

THE NEW PHYSIOLOGY OF VISION

Chapter I. Introductory

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THE faculty of vision plays an immensely important role in human life and activity. There are three different aspects of that faculty, *viz.*, the perception of form and space, the perception of luminosity and the perception of colour. Each of these categories of perception is operative over a wide range of variation of the effects perceived. Very remarkable, also, is the degree of precision and capacity for discrimination exhibited in each case. A fuller understanding of these features of our visual perceptions is obviously of the highest interest and importance.

The beliefs currently entertained regarding the matters referred to above have been largely inherited from the era of scientific advance when it was thought that the wave-theory of light was the proper foundation for an understanding of the phenomena of vision. To find a way out of the difficulties then arising, certain hypotheses and assumptions were introduced and adopted as articles of faith, thereby inhibiting an unbiassed study of the facts which would have revealed their inadmissibility. Physiological optics thus became a species of make-believe, instead of real knowledge based on reason and experiment.

On the 2nd of October 1959, the author gave at his Institute in Bangalore a lecture on "Light, Colour and Vision" which was an exposition of the outstanding features in the functioning of the visual organs of man. The lecture as actually delivered traversed only familiar ground, but the study of the subject undertaken at the time made it evident that great lacunae existed in our understanding of the facts of visual optics. The author was thereby encouraged to enter the field with a view to develop the subject on new lines.

The first steps in the direction indicated were taken in the author's address to the Annual Meeting of the Indian Academy of Sciences in December 1959, which was published in *Current Science* for January 1960. The title of the address was "The Sensations of Colour and the Nature of the Visual Mechanism" and it sought to interpret the known facts of colour perception and colour discrimination on the basis of a new concept of the

functioning of the human retina, *viz.*, that it receives the energy quanta of the incident light and transforms them into electrical impulses which travel along the optic pathways and reach the cerebral centres.

Soon afterwards, the author devised a simple but highly effective method by which an observer can view his own retina in the act of functioning, in other words, perceive the response of the retina when light of any chosen spectral composition is incident on it. The method reveals that the foveal region of the retina differs greatly from the areas surrounding it in respect of the sensitivity to different parts of the visible spectrum.

In Memoir No. 125 of the Raman Research Institute entitled "The Perception of Light and Colour and the Physiology of Vision" published in December 1960, this method of studying the retina was described in detail and its results were illustrated by a few pictures of the retina in colour as thus observed. It was shown that by using colour filters which isolate particular regions of the spectrum for illuminating the retina, the method enables the spectroscopic behaviour of the absorbing pigments present in the retina to be determined and the manner in which they are distributed over its area to be ascertained.

The use of polarised light in conjunction with colour filters and the same technique enabled further progress to be made. It was shown that the absorbing material present in the retina which is effective in the blue region of the spectrum and enables it to be perceived is a carotenoid pigment having elongated molecules. In the foveal region of the retina, these molecules set themselves radially along the nerve fibres in that region. The well-known fact that the unaided eye can detect polarised light was thus shown to be a consequence of the molecular form and absorptive properties of the visual pigment which is effective in the blue region of the spectrum. Memoir No. 133 of the Raman Research Institute entitled "The Role of the Retina in Vision" published in August 1962 discusses these findings and includes more pictures of the retina in colour.

Early in the year 1963, the author commenced a systematic study of the immense array of material available for the study of colour in the shape of the flowers and foliage of the plant world. The aim was to determine by factual observations the relation which actually exists between the perceived colour and the spectral composition of the light reflected by or transmitted through the petals of flowers or the leaves of plants. Quite simple methods, *viz.*, visual observation of the light through a pocket spectroscope provided with a wave-length scale enabled numerous samples to be quickly examined.

The results of such observation were checked and confirmed by photographic registration of the spectra and a critical study of the record.

The results of the first few months of work on these lines were described and illustrated in Memoir No. 137 of the Raman Research Institute entitled "Floral Colours and The Physiology of Vision" which was published in August 1963. The results were extremely striking and they led to some significant conclusions regarding the colour sensations excited by polychromatic radiation. Later work with more material confirmed the results and conclusions set out in the memoir. Studies of a similar nature were also undertaken with natural and synthetic gemstones, textiles and technical products of various sorts exhibiting colour. The results in every case supported the conclusions reached by the study of floral colours.

The outcome of the investigations was to establish the fundamental thesis that the primary physiological sensations are those excited by monochromatic radiation and to show that the sensations excited by polychromatic radiation are not determinable by simple additive laws. The so-called trichromatic hypothesis and the ideas regarding colour synthesis based on it were found to be definitely contradicted by various facts of observation. One of the most striking facts emerging from the study is the extraordinarily important role played in colour synthesis by the relatively narrow region of wave-lengths comprised in the yellow sector of the spectrum. Its presence or absence makes all the difference in the perceived colour of polychromatic radiation.

Under the title "Fluctuations of Luminosity in Visual Fields", the author described in the issue of *Current Science* dated the 5th of February 1964, a phenomenon of extraordinary interest discovered by him. Detailed studies subsequently made confirmed the explanation of it suggested in that preliminary communication. Briefly stated, the substance of the discovery was that a uniformly illuminated screen which diffuses the light falling on it exhibits localised fluctuations of luminosity over its entire area when viewed at some distance from it. The magnitude and character of the observed fluctuations are found to depend on the strength and spectral character of the illumination and especially also on the distance from which the screen is viewed.

It has been shown that these effects arise by reason of the corpuscular nature and behaviour of light. It is significant that they are observed over a wide range of illumination of the screen, which may be far above the absolute threshold at which the eye ceases to perceive light. Further studies have

established that these fluctuations of luminosity stand in the closest relationship to the subject of visual acuity and that they explain the well-known dependance of the visibility of the details of an object on the strength of its illumination and the distance of the object from the observer. Indeed, the variations in the visibility of detail are found to be direct consequences of the local fluctuations of luminosity in the field in which the object is located.

In an article published in the issue of *Current Science* dated the 20th of May 1964 under the title "Stars, Nebulae and the Physiology of Vision," the author discussed the explanation of various familiar facts of experience regarding the objects appearing in the night-sky and our ability to perceive them and observe their characteristics. The article sought to find answers to various questions arising in that connection and especially the following. Why are we unable with our unaided vision to perceive stars fainter than the sixth magnitude? Why do the great majority of stars appear to us merely as specks of light without any hint of colour? Why do gaseous nebulae appear as mere patches of light in small telescopes while as seen through giant telescopes they appear as blazing masses of colour? It was shown in the article that highly significant conclusions regarding the functioning of the visual organs emerge when these questions are examined in the light of the available data regarding the luminosities and spectral characters of the stars and the nebulae.

The foregoing is intended to convey some idea of the vistas of research in the physiology of vision which have been opened by the work of the author since October 1959 when his active interest in this field had its commencement. The account given above does not however attempt to state or even to summarise the results of that work. That is reserved for the succeeding chapters of this work.