Blue Colour Is So Rare In The Nature

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Abstract : With the Blue colouration is very rare in nature as statistics portray the frequency of blue flowering plant is only less than 1 in 10 while animals are even fewer because no true blue colour or pigment is present in nature. Thus both plants and animals have to rely on several physical tricks of light that inclines on their specialised biological surfaces and on some chemical interactions to represent themselves as blue. This paper scrutinises this in depth.

Key Words : Blue colour, Organisms, pigmentary colouration

Introduction : Animals come in almost every colour as they possess various coloured pigments within their cells. These are coloured organic chemical compounds that can selectively absorb incoming light and reflect the remaining wavelengths that in turn, appears as their colour. These pigments are not made within the body but can be derived from food sources after digestion and metabolism.

Pigmentary Colouration

The pigmentary colouration of organisms is the most common phenomenon, which represents their colour and it is chiefly attributed to selective absorption of incident white light. Many animals can carry out this performance and eventually display a version of the pigment in their outer body layer. Prominent examples can be cited with Flamingos, who were born with a light grey body but turn vibrant pink with age due to possession of beta-carotene pigment which they obtained from their diet that includes brine shrimp and blue-green algae. Plants also own various pigments like carotenoids, xanthophyll, anthocyanins etc. for vivacious colours of their flowers and fruits, besides having the most common pigment in nature - the green coloured chlorophyll.

Blue Pigment And Blue Colour

In nature, there is no true biological pigment that can reflect blue light as it has shorter wavelengths and higher energy. This energy is sufficient enough to raise an orbital electron of a pigment molecule to an excited state so that the molecule can absorb the blue light and reflect the others like green or red. Thus no blue colouration is observed due to pigment interferences among organisms. Still, nature exhibit quite a few plants and animals with brilliant blue colours.

How Blue Colours Are Made In Organisms?

Two methods have been employed by the organisms whereby they trust physics and chemistry to create a blue appearance. These are **-**

1. **By Chemical Alteration Of The Colour Causing Pigment**

For plants, the occurrence of blue flowers is about only 10% of the world's nearly 300,000 flowering plant species while blue leaves are even rarer as it is only found in a few plants on the floor of the tropical rain forest. Although blue blossoms may benefit plants in ecosystems where competition for pollinators is high as it is highly visible to pollinators such as bees but appearing blue is very difficult. A wide variety of mechanisms is there for making blue or violet colouration in plants by modifying the red pigment- Anthocyanin. It includes the alteration of its pH nature towards weakly acidic or neutral (Goto and Kondo, 1991) or mixing it with other pigments like - flavones, flavonols and interacting with metal ions like - $Fe3+$, $Mg2+$, $Ca2+$ etc (Shoji et.al, 2007). These modified anthocyanin pigment molecules are capable of reflecting high energy blue light and are found in cellular vacuoles in flowers while in leaves they occur in chloroplasts. Besides, the structural arrangement of respective flowering parts and their surfaces also aids proper transmission of light through these pigmentary regions and thus being bluish is clearly established. It is manifest in velvet–leaved *Anthurium sp.* where surface cells of leaves are convexly curved to focus light on chloroplast area, which contains modified anthocyanin (Lee, 2007). Although appearing blue in plants is always compromising as they reflect energy-rich blue light and thus downgrading themselves to use low energized light which ultimately affects their growth.

2. By Structural Colouration

Since blue animals develop their blueness, not from pigments, they use various optical effects on the specified structures of their body so that structural colouration happens to them where colour is achieved by interference without absorption of light. This type of colouration uses various optical phenomena like- reflection, refraction, interference, scattering of light onto the specialised micro-structure and nano-structures residing on the cell wall or the exoskeletons like scales, feathers etc. of the organism to create the blue colour. Mostly these structures contain branched ridge-like constructions with parallel and messy arrangements upon which light hits and induces interference and thus results in the blue colour escaping and not being absorbed. If these structures were formed differently or if other than air was present for filling the gaps between them, the blue would vanish due to the change of refractive index.

Bluish Animals With Structural Colouration

The scale on a butterfly's wing, the barbule of a bird's feather or the arrangement of fibres or granules embedded in dermal layers of fish is the key players in presenting this fascinating blue colour. Intricate, layered nanostructures on the wing scales of blue-winged butterflies of the *Morpho* genus are responsible for manipulating layers of light in such a way that some colours cancel each other out and only blue is reflected (Vukusic et.al.1999). Other than butterfly scales, scattered blue is formed in the epidermal cells beneath the transparent cuticle of many insects. In the case of blue Dragonflies, transparent cuticle surface is often tinged with waxy materials that eventually generate the Tyndall effect (Simonis and Berthier, 2012).

Among birds, the wings of Blue Jays contain a disorderly arranged tiny pocket like structures made of air and keratin in the spongy medullar layer of the feather barbs and their blue colouration result due to coherent scattering of light occur at the interfaces between keratin and air (Simonis and Berthier, 2012). A similar phenomenon happens in mostly blue coloured birds. In the case of Peacock, an intricate photonic crystal structure in the feather barbules are the game maker that causes the escape of blue light. This crystal structure is a rectangular lattice of melanosomes and air channels embedded in a keratin matrix of the barbule of the feather (Freyer et.al. 2018).

Truly Blue In Nature

Being truly blue is conceivable as a very small number of animals can produce true blue pigment. It includes a popular saltwater aquarium fish – Mandarin. In them, blue pigment cyanophores are present within the cyanosome of ectodermal cells which often aggregate or disperse in response to various stimuli and thus colour change happens in these fishes (Umbers, 2012).

Again pigment-based blue colouration is observed in two butterfly groups - Papilio and Graphium or Swallowtail butterfly. Here the concerned pigment is Sarpedobilin and blue absorbing carotenoid Lutein. These pigments are embedded in the scales of wings and create blue-green coloured wing patches although the actual mechanism of interaction between wing pigmentation and scale ornamentation has remained unclear.

The truly blue is the Obrina olive wing butterfly of the genus Nessaea, it is the only known animal that can produce a true blue pigment – Pterobilin which forms the dull blue stripes of its wing (Simonis and Berthier, 2012).

Concluding Remarks

'Blue' is actually originated from structural colouration in nature although what would be the biological advantage of being blue remains questionable. It seems that the dazzling blue colour is useful for receiving attention as a potential mate or threatening off predators. But turning 'blue' is difficult as it required huge structural orientation and tricks of light as true blue coloured pigment molecules are lacking in nature. Thus blue remains unexpectedly scarce in nature.

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