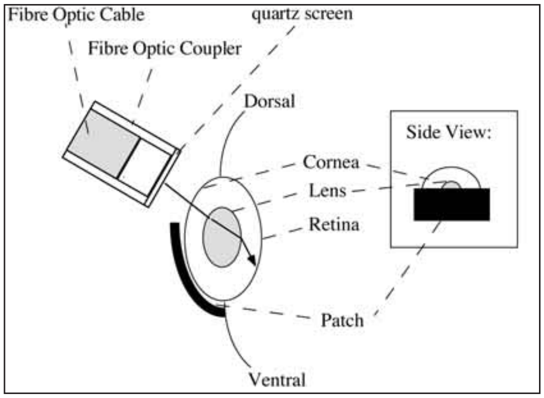


Into the Blue (p. 2401)

Let's face it, we're a pretty limited species. Next to the average pet dog we're olfactorally challenged, we can't tune into the conversations of whales and bats, and when it comes to light, many species wouldn't bother opening their eyes for the tiny slice of colour that we see! Of course, as a species, we muddle along quite well without the advantages of seeing further into the spectrum, but we're missing out on a visual world that many creatures exploit routinely. Until recently, it had been thought that UV vision was restricted to a select band of insects, and that this talent in anything larger was the notable exception rather than the rule. But as Craig Hawryshyn has watched the UV field expand over the last 20 years, the number of vertebrates that can detect UV has increased too. He says that it seems that 'it was really our own sensory constraints that made [vertebrate UV vision] so spectacular a finding in the first place'.

Hawryshyn has focused his attentions on the trout *Oncorhynchus mykiss*, which begins life with UV sensitivity, but appears to lose the sense as the fish grows. Remarkably, Hawryshyn and Browman found in the 1990s that adult fish could also detect UV wavelengths, which suggested that lost UV sensitivity might have been regained at some later stage of life. According to Mark Deutschlander, Hawryshyn's colleague, fish never stop growing, which allows fish to add new sensory cells to the retina throughout life. This leaves two possible explanations for the regained UV sensitivity in older fish. Either they never lose the sense completely in the first place, or they regenerate UV-sensitive photoreceptors at a later date.

By artificially inducing maturation (smoltification), Mark Deutschlander and colleagues were able to track the variation in UV sensitivity across the retina as the fish developed. They found that UV receptors in the dorsal half of the retina were unaffected as the fish matured, but this wasn't the case for the ventral retina. For the first four weeks of the experiment, the fish retained UV sensitivity, but this situation changed rapidly between four and six weeks, with the fish suddenly loosing all the UV vision in the ventral half of the retina. So the answer is that the fish don't appear to lose their ability to see in the UV over the entire retina. This doesn't rule out the possibility that UV vision is completely lost at a later stage and that UV receptors may regenerate afterwards, but the fish probably never become entirely UV blind.

UV and polarization vision in salmonid fish seem to be interlinked through the UV sensory cells. Many creatures navigate by using features of polarized light to orientate themselves, so why would the fish loose their main navigational aid when they're about to embark on the longest migration of their lives? Possibly because they don't need that style of navigation in their early life. Hawryshyn thinks that UV and polarization sensitivity may be a critical facet of their homing instinct that they use to recognise the aquascape on the return migration to the streams where they spawned. It is possible that the fish is able to modify the retina to fit its life style.

From the quality and range of discussions in this edition, you will see that although there has been an explosion of interest in UV and polarization vision, the current protagonists are only just scratching the surface. According to Hawryshyn, 'the discovery potential is high… any findings will be both novel and exciting in the field'. Just like the old saying 'there are plenty more fish in the sea', there are also plenty more extreme vision questions to be answered too.

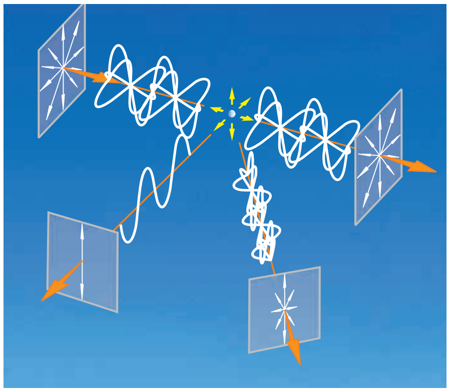
A Sense of Perspective (p. 2491)

Every day seems to bring another news story about endangered species that are teetering on the brink of extinction, and conservation of biodiversity is possibly one of the most important struggles that faces society at the turn of the new Millennium. Until recently the natural world looked after its own and managed to sustain diversity naturally. But as man-made pressure increases on the environment, it has become ever more important to understand the complex network of relationships that sustain diversity among populations. For example, foraging behaviour can have a catastrophic effect if a rare species is completely destroyed by a hunter, but if the hunter feeds mainly on abundant prey, then biodiversity is maintained and that guarantees a healthy environment. In turn, what part does the environment play in foraging strategies? Stuart Church and his colleagues in Bristol have been wondering about this question, and turned their attention to the role of light in the environment.

