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THE DISCRIMINATION OF POLARIZED LIGHT BY *OCTOPUS*: A BEHAVIOURAL AND MORPHOLOGICAL STUDY

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With 14 Figures in the Text

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A. Introduction

Since the classical work of von Frisch (1948, 1949, 1950) many animals have been found to orient themselves with respect to the plane of polarization of plane polarized light[1]. The method by which these animals find the direction of the plane of polarization presents an important problem to receptor physiology. But before making a detailed study of the anatomy and physiology of an animal's visual organs we must be sure that these organs really are analysing the plane polarized light. For polarized light readily produces reflection and scattering patterns characteristic of the direction of the plane of polarization, and these

[1] These experiments have been comprehensively reviewed by Stockhammer (1959).

patterns might enable an animal to determine this direction even if its visual organs give no special responses to polarized light. Indeed, certain optomotor reactions to plane polarized light have recently been shown to disappear when the experimental situation is redesigned so that the scattering and reflection patterns cannot arise. Reviewing these and other experiments, KALMUS (1959) concludes that nevertheless many reactions to polarized light probably do depend on specialized visual receptors.

Two lines of work contribute to further understanding of this problem: experiments showing specific reactions to polarized light that eliminate as far as possible scattering and reflection patterns on which the reaction can be based[1]; and, secondly, studies of the animal's sense organs showing to what extent they possess physiological and anatomical specialization that would explain the reactions to polarized light.

This paper presents contributions to both these lines. First, it describes responses of *Octopus* to polarized light in a training situation in which the possibilities of reflection and scattering patterns arising are minimized. Second, it presents a full discussion of a possible mechanism by which the *Octopus* retina might analyse the plane of polarization and contributes new electron microscopical findings to this discussion. Finally, an attempt is made to correlate the two lines, and the deductions from the training experiments are compared with the requirements of the theoretical analysing mechanism.

The most plausible theory of how a photoreceptor might analyse polarized light postulates an orientation of the visual pigment molecules, which causes them to absorb light more strongly when the plane of polarization is in one direction than when it is at right angles to this direction (dichroism) (STOCKHAMMER 1959). But in the absence of conclusive evidence for this dichroism the theory remains unproved. However, suggestive support for it is provided by electron microscopical observations of the structure of arthropod ommatidia (GOLDSMITH and PHILPOTT 1957, FERNÁNDEZ-MORÁN 1958). The photoreceptor regions of these ommatidia consist of parallel, close-packed fine tubules whose orientation provides a possible morphological basis for the supposed orientation of the visual pigment. The considerations of the second section of this paper lend support to this dichroism theory of polarized light analysis.

A preliminary report of the training experiments has already been published (MOODY and PARRISS 1960).

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[1] See for example the recent studies by v. FRISCH, LINDAUER and DAUMER (1960) and by WATERMAN (1960).