**Organic Nano-crystals in the eyes of aquatic organisms: Biogenic Scatterers, Mirrors, Multilayer Reflectors and Photonic Crystals**

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Organisms construct 'devices' based on assemblies of organic nano-crystals with optical functions. The crystal structure, polymorph, size, morphology and superstructural arrangement determine the optical properties. The constituent molecules are mostly purines and pteridines. All the crystals have unusually high refractive indexes for light impinging perpendicular to the hydrogen-bonded layers of the polycyclic molecules. The controlled assembly of nano-crystals creates multilayer reflectors, mirrors or light scattering layers that function to increase the light sensitivity of the eyes. Scallops have tens of eyes, each containing a concave multi-layered mirror perfectly tiled with a mosaic of square guanine crystals, reflecting the light to form images onto the overlying retinas (1). Shrimp, crayfish and lobsters possess compound eyes that contain two sets of mirrors, composed of isoxanthopterine crystals. The two mirrors have very different ultrastructures and functions that we can rationalize in terms of the optical performance of the eye (2, 3). Light scattering spherical nanoparticles in the reflective layer behind the retina, are hollow spherical shells, composed of perfectly oriented nano-crystals. The unusual zander fish eyes contain two layers of organic crystals: thin guanine crystals form a reflective layer in the back of the eye, whereas block-shaped crystals of 7,8-dihydroxanthopterin in the inner tapetum layer back-scatter light into the retina, increasing the light sensitivity of the eye (4). In all these examples, the hierarchical organization is controlled from the crystal structure at the nanoscale to the complex 3D super-structure at the millimeter level.

**References**

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