of future. Since the sea level is rising due to global warming, human beings must evolve once more to adapt to the environmental changes and survive, or face extinction in the future and everything will go back to where it began. McQueen once said that he had no way back, and he would take you to travel to where you have never imagined [2].</p>



4.3 Analyzing the Apparel Design Belongs to “Coincidence” In The Classification of Pheonomenography

Coincidence is the occurrence of events that happen at the same time by accident but seem to have some connection; moreover, in this study refers to the feeling of a chance encounter with Biomimicry design [15]. The examples are shown and analyzed as below.

Based on the analysis of this study, fashion designers whose collections fit into the coincidence category including Viktor Dzenk, Tear Gas, Borodulin, Sophia Kokosalaki, Alexander McQueen, Rei Kawakubo, Jean Paul Gaultier, Hussein Chalayan, and Yohji Yamamo. Their works are considered as a coincidence with Biomimicry elements, because these designers have no intension to mimic the great nature or do not deliberately use Biomimicry design method into their clothing. This consequence can be explained as “coincidence”. By observing the clothing appearance, texture, structure with Pheonomenography, the findings determine the inspiration of the haute couture is from a type of species. Regardless of shape, structure, texture, all creatures have the possibilities being the Biomimicry object or element in this study. The intention is to explore more the Biomimicry design strategy and relevant Biomimicry designs from these clues.

This study found Biomimicry clothing design can be presented in various forms, but these forms seem to have rules and principles; therefore, the possible formations can be summarized into factors that identify the path of Biomimicry design, and propose an alternative fashion design approach and instructional design model with Biomimicry.

Table 4. The analysis of the Biomimicry fashion design-- under the category of Coincidence

The target for Biomimicry	The creation of fashion design
	

Grusjaponensis

The analysis of the features




Kingdom: Animalia
 Phylum: Chordata
 Class: Aves
 Order: Gruiformes
 Family: Gruidae
 Genus: Grus
 Species: G. japonensis
 Grusjaponensis are the only crane species that have white feathers which extend from behind the eyes and meets sharply with the black lower neck. Adult forehead is covered with bare red skin. Eyes are black and legs are grayish black [5].

Irregular collar and vest have been assembled in a translucent dress, very Japanese-style cut with the change of color, showing the avant-garde sense. Skirt with a large proportion of red dot to show the characteristics of Grusjaponensis as well as to be intuitive to think of Japan, which is also the designer's intentions [17].

Biomimicry element **Features of Biomimicry Design**

Form

Imitation Grusjaponensis of which color transforms as a Biomimicry elements in different parts of the clothes. Its collar is mining asymmetric capture the upper and lower collar piece to deconstruct and collage in order to present the innovative image.

	Vivid Red	White	Black
Main Color			
	C 0	C 0	C 0
	M 100	M 0	M 0
	Y 100	Y 0	Y 0
	K 0	K 0	K 100

Color image

Enthusiastic, intense, revolutionary

Pure, clear, clean

Dark, death, serious

Color analysis

Emphasis on the accent color, by adding a small amount of clever contrasting colors to accent the color focus in a single tone [20].

Material	Black wool, white chiffon, red thin flannelette
Analysis of the formation	The red dot on Forehead is one of its characteristics of Grusjaponensis. White feathers on body and black feathers around its neck as embellishment, all these characteristics have brought the focus of fashion designers in the clothing design. Therefore, the Biomimicry design of this clothing is to imitate the "color".
Year / Title	2007 Future Beauty : 30 Years of Japanese Fashion
Designer	Rei Kawakubo

4.4 Biomimicry Instruction Method for Fashion Design in This Study

In the graphic tables shown above, we have analyzed the design collections through the concept of Phenomenography, and under two different categories--“Intention” and “Coincidence”. From the tables we have explored the causes of the formation of Biomimicry design consisting of the Biomimicry factors and features. The Biomimicry factors, including form, color and material, construct the outline, proportion and template of the clothing design. As a result, the target of imitation is the key point of the creation style. And this study discovers that the elements in fashion design could be derived from the rules of natural selection. Five ways of Biomimicry design are generalized as below.

