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Confessions of a deuteranope

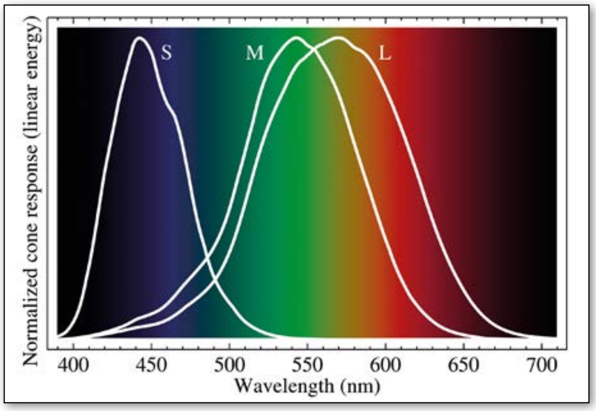
About 8% of men – but only about 0.6% of women – among us exhibit Colour Vision Deficiency (CVD), i.e., are said to be colour blind. This genetic defect, by the way, is called *"Daltonism"* in French, named after John Dalton the noted chemist, who was one of its more notorious sufferers and generators of anecdotes.

The most common form of colour blindness, called red-green colour blindness, is caused by a defect on the X chromosome, of which males have only one copy, whereas females, who have two copies may be protected by the other X chromosome if it has a non-defective gene. However one half of their male offspring will be afflicted and thus they are "carriers". In my case, I inherited my colour blindness from my maternal grandfather, and my grandson got it from me, via my daughter, who has perfect colour vision. Half my daughters and my grand-daughters, are likely to be carriers.

So, what is this defect? As is well known, there are two types of light receptor cells in the human retina: rods and cones. It is the cones that are responsible for colour vision; the more abundant rods are extremely sensitive to light but only give black-and-white information for night-vision (and information on motion and edge detection in brighter light). By the way, recent experiments have shown that one single photon is capable of triggering the receptors, provided that they have escaped capture by intervening tissue.

There are three types of cones, responsive to short, medium and long (*i.e.* S, M and L) wavelengths of visible light, but actually they have three different spectral sensitivities, as shown in Fig.1.

In a somewhat simplified explanation, if one of the M or S cones is missing (or has a much reduced abundance) in a person's retina, they will be a so-called "dichromat" or colour blind: "green-blind" or "deuteranope" (like I am) if missing the M cones; "red-blind", or "protanope" if missing L cones; "blue-blind", or "tritanope" in the rare case of missing the S cones.

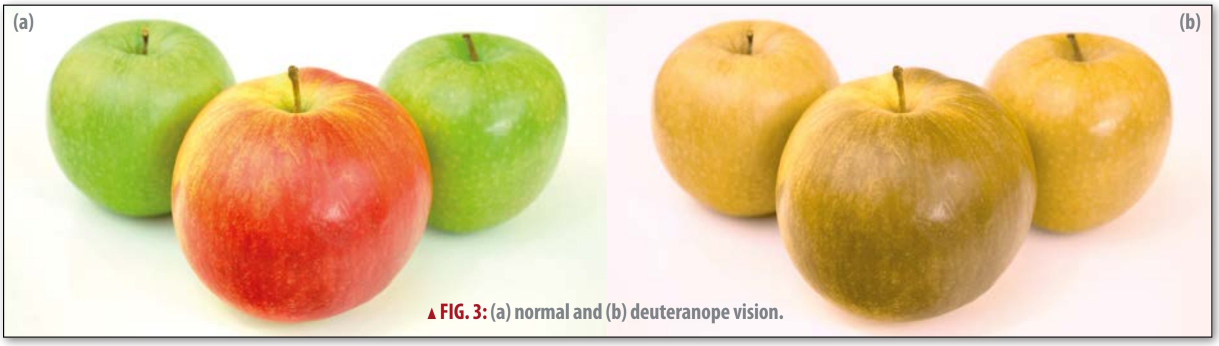


▲ **FIG.1:** Spectral Sensitivities of the three types of cone cells.

What does this mean in practice? In the case of protanopes, they cannot see red traffic lights or only very dimly, and can't see red flowers very well at all. In my case, I see grass *etc.* as some shade of brown – but it's really more complicated than that. Our world is still full of colour – around 10,000 different hues, in fact, whereas people with normal colour vision can see about 1,000,000. I do, however, have trouble with red flowers having very low contrast with the surrounding green leaves in certain beautiful trees like the "flame tee" or Poinciana. Often I can't see them until up close. But I have no trouble at all with traffic lights: The "green" is really very bluish.

