Title:

***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 research[1]. Complex photonic bandgap (PBG) structures in Colepotera[2] and Lepidoptera[3] 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 simple dielectric material and air[3]. This contrasts, in other species, to photonic structures designed more for camouflage. These not only may produce strong linear and circular polarisation effects but can also create additive colour mixing using highly adapted structures[4]. Optical systems also exist that employ remarkable 2D and 3D photonic crystals of cuticle to produce partial PBGs. The effect of this is that bright colour is reflected, or fluorescence emission is inhibited[5], over specific angle ranges. The high structural order and saturated colour appearance of these systems is contrasted in other insects which exhibit very efficient broadband scattering arising from highly disordered nanostructures[6]; their brilliant whiteness is a trait that serves specific cryptic functions. From the perspective of modern optical technology, these structures arguably indicate a significant evolutionary step, since in principle, such 2D and 3D order, quasi-order and disorder are potentially able to manipulate the flow of light more completely. Complex hierarchical photonic structures have also recently been discovered in floral[7] and bacterial systems[8]: the study of these has yielded novel information about their ecology and the factors influencing growth and success.
This presentation will offer an overview of this emerging field of study, as well as several of the exciting recent discoveries that reflect nature's optical design ingenuity, and some technological applications to which they are currently being applied.

1. P. Vukusic & J.R. Sambles, *Nature,* **424**, 852-855 (2003).
2. P. Vukusic, B. Hallam and J. Noyes, *Science*, **315**, 348 (2007).
3. P. Vukusic, et al., *Proc Roy Soc B,* **266**: 1403-1411 (1999).
4. P. Vukusic, J.R. Sambles, C.R. Lawrence, *Nature,* **404**, 457 (2000).
5. P. Vukusic and I. R. Hooper, *Science*, **310**, 1151, (2005).
6. P. Vukusic et al, *Science*, **315**, 5810, 348, (2007).
7. M. Kolle et al, *Advanced Materials*, [10.1002/adma.201203529], (2013).
8. B. Kientz, et al, *Appl Environ Microbiol*., **78**, 7, 2092-9, (2012).

Short Biography:

PV graduated from Imperial College 1989 and from the University of Exeter in 1993 with a PhD in Optical Physics, followed by a research fellowship at CSIRO Melbourne. He returned to Exeter in 1998 as a research fellow, to begin investigating structural colour in natural systems. In 2001 he was awarded a 5-year Personal Fellowship from the BBSRC, and in 2003 was appointed permanent lecturer at the University of Exeter School of Physics. He leads a research team whose work comprises the discovery, characterisation and technological application of the unique optics and photonics systems that have evolved naturally in animals and plants. Their work is frequently featured on scientific programs of the BBC and National Geographic. PV regularly lectures on the science of light and colour to children in schools and to international audiences.