Emulating Colors of Animal Kingdom in Textiles

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Human being is the only animal known to wear cloths. The use of textile material for apparel wear by primitive man originated in prehistoric times, probably started in Palaeolithic era, has evolved from mere protection from climatic conditions, providing comfort and maintaining decency to the modern day fashions.

The primitive man initially used material available in nature - animal hides and plant leaves for clothing, to cover and drape his body and gradually developed textile garments made from the natural resources like plant fibres – cotton, jute, flax, etc. and from animal hair – wool and silk. With the industrial revolution of the 20th century development of various manmade fibres including synthetic substrates evolved, however, even then almost half of the textile clothing material used worldwide comes from natural fibres. Further, with the growing awareness about environmental concerns, sustainability, impact on carbon footprint and global warming owing to the manufacturing processes of such synthetic fibres the search for development of natural fibres from other renewable resources like polyester based PLA fibres developed from Corn, could gain momentum and it is expected to shift the trend in favour of more use of natural fibres - going back to the Nature !.

The textile substrates are converted into the garment form by process of weaving and knitting and are further processed to make it colorful by adding a colorant – a dye or pigment which imparts color. The coloring compounds generally absorb and reflect light in the visible spectrum and the combinations of which can provide countless numbers of color hues and print patterns and make the garments attractive and appealing. Textile dyeing is an ancient art which predates written records. The method of coloration has also evolved from simple pot dyeing and hand printing to the sophisticated continuous

dyeing and computerised digital printing. Initially, natural coloring compounds extracted from various parts of plants – root, bark, leaves, fruits, etc. and from animals or insects was in vogue, however, post 1856 with the development of synthetic dyestuff by Perkin a new era of low cost dyestuff industry and new coloration technique of textiles began. Today, the global synthetic colorant industry is estimated to have reached a level of about 6 bn USD comprising of about 10,000 different synthetic colorants with annual production of over 10 mn MT. With the invention of consistent quality synthetic dyes and simple dyeing methods providing optimum fastness levels, the use of natural dyes declined to an extent of becoming obsolete. However, owing to the growing awareness about the health hazards due to toxicity, mutagenicity and carcinogenicity of many synthetic dyes as well as the non bio-degradable polluting nature of these synthetic colorants and their impact on environmental emission, effluent and the waste, the exploration of natural dyes from renewable resources and environment friendly industrially viable application process has gaining momentum. Again trend is going back to the Nature!

Color is one of the basic elements of nature that made human living more aesthetic. Colors are closely associated with emotions, festivals and passions of human life. Observing the colors and patterns from the surrounding plants and animals, man began ornamenting his clothing as the civilization progressed and the associated psychological impact of color has evolved the color sense of human being. This probably led to the basic concept of emulating color schemes and patterns of animal kingdom.

Gleaning from the literature available on this topic from various sources and selecting pictures from the web gallery, an attempt is made to provide an overview of this subject in brief.

Animal coloration is considered to be the general appearance of an animal resulting from the reflection or emission of light from its surfaces and there are several reasons why animals have evolved such colors. Animals produce color in different ways and their coloration may be the result of any combination of pigments, chromatophores,

bioluminescence and structural coloration. The major factors related to coloration in animal kingdom are considered to be

- To look attractive
- To differentiate from others
- To enhance self satisfaction - feel good factor
- To warrant specific occasion like group | herd gathering
- To ensure suitability for work | climate convenience
- To provide protection
- To signal or advertising presence
- To generate structural colors or patterns

On the planet earth "light is life" for existence of all animals and a narrow band of this light consists of visible range for human beings. The psychological properties of the colors - VIBGYOR range of this spectrum, relates to the body, mind and emotions and its essential balance between these three. Researchers like Max Luscher have studied and developed correlation between color and its effect. Given below are major colors observed in animals and their psychological association in humans.

Red Color – has the longest wavelength and is a powerful color having property of appearing to be nearer than it is and grabs attention first. It tends to stimulate and raise the pulse rate and relates to the "fight or flight" instinct. It is perceived as demanding and aggressive.