It's a bit like a colour printer with one of the cartridges missing, but not really: The Cyan, Yellow, Magenta system of colour printing is quite different from the Short, Medium, Long cones in the retina, but each system has in common a triple manifold of colours, *i.e.*, needing three numbers to specify a hue. I found a better set of examples in Wikipedia, while researching this column. Under "Colour Blindness" (which tells you more about the subject than you might wish to know) there are pairs of pictures that show what a normal and a red-green blind person would see. In spite of the limitations of the computer screen or

▼ **FIG. 2a:** Normal vision ▼ **FIG. 2b:** Deuteranopic vision ▼ **FIG.2c:** Tritanopic vision.



▲FIG. 3: (a) normal and (b) deuteranope vision.

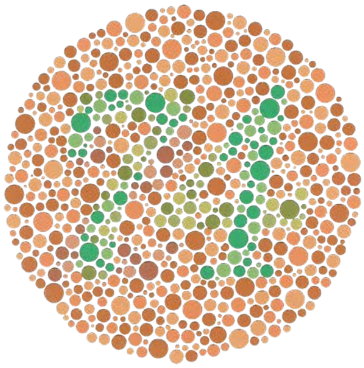
of the printed page, they look pretty good to me: I can't tell the difference! If you, the reader can't either, then you may be part of the 8% (if male) or the 0.6% (if female) – join the "club". The pictures are shown in Figs. 2a, and 2b and for the sake of completeness 2c: Tritanopic vision, the rare condition of missing the S cone.

A very interesting issue concerns colour vision in animals: It turns out that most animals (except insects) have no colour vision at all. However, birds, reptiles and amphibians (as well as some rare human females), can have four different cone types. But it turns out that most mammals are deuteranopes, *i.e.*, green blind – so people like me are by no means alone. And more recent research shows that the third type of cone has evolved rather more recently in (old-world) monkeys and presumably humans and other fruit-eaters in order to distinguish ripe fruit. This is illustrated in Fig. 3: Red and green apples as they appear to normals (a) and deuteranopes (b). Once again, I can't tell the difference!

So what sort of handicap is colour blindness and how is it diagnosed? In my case, at around the age of 3, it was found by my mother that I was using "crazy" colours in colouring books, *e.g.* ships sailing on violet seas instead of blue. She knew that her father had trouble with colours but they all thought that he had trouble naming colours because they didn't understand the concept of CVD. But to me it represented hardly any handicap in perceiving the wonderfully coloured world.

Much later, however, as a teenager, I was chucked out of flying school (much to the relief of my parents) when my CVD was properly diagnosed. This was done by the use of the most common test, the one named after its promulgator, Professor Ishihara. (Several other tests exist for other, more subtle types of CVD). The Ishihara test consists of subtly coloured dots showing numbers hidden among other coloured dots. The perceived numbers are different for normal and colour blind subjects. An example of one such test pattern is showed in Fig. 4:

Apart from being prohibited from certain occupations such as piloting or train-driving, I have hardly felt any handicap apart from a few incidents with colour-coded wires and electronic components. But otherwise it was more of a source of amusement, such as when a cousin and I (who shared a common maternal grandfather) marvelled at a rare Australian orange-bellied parrot, which turned out to have been bright green. But we had no trouble at all with other more common (Australian) coloured birds, such as rainbow lorikeets and rosellas which are, to us, bright red and what we see as nearest thing to bright green. ■



◂FIG. 4: Example of an Ishihara test plate. People with normal colour vision see the number 74; I, a deuteranope, see the number 21 or 81. Protanopes see other numbers, or simply can't tell.

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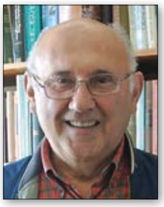
About the author



Professor Emeritus **Tony Klein** held a Personal Chair in Physics in the University of Melbourne until his retirement in 1998. He served as President of the Australian Optical Society (1985-86); President of the Australian Institute of Physics (1990 – 91); Head of the School of Physics (1986 –95). He was elected a Fellow of the Australian Academy of Science in 1994 and was appointed a Member of the Order of Australia in 1999. He has published extensively in experimental physics, particularly about neutron optics, including focusing of neutrons with a Fresnel Zone Plate.