

ARC Vision Centre

MEDIA RELEASE

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## NEW THEORY ON THE ORIGIN OF OUR EYE

Treat your eyes with respect: they are more than 500 million years old. In fact, in parts they may be closer to a billion.

New scientific advances are providing surprising answers to what Charles Darwin himself acknowledged as one of the greatest difficulties with his evolutionary theory: explaining how an organ as marvellously complex as the eye could have developed through natural selection. And Darwin didn't know the half of it.

"Eyes of one kind or another occur in around 95 per cent of all animal species, indicating that vision confers a huge survival advantage in many environments," says Professor Trevor Lamb, director of the ARC Centre of Excellence in Vision Science, at the Australian National University John Curtin School of Medical Research.

Prof. Lamb is lead editor of a new theme issue of the world's oldest scientific journal *Philosophical Transactions of the Royal Society*, which describes the latest scientific insights into the origins of vision and seeing organs.

In it he describes a new theory for how the human-style eye evolved through a piece of chemical serendipity in primitive creatures fleeing from predators into the darker depths of the ocean.

"Seeing organs have evolved many times in different lines of animal, and there are two main sorts of eye – the compound sort used by insects and spiders, and the camera-style system used by squid and octopus as well as by vertebrates including ourselves."

Professor Lamb says that when our camera-style visual system emerged, it probably did so at lightning speed in terms of the pace of evolution – over less than 30 million years, about 500 million years ago.

The transition between primitive light sensing organs – good only for detecting the time of day and driving circadian rhythms for feeding and breeding purposes – and real camera-style eyes capable of seeing, took place about half a billion years ago. It occurred around the time of the last common ancestor that we share with hagfish, an 'eyeless' eel-like creature without a backbone, and lampreys, which have eyes like ours and a backbone but not yet a jaw.

“Hagfish have two small patches on either side of their head which resemble eyes, but aren’t. Beneath these are light-sensing cells, but no lens, cornea, muscles or other apparatus needed for vision. These organs have been around for 500 million years, and if they were useless they’d be long gone by now.” Prof Lamb concludes the hagfish, which lives in deep, dark water uses its light sensors for circadian purposes, as a guide to time, season and breeding cycles.

“In lampreys, the larva begins life in river sediment with much the same sort of organ, capable of detecting light but useless for vision. Then, at about 5 years old, the animal undergoes a metamorphosis, and a pair of real eyes suddenly pops out on its head fully capable of vision. This parallels the sort of change which the ancestral eye underwent, from circadian organ to seeing device.”

In the *Philosophical Transactions*, Prof Lamb theorises that this momentous development – one that changed the entire history of life on Earth – happened when certain primitive slug-like chordates (ancestors of creatures with backbones) took refuge in the deep, fleeing from hungry predators equipped with early insect-style vision.

“These creatures carried the c-opsin, a version of the light-sensing chemical rhodopsin that could be chemically re-set in the dark after it had detected light. Their enemies had a version of rhodopsin (an r-opsin) that needed light to re-set it. This gave the fugitives a huge advantage in a dark and gloomy environment – as they could survive and evolve, while their hunters could not.

“Later, the descendants of these blind hagfish-like animals came back to the brighter levels near the surface, and evolved the optical and neural gear which converted their circadian organ into a visual eye, enabling them to compete with animals that had by then evolved compound eyes.”

The new organ had a retina like ours, as well as a lens to focus an image of the world onto it, muscles to move and point it, and a marvellous network of nerves to translate what it saw into cascades of signals to the brain. It conferred a huge evolutionary edge, from which its owners have never looked back.

This organ, with small variations, serves almost every creature with a backbone, from lampreys on up. It is so good at what it does that the basic model has hardly changed in half a billion years.

Today the rod and cone cells of the human eye use fundamentally the same c-opsins that gave our sluglike ancestors a survival edge in the deep. However our genes also contain one of the rhabdomeric r-opsins which characterise insect eyes – though in cells of the retina that detect the time of day. Thus our genes point back to the deep origins of light sensing a billion years ago among the common ancestors of all living animals. Indeed we still share many traits of our eyes with the box jellyfish.

Curiously, says Prof. Lamb, most of our daily seeing is performed using the more primitive light-sensing cells, the cones, which also underlie colour vision. “Yet 95 per cent of our

retina is made up of rods, which are really only used in extremely low-light conditions such as starlight, when you cannot see colour. But it was actually the cone cells, now the minor partners, which gave our distant ancestors the evolutionary advantage that led, ultimately, to eyes and to us.

“Darwin himself was troubled how to explain how the eye emerged through natural selection. But now, from genetic, molecular and other clues we can clearly decipher the gradual process of eye evolution – even though no fossils of the earliest camera-style eyes survive. It happened smoothly, though in a remarkably short time, and things were never the same again.

“It provides clear evidence for gradual evolution - and a further rebuttal to those who have used the eye as an argument against Darwin’s theory of natural selection.”

The ARC Vision Centre is funded by the Australian Research Council as the ARC Centre of Excellence in Vision Science.

More information:

Professor Trevor Lamb, ARC Vision Centre, ph +61 (0)2 6125 8929 or 0434022375

Professor Julian Cribb, ARC Vision Centre media contact, 0418 639 245

Martyn Pearce, ANU media , ph +61 (0)2 6125 5575 or 0416 249 245

*The evolution of phototransduction and eyes*. Philosophical Transactions of the Royal Society, 2009. Editors TD Lamb, D Arendt and SP Collin.

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