Orange Color - it is a combination of red and yellow, it stimulates Physical comfort – food, warmth, shelter. It energises mind and renews interest in life. It is anti-depressant and helps lift mood.

Yellow Color - has relatively long wavelength and provides emotional stimulation for sharing and caring. It also contributes to the

expression of thoughts, self confidence and encourages optimism.

Green Color – is in the centre of the visible spectrum and is considered to be the color of balance, reassurance and comfort. Has a strong affinity with nature, and helps us connect with others. It reduces stress and steadies emotions.

Blue Color - is soothing and considered to be the color of the mind which calms the mind and aids concentration. It is the color of peace, clear communication, self-expression and honesty.

Indigo Color – is considered to stimulate intuition and imagination and is a strong sedative which can reduce pain. It is also the color of divine knowledge.

Violet Color – has the shortest wavelength, relates to introvertiveness and meditation. It helps transform obsessions and combat fears. It has associations with royalty and communicates the finest quality.

Brown Color –is considered to be the color of Mother Earth and most of the grassland animals have varying degree of hues of this color with different patterns.

Grey Color – it is an achromatic color with varying intensity of white and black. It is associated with independence, self-reliance and self-control. Grey is a color of evasion and non-commitment. It also relates to isolation and self-criticism.

To look attractive, some animals including many butterflies and birds have microscopic structures in scales, bristles or feathers which give them brilliant iridescent colors. Other animals including squid and some deep-sea fish can produce light, sometimes of different colors. Animals often use two or more of these mechanisms together to produce the colors and effects they need. Such different color combinations are emulated by human beings to look attractive.

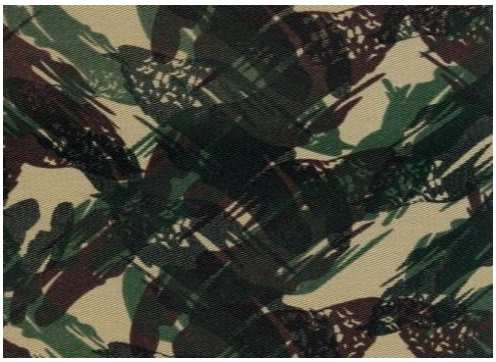
Colors and their pattern enables an animal to differentiate from others on a special occasion or provide signals for certain behavioural aspects or to communicate information such as warning of its ability to defend itself. Observing such color effects man has also evolved sense of differentiation through the textile clothing that he or she wears.

Some animals develop camouflage designs and patterns for protection | hiding from the predators or enemy and remain undetected which is classified as protective coloration. Camouflage enables an animal to remain hidden from view and thereby protect itself from predators. While some animals use color to divert attacks by startling | surprising a predator e.g. with eyespots or other flashes of color, confusing a predator's attack by moving a bold pattern (such as zebra stripes) rapidly. Some animals are colored for physical protection, such as having pigments in the skin to protect against sunburn, while some frogs can lighten or darken their skin for temperature regulation. Animals colored in these ways can have striking natural patterns.

Protective resemblance is used by prey to avoid predation - includes special protective resemblance called mimesis, where the whole animal looks like some other object, for example when a caterpillar resembles a twig or a bird dropping, while the protective resemblance, called crypsis, is where the animal's texture blends with the background, for example when a moth's color and pattern blend in with tree bark. In variable protective resemblance, an animal such as a chameleon, flatfish, squid or octopus

changes its skin pattern and color using special chromatophore cells to resemble whatever background it is currently resting on. The main mechanisms to create the resemblances blending into the background so as to become hard to see; disruptive patterning, using color and pattern to break up the animal's outline, which relates mainly to general resemblance; mimesis, resembling other objects of no special interest to the observer and counter shading, using graded color to create the illusion of flatness.

Similar camouflage coloration by dyeing and printing is used by human beings in military wear for protective clothing to avoid detection from enemy.



