THE SCIENCE OF VISION

IN his Presidential Address to the Indian Academy of Sciences at Nagpur, Professor Raman sought to elucidate the functioning of our visual organs and to explain various facts concerning the same which have so far remained unexplained. In particular, he dealt with the subject of the acuity of vision and the very striking variations which it exhibits in various circumstances. The following is a summary of the main features of his Address.

When we wish to observe any object closely, we turn our eyes so as to ensure that the focused image of the object falls precisely on the central region of the retinæ of both eyes. It is well known that the visual acuity is highest when the image of the object is located precisely on the depression in the retina known as the fovea and the acuity falls off with extreme rapidity when the image moves away from that position. A movement away from the fovea of ten degrees of arc in either direction is sufficient to reduce visual acuity to a fifth of its maximum value, while a displacement of twenty degrees of arc brings it down to a tenth part of the same. Beyond this again, the acuity for daylight vision continues to fall off, but more slowly.

The influence of the intensity of illumination on visual acuity is a matter of familiar experience. The acuity is highest at high illuminations and diminishes at first slowly, and then much more quickly, and becomes a small fraction of its maximum value when the illumination is weak, even when it is well within the daylight range. These changes in the acuity of vision with diminishing illumination become evident, for example, when we seek to read the pages of a printed book by daylight in the late hours of the afternoon when the sun is about to set and before it has actually become dark. The smaller the print, the greater is the difficulty felt in recognising the letters on the page.

If the finest detail of the object under observation is to reveal itself to our perceptions, it is evidently necessary that well-defined optical images of the object should be formed on the retinæ of our eyes. This condition, of course, is not satisfied in the case of persons with defective vision. But since such defects can in many cases be rectified by appropriate measures, we need not here consider such situations, but may proceed on the basis that the observer has normal vision, in other words, that the image on the retina has the maximum degree of perfection allowed by optical theory.

Even when a perfect optical image is formed on the retina, it is evident that the detail contained in it cannot be perceived unless the retina itself contains an immense number of elementary structures or receptors which can transmit the details of the image through the optic nerves to the visual cortex in the brain. The more numerous these receptors are and the more closely they are packed, the more accurately we can expect the details of the image to be passed on to the visual cortex and made available for perception. In other words, the fine structure of the retina including especially the number and sizes of the cones and the manner in which they are placed relative to each other in the mosaic of the retina determine the possible acuity of vision.

Anatomical studies have shown that the depression in the retina which constitutes the fovea which has an area of between one and two square millimetres contains over a hundred thousand cones. They are closely packed into a solid formation without any gaps. The entire formation resembles an evenly distributed mosaic. The smallest cones in the mosaic appear around its very centre and the cones gradually increase in size from these outwards to the periphery. The individual cones are mostly hexagonal in shape. They are very thin and of elongated shape and stand up vertically with respect to the retina at the very centre where they are most crowded together. In that region they are about a thousandth part of a millimetre in diameter. Their size increases as we proceed outwards from the centre towards the periphery of the fovea. The distance between adjoining cones widens as we proceed outwards from the fovea and becomes as much as three, four or even five thousandths of a millimetre towards the periphery of the retina.

These features of the retinal structure enable us to understand in general terms why the visual acuity diminishes rapidly as the optical image of external objects is shifted outwards from the very centre of the fovea to the peripheral regions. A significant feature in the organisation of the retina indicated by anatomical studies is that each cone in the retina apparently possesses a private channel of nerve fibres along which it can send its messages to the brain. Unless some such arrangement exists, it is difficult to understand how the confusion in our perceptions which would arise from a superposition of the messages arising from adjoining cones could be avoided.

The foregoing remarks leave the observed dependence of visual acuity on the strength of the illumination unexplained. Such dependence is of a quantitative nature and can be demonstrated with the same technique as that used by ophthalmologists for the examination of defective vision. A chart containing rows of letters of progressively diminishing size is viewed by the observer from such a distance that the smallest letters can be read when the illumination is adequate. On progressively diminishing the illumination, one line after another becomes blurred and the letters in it cease to be observable. Precise measurements can be made using special forms of test object, as for example two black bars with a white bar between them, the three bars being of equal lengths and equal widths. If with such an arrangement, a grey bar instead of a white bar is set between two black bars, the visibility falls off even more rapidly with diminishing illumination.

The facts set forth above indicate that the dependence of acuity on illumination has a physical origin. Light consists of quanta or indivisible units of energy which can only be perceived when they are absorbed by the retinal receptors and the energy passed on to the visual cortex. The fact that our eyes can adapt themselves to very high levels of illumination indicates that in daylight vision, the retina is not capable of absorbing more than a very small percentage of the number of light quanta falling on it. If, in addition, the retinal illumination is itself of very low intensity, the number of quanta incident on the retina and actually absorbed by it may be insufficient to enable all the cones present in the illuminated area to function effectively and continuously all the time. When such a situation arises, a fall of the visual acuity is inevitable.

INDIAN ACADEMY OF SCIENCES: 29TH ANNUAL MEETING

THE Twenty-Ninth Annual Meeting of the Indian Academy of Sciences was held at Nagpur on the 20th, 21st and 22nd December 1963 under the auspices of the Nagpur University. Shrimati Vijayalakshmi Pandit, Governor of Maharashtra and Chancellor of the Nagpur University, inaugurated the session. Mr. Justice S. P. Kotval, Vice-Chancellor of Nagpur University, welcomed the Delegates. Sir C. V. Raman, Nobel Laureate and President of the Academy, delivered the Presidential Address. The inaugural function was held in a specially erected and decorated spacious shamiana before a distinguished gathering of more than three thousand people which included Fellows of the Academy, Delegates, University and College professors, research workers and students. The three-day session included invited addresses, symposia and public lectures.

In her inaugural address Shrimati Vijayalakshmi Pandit called for utilising the achievements of science to the maximum benefits of