COLOUR VISION

Seeing red

André A. Fernandez and Molly R. Morris have revisited a question that evolutionary biologists just can't let go of. Many species of primate have trichromatic colour vision. But what factors drove its evolution?

The authors have tested the 'pre-existing-bias hypothesis' (*Am. Nat.* doi:10.1086/518566; 2007). This holds that the evolution of a trait such as colour vision might have evolved to meet one particular need, but was subsequently favoured by selection for another.

A long-standing idea is that trichromatic vision is of great benefit in foraging — in allowing red or orange food items to be seen more easily in green foliage. Another is that its genesis lies in promoting sexual selection — that intense colour, in particular red as skin or fur coloration, evolved for example as a signal of sexual state or prowess. Fernandez and Morris set out to provide a statistical test of the possibility that selection of this latter putative function was due to a pre-existing bias.

Their approach was to mine the literature to produce 'ancestral state reconstructions' of the incidence among primate groups of colour vision, fur colour, skin colour and form of mating system. The thinking behind the inclusion of this last characteristic was that selection for colourful signals is likely to be greater in gregarious species. These reconstructions were then subjected to tests of whether red fur and skin were more likely to have evolved in the presence of colour vision and gregarious mating systems.

The conclusion that emerges is that trichromatism preceded a tendency towards red coloration and gregarious mating systems — that is, that there was indeed a pre-existing bias towards red (probably, think the authors, for more efficient foraging) that then prompted the coevolution of red skin and fur through sexual selection.

There are obviously plenty of exceptions to the correlation between trichromatism and red coloration. Explanations for such exceptions include lack of suitable genetic variation in the species concerned, lack of the appropriate diet or predator pressure.

Fernandez and Morris add that their research may tie in with work on the evolutionary history of the vomeronasal organ. This is a sensor for scent signalling, and there

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is evidence that its functional loss in Old World monkeys coincided with the advent of colour vision — prompting the idea that chemical signalling gave way to visual cues.

Tim Lincoln

state could form. This was achieved by using resonant pumping of the cavity with photons at a specific angle[3]. The polaritons created by this excitation effectively scatter to the lowest-energy polariton mode, and can be amplified there through polariton–polariton stimulated scattering. The result was another type of laser, dubbed the polariton parametric amplifier.

The first demonstration of this laser was at cryogenic temperatures. The upper temperature for the polaritons is ultimately limited by the exciton binding energy: a polariton's constituent exciton will dissociate at high temperatures T when $k_B T$ becomes comparable to its binding energy (k_B is Boltzmann's constant). With materials of a suitably high exciton binding energy, however, success was possible at temperatures as high as 220 K (−53 °C)[4].

Christopoulos *et al.*[1] focused their research on creating a coherent polariton state in a semiconductor microcavity using non-resonant pumping in the strong coupling regime. Such a coherent state was proposed[5] and has been realized[6,7] in both GaAs and cadmium telluride (CdTe) microcavities at cryogenic temperatures. Success at room temperature, however, required a new solution and new materials with a high exciton binding energy and exciton–photon interaction strength[4,8]. Gallium nitride (GaN) was Christopoulos and colleagues' material of choice. They achieved the transition to the coherent polariton state at a remarkably low threshold power, an order of magnitude smaller than in the best GaN-based VCSELs.

So is this polariton coherent state similar to a laser, to a Bose–Einstein condensate, or somehow to both? In other words, is it the electromagnetic-wave or the matter-wave component of the polariton that is responsible for establishing the coherent state? This is an issue of more than semantic significance. The fundamentally different nature of a laser and a Bose–Einstein condensate is revealed in, for example, the different critical temperatures below which lasing or condensation occurs. Results so far show that the coherent states of microcavity polaritons disappear when the photon component vanishes in a system of bare excitons, but remain strong when the exciton component vanishes in the weak-coupling regime. It seems that the coherence of the microcavity polaritons arises from the coherence of an electromagnetic field — just as in a laser.

Christopoulos and colleagues' breakthrough opens up intriguing avenues for investigation. First, it provides a model system for fundamental studies of light–matter interaction at elevated temperatures. Second, there is the promise of practical applications of the polariton lasers, for instance in fibre-optic communications. ■

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PROTEIN SCIENCE

Discriminating taste of prions

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Prions are infectious proteins that are involved in brain-wasting disorders such as mad cow disease. In yeast, specific sequences of amino acids in prions seem to mediate prion propagation and cross-species transmissibility.

Few diseases have generated as much interest and controversy in recent years as transmissible spongiform encephalopathies (TSEs) — a group of fatal neurodegenerative disorders that includes Creutzfeldt–Jakob disease in humans and 'mad cow' disease[1,2]. The protein-only hypothesis of TSE propagation postulates that the infectious pathogen, called a prion, is devoid of the nucleic acids that comprise genes, and is an abnormally shaped version of the normal prion protein, a naturally occurring molecule of unknown function. The infectious prion replicates by binding to its host's normal prion protein and forcing it to take on the abnormal conformation[1]. Once heretical, this notion that proteins alone can be infectious is now rapidly gaining acceptance. Paradoxically, the most compelling evidence for this idea has come not from studying TSEs, but from prion-like entities in yeast and other fungi[3–6].