

All things bright and beautiful: photonics in biological systems.

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Abstract: The study of structural colour in brightly coloured animals is an exciting interdisciplinary area of research¹. Complex photonic bandgap (PBG) structures in Coleoptera² and Lepidoptera³ suggest broad innovation in nature's use of materials and its manipulation of light. In certain butterflies, ultra-long-range visibility of up to one half-mile is attributed to photonic structures that are formed by discrete multilayers of cuticle and air³. This contrasts, in other butterfly species, to photonic structures designed more for crypsis and which not only produce strong polarisation effects but can also create additive colour mixing using highly adapted structures⁴. Optical systems also exist that employ remarkable 2D and 3D photonic crystals of cuticular protein to produce partial PBGs, with the effect that bright colour is reflected, or fluorescence emission is inhibited⁵, over specific angle ranges. From the perspective of modern optical technology, these structures arguably indicate a significant evolutionary step, since in principle, such 2D and 3D periodicities are able to manipulate the flow of light more completely.

This tutorial will offer an overview of this emerging field of study, describing several of the exciting recent discoveries that reflect nature's optical design ingenuity, as well as some technological applications for which they are currently being developed.

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