We all know that an early-morning-frog can be transformed into Prince Charming if he's cast in a different light. But what if we could include an extra waveband and peer beyond the blue and into the UV, how would the picture be changed? Some foraging creatures do, and Church wondered whether the extra light dimension would modify the way some foragers would select their prey. Would the rarer prey become more conspicuous? Would they blend in better with the background? Or is it just a daft human question to think that UV light may have some special power, just because we can't see it?

Church tempted zebra finches with different mixtures of red and white millet seeds, to see whether the birds preferred the red seeds when they were common or rare. When he tested how the birds foraged in the presence of light that included UV they seemed to prefer eating the red seeds when they were rare. When he watched the birds foraging under human-visible light alone, their behaviour changed, so that they now tended to prefer red seeds when they were common. Including UV in the spectrum had changed the way the birds behaved. Now he asked the question the other way round. Is taking UV light out of the spectrum more significant than taking away blue, green or red wavebands? Not as far as the zebra finches were concerned. Their preference for seeds did not change, no matter how the light had been filtered.

The take home message is that UV wavelengths can have an important affect on a bird's dietary habits, but that short, medium and long wavelengths are equally as important. From a rare red seed's perspective, including UV is bad news, but probably no worse than any other waveband. UV only seemed unique to us because it's something we can't see.



If I Could See Like the Animals (p. 2589)

Just because we can't see it doesn't mean that it's not there. Humans only detect the wavelength and frequency of light and variations in intensity. We interpret these aspects of light as colour, and light and shade. The fact that most light is also polarized is completely lost by the human eye. But polarization is not overlooked by a host of beasts and bugs that have capitalised on this extra facet of the visual world, and applied it to their everyday lives.

Ants use it to navigate efficiently across desiccating desert sands, bees use it for finding honey, water fleas use it to home-in on deep water, and squid probably use it to say 'Hi' to their nearest and dearest. These creatures live in the oceans, on the land and in the air, in fact they're everywhere. Even if they were related, it was a long way back, so is it possible that they all evolved this talent from a single proto-polar-philic system? Rüdiger Wehner thinks that the receptor hardware could be ancient, but given the variety of applications that evolution has dreamt up for polarization, he thinks it's unlikely that the software that untangles the inputs originated from one original solution. He explains why.

Polarization is just another visual parameter that that can be detected by specially adapted light receptor cells. Each cell is packed with a light sensitive protein called rhodopsin. When the rhodopsin molecules are aligned in a receptor, the cell only fires off when it picks up light that is polarized in the same direction as the rhodopsin molecules are aligned. If the light is polarized in a particular direction, only a few cells will be aligned to pick up the light. The brain then has to unscramble those signals to extract other information about the light, such as its colour and brightness, to add to the polarization information. Although every creature that is sensitive to polarized light picks up the information using the same basic receptor hardware, they've all developed different decoding strategies, and 'that can be very complicated' says Wehner.

If you're a simple soul, like *Daphnia*, all you want is to find deep water. Light in the deep oceans is scattered and polarized more than light from shallower depths, so *Daphnia* just want a system that will help them navigate toward the strongest source of polarized light. But if you're an intrepid ant setting forth into the complicated desert terrain, you need a great deal more information than simply 'there's polarized light over there'. So the ant's analysis system must be hugely more complex than the humble *Daphnia*'s.

Neurological wiring is costly, and no beast is going to invest valuable energy in building a Rolls Royce when they only need a bicycle. Which is why Wehner doesn't believe that all polarized vision stemmed from a single precursor. He says that 'Nature is *ad hoc*, it does what it has to, to get by'. *Daphnia* probably didn't start out with a finely tuned system to rival that of the ant, it just patched together the minimum it needed to get the job done, and is doing 'just fine'!

So, Wehner concludes that there probably never was an all-singing all-dancing system for detecting polarized light that has been whittled down to fit simpler demands. Probably everyone just got on and devised their own solutions to the different challenges of their everyday lives, whether they were getting into deep water or racing against time and dehydration.

Kathryn Phillips

Magneto-newt

The role of extraocular photoreceptors in newt magnetic compass orientation: evidence for parallels between light-dependent magnetoreception and polarized light detection in vertebrates. *J. Exp. Biol.* **204**, 2543-2552.