

A new blue: Mysterious origin of the ribbontail ray's electric blue spots revealed

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Bluespotted ribbontail ray. Credit: Morgan Bennet Smith

Researchers have discovered the unique nanostructures responsible for the electric blue spots of the bluespotted ribbontail ray (*Taeniura lymma*), with possible applications for developing chemical-free coloration. The team is also conducting ongoing research into the equally

enigmatic blue coloration of the blue shark (*Prionace glauca*).

This research, titled "Ribbontail Stingray Skin Employs a Core–Shelf Photonic Glass Ultrastructure to Make Blue Structural Color," is published in *Advanced Optical Materials* .

Skin coloration plays a key role in organismal communication, providing life-critical visual clues that can warn, attract or camouflage. Bluespotted ribbontail rays possess striking electric blue spots on their [skin](#). However, the [biological processes](#) that produced these electric blue spots were a mystery until now.

"If you see blue in nature, you can almost be sure that it's made by tissue nanostructures, not pigment," says Mason Dean, Associate Professor of Comparative Anatomy at City University of Hong Kong (CityU).

"Understanding animal [structural color](#) is not just about optical physics but also the materials involved, how they're finely organized in the tissue, and how the color looks in the animal's environment. To draw all those pieces together, we assembled a great team of disciplines from multiple countries, ending up with a surprising and fun solution to the stingray color puzzle."

Structural colors are produced by extremely small structures that manipulate light, rather than as a product of chemical pigments.

"Blue colors are especially interesting because blue pigments are extremely rare, and nature often uses nanoscale structures to make blue," says Viktoriia Kamska, a postdoc studying natural coloration mechanisms at CityU. "We're particularly interested in ribbontail stingrays, because unlike most other structural colors, their blue color doesn't change when you look at them from different angles."

The research team combined a variety of techniques to understand the

skin architecture under different natural conditions.

"To understand the fine-scale architecture of the skin, we used microcomputed tomography (micro-CT), scanning electron microscopy (SEM), and transmission [electron microscopy](#) (TEM)," says Dr. Dean.

"We discovered that the blue color is produced by unique skin cells, with a stable 3D arrangement of nanoscale spheres containing reflecting nanocrystals (like pearls suspended in a bubble tea)," says Amar Surapaneni, a postdoc with Dean's group until recently, and now a visiting academic at Trinity College Dublin. "Because the size of the nanostructures and their spacing are a useful multiple of the wavelength of blue light, they tend to reflect blue wavelengths specifically."



Blue shark. Credit: Viktoriia Kamska

Interestingly, the team discovered that the unique "quasi-ordered" arrangement of the spheres helped to ensure the color remained unchanged at the viewing angle.

"And to clean up any extraneous colors, a thick layer of melanin underneath the color-producing cells absorbs all other colors, resulting in extremely bright blue skin," says Dr. Dean. "In the end, the two [cell types](#) are a great collaboration: the structural color cells hone in on the blue color, while the melanin pigment cells suppress other wavelengths, resulting in extremely bright blue skin."

The team believes that this fascinating blue coloration is likely to provide camouflage benefits for the stingrays.

"In water, blue penetrates deeper than any other color, helping animals blend with their surroundings," says Dr. Dean. "Bright blue skin spots of stingrays do not change with viewing angle; therefore, they might have specific advantages in camouflage as the animal is swimming or quickly maneuvering with undulating wings."

The applications for this research currently being explored include bio-inspired pigment-less colored materials.

"We are pursuing collaborations with fellow researchers to develop flexible biomimetic structurally-colored systems inspired by the soft nature of stingray skin for safe, chemical-free colors in textiles, flexible displays, screens, and sensors," says Dr. Dean.

As well as their work on stingrays, Dr. Kamska and her team are also investigating the blue coloration of other rays and sharks, including the blue shark.

"Despite the name 'blue shark' and its ecological aspects being well

studied, no one still knows how the [blue color](#) is produced on its skin," says Dr. Kamska. "Preliminary results demonstrate that this coloration mechanism is different from the stingray's—but just like the stingray, we need to try different combinations of fine imaging tools and address multiple related disciplines in optics, material, and biological science."

There is also a forthcoming article in *Frontiers in Cell and Developmental Biology*, titled "Intermediate filaments spatially organize intracellular nanostructures to produce the bright structural blue of ribbontail stingrays across ontogeny."

This research is being presented at the [Society for Experimental Biology Annual Conference](#) in Prague from 2–5 July 2024.

More information: Venkata A. Surapaneni et al, Ribbontail Stingray Skin Employs a Core–Shell Photonic Glass Ultrastructure to Make Blue Structural Color, *Advanced Optical Materials* (2024). [DOI: 10.1002/adom.202301909](#)

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