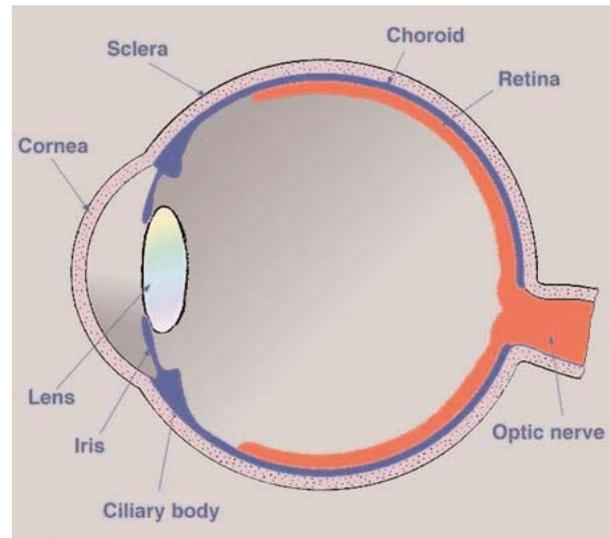


## Vision & colour perception

### The Human Eye

We are all aware of the importance of protecting that precious asset called sight and the little organ that provides this, the human eye. A brief look now at the anatomy of the eye will facilitate a better appreciation of the contents of this article. The aqueous and vitreous humour is a liquid that fills the matrix of the vacuum in the anterior and posterior chambers and without which the eyeball would collapse. The lens provides the focusing media and the retina the photographic media on which the image is developed. For the purpose of this article, I would like to concentrate on the following part of the anatomy of the eye – the Retina.



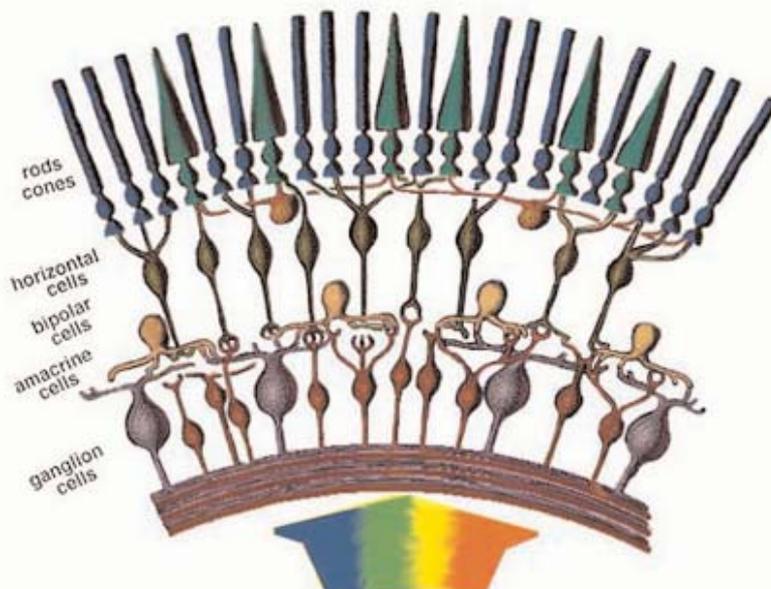
### The Retina

#### Light falling upon the retina

Light enters the eye through the cornea and lens and then has to pass through the complete thickness of the retina before striking the photosensitive elements, the rods and cones. This delicate 'photographic film' is responsible for processing the image that falls upon it and then sending this processed image to be interpreted by the brain. Two components of the retina comprising the Rods and Cones will now be examined.

#### Introduction to Colour Vision

Normal colour vision begins with the stimulation of these photoreceptors. These receptors contain photopigments in their outer segments. When light falls upon them, these photopigments undergo certain changes which stops them from sending visual signals to the brain. Both the rods and cones undergo this 'bleaching' process (so called because the photopigment colour actually becomes transparent). In the dark, they regenerate and regain their pigmentation again. Our visual system is most sensitive when the photopigments have not absorbed any light for about 30 minutes. They are then said to be fully re-generated. This phenomenon is easily experienced when we walk from the bright outdoors and into a darkened theatre.



#### Normal trichromatic vision

Normal colour vision begins with the stimulation of 3 distinct populations of retinal cone receptors by visible light energy. Each cone type is maximally sensitive to either long (red Lambda max 590nm), medium (green Lambda max 540) or short (blue Lambda 440nm) wavelength energy. This last wavelength figure will be referred to when discussing sunglasses.