The imitation of the living being’s outlook—the creation of the form—the appearance of the design.

The imitation of the living being’s structure—the creation of the proportion —the structure of the design.

The imitation of the living being’s texture—the creation of the material—the texture of the design.

The imitation of the living color—the creation of the color—the color of the design.

The imitation of the living mechanism—the creation of the function—the functional attributes of the design.

These five ways of Biomimicry form the factors of fashion design (the outlook, struck, texture, color, and function). Through these five steps, students can create fashion design with the application of Biomimicry. Furthermore, each steps could also stand by itself. That is, students could imitate only one feature to form their own unique character thus resulting in different individual features of Biomimicry design. In addition, the “Living Mechanism” of all kinds of living beings could also make a good theme for students to design clothing.

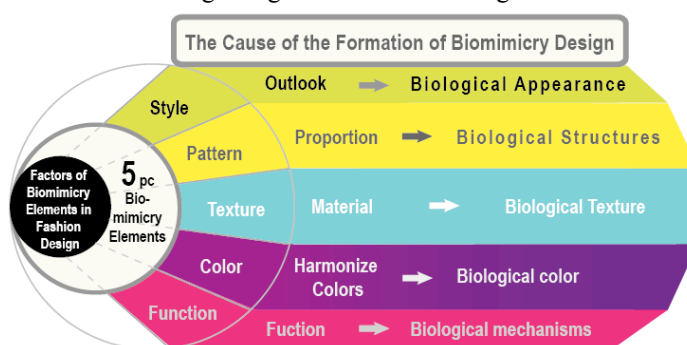


Figure 1. Factors of Biomimicry elements in fashion design (Source: this study draw).

"Natural selection" refers to the successful survival and reproduction of creatures, inherited characteristics to the offspring in certain circumstances. The survival species are more likely to adapt to the environment (Beyuns: 18). This study found that many designers capture their characteristics to design clothes that formed a bionic design through the transformation of fashion designers. If so, we can also follow the steps of these designers to design our own Biomimicry clothing. The stepping are summarized as follows:

- Outlook: based on the appearance of the organisms shapes contours of the outfits
- Structure: based on the example of the biological structure ratio the proportion for clothing
- Texture: based on the example of biological texture produces fabric
- Color: based on the example of biological color harmonize colors on clothing
- Mechanism: based on the example of the biological mechanism creates the functional properties

These four bases can become the Biomimicry factors such as shape, material, patterns, and functions. Students are able to combine clothing materials through the four bases of the Biomimicry design. Furthermore, these four bases can be stand-alone that emulate biological characteristics can also be formed of a single characteristic alone. Through different observation methods, designers will produce different Biomimicry design features.

4.5 Follow The Biological Mechanism

In addition, the biological mechanism can also become a design method in student learning. The mechanism of biological instinct to the following four ways:

- Camouflage
- Mimicry
- Symbiosis
- Defensive mechanism

From the analysis above shown, some living mechanism could be captured for imitation and inspiration, and also for students to learn the concept of Biomimicry. For instance, a Frilled Lizard scares away the enemies when being threatened by opening its cloak. The shape of the opening cloak could be applied to the outline of the clothing. Furthermore, the microorganism's symbiosis could serve as another good example. Since the microorganism can self-spin to make fiber, it can be made into decomposable clothing material. All in all, learning from living being's mechanism could make fashion design more interesting and meaningful.

