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## HUMAN VISION AND THE SPECTRUM

By Professor GEORGE WALD<sup>1</sup>

BIOLOGICAL LABORATORIES OF HARVARD UNIVERSITY

THE basic relation which describes the response of the eye to radiation is its sensitivity to the various wave-lengths of the spectrum. The limits of this function define what is meant by light. Its form expresses fundamental properties of the retinal receptors, and of the ocular structures which light must penetrate to reach them.

The human retina contains two groups of receptors:

<sup>1</sup> This research was supported in part by a grant from the Josiah Macy Jr. Foundation. Part of the work was reported to the Optical Society of America at its meeting in October, 1944 (*Jour. Opt. Soc. Amer.*, 34: 769, 1944). The remainder was to have been reported to the society at its meeting in April, 1945, since cancelled. Most of the experiments on aphakic eyes were performed in the summer of 1943 at the Dartmouth Eye Institute, Hanover, N. H., to whose director, Professor Adelbert Ames, Jr., and ophthalmologist-in-chief, Dr. Hermann Burian, I am most grateful. I wish to acknowledge also the technical assistance of Ruth Hubbard with some of the experiments.

rods, which function in dim light; and cones, the organs of vision in bright light, and color vision. The rods are mainly sensitive at lower wave-lengths than the cones. Hence, in the passage from dim to bright light, the spectral sensitivity of the eye shifts toward the red. This is the Purkinje phenomenon.

A small central area of the human retina—the fovea—which subtends a visual angle of about 1.5°, contains only cones. Within this region, therefore, no Purkinje phenomenon is observed.<sup>2</sup> Even in the dark-adapted eye, in which all peripheral responses are dominated by rods, the fovea retains the characteristics of pure cone vision.

The intrinsic sensitivities of rods and cones are

<sup>2</sup> A. Kohlrausch and J. Teufer, *Tab. Biol.*, 1: 309, 1925; K. Gross, *Z. Sinnesphysiol.*, 59: 215, 1928; S. L. Polyak, "The Retina," Chicago, 1941, p. 202.

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