The physiological response of each type of cone receptors will be dependent upon the spectral energy distribution present within the retinal stimulus. After subsequent complex neurological processing within the retina and visual pathways, visual cortical cells in the occipital region of the brain receive coded neural impulses that ultimately result in the phenomena of 'vision'. Colour vision is thus entirely subjective and is completely dependent on the integrity and function of the 3 cone receptor populations and retino-neural processing system. People with normal colour vision

are therefore referred to as normal trichromats. When one of the pigments is either partially or totally dysfunctional, abnormal colour perception develops. 'Protan' dysfunction results from reduced red pigment function (Protanomalous – partial dysfunction, Protanope-total red pigment dysfunction). Green pigment dysfunction results in 'Deutan' disorders (Deuteranomaly-partial, Deuteranopia-total green pigment dysfunction). 'Tritan'- dysfunction results from blue pigment dysfunction leading in turn to Tritanomaly and Tritanopia respectively.

### ***Abnormal colour vision***

Colour blindness is therefore a general term used to describe a number of anomalies of colour vision perception resulting from any interference, alteration or malfunction of the trichromatic colour vision system. Generally, the total loss of all colour vision is rare (achromatopsia). Most involve the inability to discriminate specific visual stimuli (dyschromatopsia) – hence a more appropriate term to describe these individuals would be as colour deficient.

It is interesting to note that small variations in colour recognition in normal colour vision individuals does take place, however these variations are much smaller than those found in colour defective individuals.

### ***What can't colour defectives do?***

Colour defectives have as a result of dysfunctional colour receptive pigments in their cones, diminished ability to discriminate between colours. Colour is that property of light determined by its wavelength. Where colour normal individuals are able to discriminate between more colours, colour deficient individuals are able to do less. Very rarely are individuals totally colour blind. Colour defectives cannot as easily identify and name colours as colour normal people can.

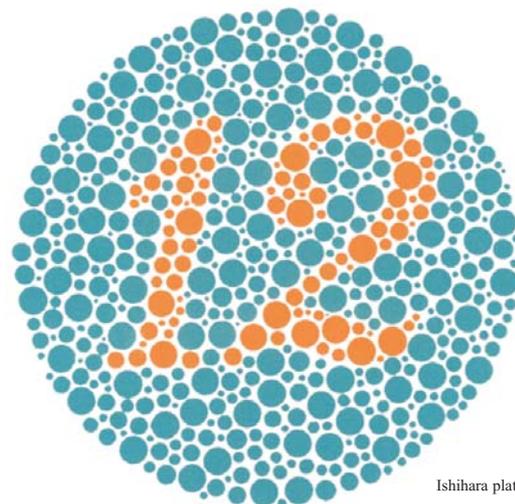
Current colour testing procedures rely on this discriminative ability to detect and grade the degree of dysfunction.

## **Diagnostic Testing**

Due to the large numbers of people who may be required to undergo diagnostic testing for colour deficiencies e.g. school children, drivers, pilots undergoing routine medical renewals etc., the diagnostic tests must out of necessity be easy, time saving and cost effective to administer. Additionally, a great advantage would be if the results could be immediately interpreted.

Detailed colour vision tests involve the use of sophisticated instruments such as colorimeters and anomaloscopes which would typically provide a greater degree of information useful more for the research scientist than the average clinician.

Current testing involving the use of Pseudo-Isochromatic Plate tests and the Farnsworth Panel D-15 tests seem to meet the general clinicians' requirement.



Ishihara plate

### ***Pseudo-Isochromatic plate tests***

One of the first attempts to simplify the colour vision diagnostic procedure was made as long ago as 1917 by Ishihara. He developed a series of pigment based coloured figures in which the observer views a series of coloured numbers against different coloured background. The plates contained figures and backgrounds whose pigment colours (hues) lie along the confusion axes for protans or deutan observers. During administration of the Ishihara tests, normal observers will see one series of numbers while colour deficient observers would see no number at all or a different number than normal. One drawback of the Ishihara test is that the source of illumination must be controlled and also the plates must be replaced from time to time due to fading of the colour pigments (something very few clinicians practice). The Ishihara test does not test for Tritan deficiency and despite its limitations; it is still useful for identifying a protan (red) or deutan (green) defect and approximating its severity.

### ***Farnsworth panel D-15 test***

The Farnsworth Panel D-15 test is a hue discrimination test that was designed to differentiate observers with defective colour vision from those with no or mild deficiencies. The 15 test chips were designed to have equal luminance and saturation values and vary only as a function of hue. The actual hues were designed so that protans will arrange them in one way and deutans in another and tritans in yet another pattern. By analysing and recording these patterns, a diagnosis as to type or classification of colour vision deficiency is then possible.

This test is also not without its drawbacks. The person with mild colour vision deficiency will arrange the chips on an apparent brightness gradient rather than on colour. Thus although the theoretical design does not provide for the ability to quantify the degree of severity of the deficiency, it nevertheless is considered valid.



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