Color is widely used for signalling and advertising by animals as diverse as birds and shrimps. Signalling encompasses at least three purposes:

- To signal a capability or service to other animals,
- To warn that an animal is harmful
- To advertising its presence

Signalling enables an animal to communicate information such as warning of its ability to defend itself (aposematism). Animals also use color in advertising | signalling services such as cleaning to animals of other species and to signal sexual status to other members of the same species. Warning coloration is effectively the "opposite" of camouflage. Its function is to make the animal, for example a wasp or a coral snake, highly conspicuous to potential predators, so that it is noticed, remembered, and then avoided.

Human warning signs employ the concept that the nature uses to signal or advertise particular function – for example Khakhi dress of Indian Police, Black or dark navy Blue of commandos and high visible | fluorescent vests of construction workers.



School uniforms and workwear of industrial workman.



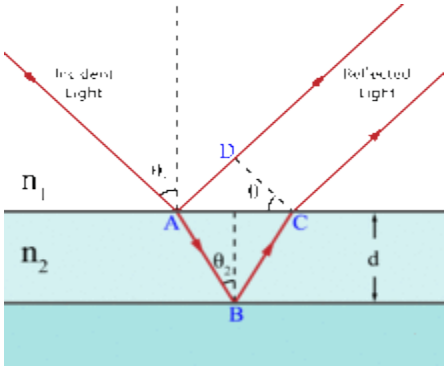
For protection from harsh climate or weather conditions – we wear thick, warm clothes with dark colors in winter or thin garments with cool, light pastel shades in summer.

Many animals have dark pigments such as melanin in their skin, eyes and fur to protect themselves against sunburn (damage to living tissues caused by ultraviolet light). Brightly colored and patterned animals are more characteristic of tropical areas. This holds true across a wide range of animal groups including insects, reptiles, birds, and mammals.

Structural colors – also called as schemochromes, are based on physical and geometrical properties of optics in terms interference, reflection, refraction and diffraction of light.

The phenomenon of structural colors was first reported by Robert Hooke and Isaac Newton.

It is based on production of color by microscopically structured surfaces fine enough to interfere with the visible light, sometimes in combination with pigments: for example, peacock tail feathers are pigmented brown, but their structure makes them appear blue, turquoise, and green, and often they appear iridescent.



It is the result of interference between reflections from two (or more) surfaces of thin films, combined with refraction as light enters and leaves such films. The geometry then determines that at certain angles, the light reflected from both surfaces adds (interferes constructively), while at other angles, the light subtracts. Different colors therefore appear at different angles. When light falls on a thin film, the waves reflected from the upper and lower surfaces travel different distances depending on the angle, so they interfere.

In animals such as on the feathers of birds and the scales of butterflies, interference is created by a range of photonic mechanisms, including diffraction gratings, selective mirrors, photonic crystals, crystal fibres, matrices of nano-channels and proteins that can vary their configuration. Many of these mechanisms correspond to elaborate structures visible by electron microscopy.

Thus, structural colors are developed by microscopically-structured surfaces fine enough to interfere with visible light, sometimes in combination with pigments: for

example, peacock tail feathers are pigmented brown, but their structure makes them appear blue, turquoise and green. Structural coloration can produce the most brilliant colors, often iridescent.

Iridescence, is created when extremely thin films reflect part of the light falling on them from their top surfaces. The rest of the light goes through the films, and a further part of it is reflected from their bottom surfaces. The two sets of reflected waves travel back upwards in the same direction. But since the bottom-reflected waves travelled a little further – controlled by the thickness and refractive index of the film, and the angle at which the light fell – the two sets of waves are out of phase. When the waves are one or more whole wavelength apart – in other words at certain specific angles, they add (interfere constructively), giving a strong reflection. At other angles and phase differences, they can subtract, giving weak reflections. The thin film therefore selectively reflects just one wavelength – a pure color – at any given angle, but other wavelengths – different colors – at different angles. So, as a thin-film structure like a butterfly's wing or bird's feather moves, it seems to change color.

Recently, with the growing awareness of environment sustainability aspects and the considerable contribution of dyestuff and pigment industry towards alarming pollution issues, the researchers are working on the development of such structural colors to produce effects and patterns in textile without using coloring compounds.

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