4.6 The Design Procedure of Biomimicry Clothing

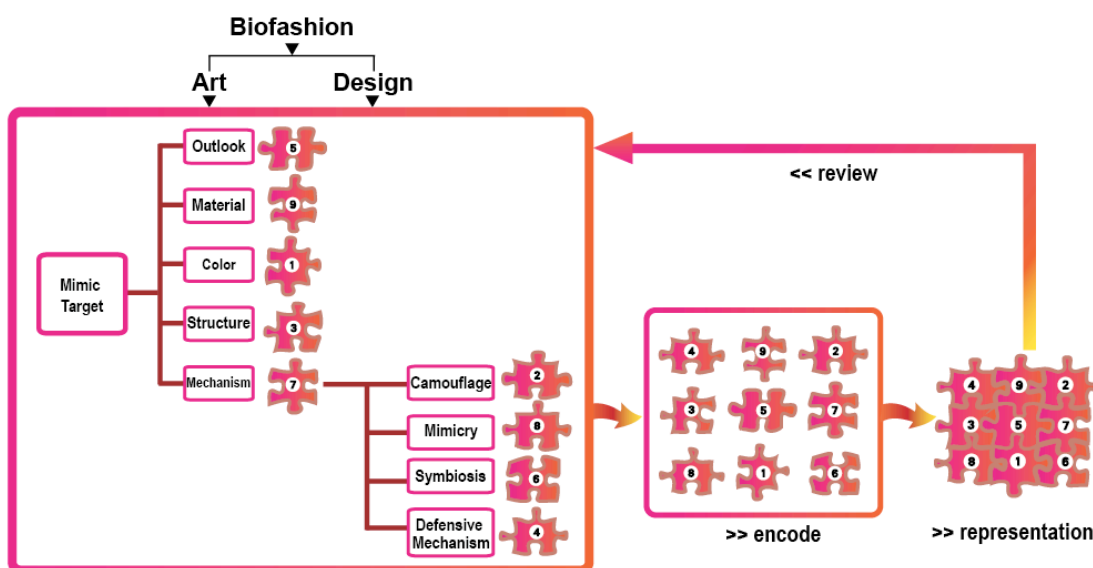


Figure 2. The design procedure of Biomimicry clothing (Source: this study draw).

From the designer works, this study explores Biomimicry collage and harmony to create Biomimicry clothing design. International fashion designers cleverly use the heterogeneous elements of the assembly showing an alternative style of clothing. A scholar, Schneider (2001) states that collage theory as pronunciation, assembling the results will not always be the same. On the contrary, the selection and removal of certain substances will create or constitute an original and assembled pronunciation [26]. This assembly process is applied to the analysis, and deconstruction of clothing used to help determine the type of garment corresponding to the species. This dismantling element model, the unraveling of the component layers of the work, clarifies the design concept of each component, which you can easily grasp the bionic elements to create a new clothing outline.

5. Conclusion

Learning from nature inspires us and stimulates limitless creativities, and these creativities could be used as solutions to difficulties encountered in the process of fashion design. Using the concept of Biomimicry to observe our surrounding living animals and plants, we can find out that many living mechanisms are beyond imagination of the scientists and mankind. There is still a lot that human beings don't know and much of what we thought was known which has been overthrown later on. The application of Biomimicry instruction on fashion design enables students to learn from two different subjects of design and nature. That is, to learn how to apply Biomimicry to their design students need to obtain the knowledge of the outlook, material, formation and mechanism of the living beings. Subsequently, students combine what they know about design with the knowledge of nature to create their fashion work. From the analysis of the Biomimicry fashion collections generalized in this study, we can see that knowledge and inspiration from nature is inexhaustible and infinite. The outline, color, material and formation of the fashion design could imitate all kinds of living beings from nature, which is being suggested as one of the design teaching methods to promote learning. From the analysis in the graphic tables in the study, we discover that colors and materials of the clothing design could borrow inspiration from the art of nature, including the colors of living beings, the natural skin texture of the land, and the outline of an insect or animal. All the features of the living beings could also be mixed to form a new style. This way of design not only makes the clothing more vivid but also effectively solves the problems of teaching strategies, giving the lawless world of fashion design a certain path to follow and also using it to activate creative thinking.

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