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Closure of Ionic Channels in Turtle Cones*

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Abstract. Recent observations from turtle cones on the kinetics of the light response and the variance and power spectrum of spontaneous noise are discussed in terms of the behaviour of membrane ionic channels.

Key words: Retina – Cones – Light response – Noise – Ionic channels.

To explain the observed decrease in cone conductane during light, Baylor and Fuortes (1970) suggested that absorption of photons leads to the production of an intermediary substance which decreases membrane conductance by interacting with ionic channels in the outer segment. This hypothesis and its implications were discussed in terms of evidence from intracellular recordings in turtle cones.

It has been shown that in the early stages of the response to flashes of widely varying intensity the response amplitude is consistent with the idea that the concentration of blocking molecule varies linearly with light intensity and that there is rapid equilibrium with ionic channels (Baylor, Hodgkin, and Lamb, 1974). It has also been shown that the small signal response kinetics are consistent with the molecule being produced by a chain of about six reactions.

Recently, spontaneous electrical noise has been detected in turtle cones in darkness, and this noise is reduced by bright light (Simon, Lamb, and Hodgkin, 1975). Although the noise is small in most cells, it is much larger in a few cells having narrow spatial sensitivity profiles, and the difference can be attributed to variations in the degree of electrical coupling between cells (Lamb and Simon, 1976). As a result it is concluded that all turtle cones possess a similar source of noise, which in the absence of coupling would give rise to a voltage variance of about 0.4 mV^2, and which is made up of elementary events roughly 100 μV in amplitude. It is likely that the noise arises from the random opening and closing of the light-sensitive channels as a result of interaction with the blocking substance, which in darkness has a residual concentration. In strong light the concentration is greatly increased so that all channels are closed and there is no source of noise. The expected noise versus

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voltage relationship can be predicted from simple models of binding and is consistent with experiment.

The power spectrum of the noise allows estimation of the mean duration of the elementary events as about 20–50 ms, and this is probably related either to the rate constant of removal of the blocking substance from the outer segment, or to the rate constants of binding and unbinding of channels.

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