news and views

The ultraviolet sense in flies

from Jonathan Ashmore

MANY insects can detect light in the near ultraviolet. So also can humans but there are problems in explaining the much greater insect ultraviolet sensitivity in terms of what is known about the visual pigments. Rhodopsin is probably one of the most intensively studied membrane proteins, yet great gaps exist in the description of the chain of events starting with the photoisomerisation of the chromophore 11-*cis* retinal and ending with the signal appearing in the nervous system. But in both vertebrate and invertebrate systems the chromophore has always turned out to be retinal, the aldehyde of vitamin A. The peak absorption wavelength λ_{max} for those rhodopsins which have been studied either in the membrane or in solution lies in the range 460 nm to 535 nm. Free retinal has a λ_{max} of 378 nm, and its association with the protein by way of the usual protonated Schiff base would tend to move λ_{max} to longer wavelengths only.

However, the insect ultraviolet peak measured in the photoreceptors of a number of species both by electrophysiological and microspectrophotometric methods occurs around 360 nm. A pigment from the moth *Asculaphus* has been isolated by Hamdorf and co-workers (*Nature* **231**, 438; 1971) with a λ_{max} at 350 nm and retinal as the presumed chromophore, but the matter is not settled there. In rhabdomeres R1–6 of the dark adapted dipteran ommatidium, spectral absorption peaks not only at 500 nm but also in the ultraviolet. The precise wavelengths are species dependent, but the ultraviolet absorption has peculiarities: the phenomenon appears to be fairly labile, varying from cell to cell and may even change seasonally (Horridge & Mimura *Proc. R. Soc.* **B 190**, 211; 1975). Since its first description 15 years ago it is still not clear whether one or two pigments are present. The sharp angular sensitivity of the receptors seems to rule out the possibility that there is coupling from the specifically ultraviolet receptors R7 and R8.

On page 386 of this week's issue of *Nature* Kirschfeld *et al.* sidestep the one/two pigment issue by suggesting that the ultraviolet sensitivity of dipteran photoreceptors may be due to a mechanism similar to that used to extend the spectral sensitivity of photographic emulsions. Performing the microspectrophotometry on rhabdomeres R1–6 of the housefly *Musca,* they extend the earlier work on *Calliphora* by Langer and Thorell (*Expl Cell. Res.* **41**, 673; 1966) to show that although the ultraviolet peak occurs in absolute absorption spectrum there is no conspicuous change in the ultraviolet extinction following adaptation by ultraviolet light. Such a change is virtually a prerequisite for the presence of a rhodopsin-like pigment, and special mechanisms need to be invoked to explain its absence.

The first relatively stable reaction product of rhodopsin following the absorption of light is metarhodopsin. Insect metarhodopsins are distinguished by the large redshifts of the absorption peak relative to rhodopsin. In *Musca* the effect of absorption of ultraviolet light seems to be the production of only the metarhodopsin with λ_{max} of 580 nm which is that formed from the blue-absorbing rhodopsin with a λ_{max} of 490 nm.

Where is the ultraviolet light being absorbed? The new technique which has been used to study the mechanism further is electrophysiological. Pak and Lidington (*J. gen. Physiol.* **63**, 740; 1974) reported that the fast potential elicited by short intense flashes of light with external recording from the photoreceptors is proportional to the metarhodopsin concentration. This provides a direct assessment of the pigment state, whereas earlier work relied on the slower receptor potentials where several stages of transduction are involved before the electrical signal can be measured. Kirschfeld *et al.* find in *Drosophila* that those flies fed a vitamin A deficient diet have a lower ultraviolet quantum efficiency compared to blue light than those flies raised on a vitamin A enriched medium. The method used can now leave little doubt that the vitamin A deficiency alters in some way the efficiency of ultraviolet light absorption at the level of the visual pigment itself. Species differences in visual performance between various dipteran species have been noted as a result of vitamin A deprivation (reviewed by Stark *et al. Naturwissenschaften* **63**, 513; 1976), but the differences between *Musca* and *Drosophila* are probably not significant here.

The novel explanation offered for these observations is that a photostable pigment is present in normal flies which absorbs in the ultraviolet and transfers energy to the chromophore on the rhodopsin molecule. Although vitamin A deficiency may be working by reducing the rhodopsin concentration (see for example Harris *et al. Nature* **266**, 648; 1977), the primary effect must be the reduction in retinal and its derivatives. A vitamin A derivative is thus a likely candidate for the photostable pigment postulated, presumably membrane-bound in view of the sensitivity of these receptors to the plane of polarisation of ultraviolet light (Horridge & Mimura *op. cit.*). Cattle rhodopsin has in fact been prepared artificially with two retinals bound and has a double absorption peak, one in the ultraviolet (Rotmans *et al. Biochim. biophys. Acta* **357**, 151; 1974). Functional studies of such a system have not been made but it is known that fluorescent probes can be attached to sites on the rhodopsin molecule (Wu & Stryer *Proc. natn. Acad. Sci. U.S.A.* **69**, 1104; 1972) whose behaviour suggests that the kind of energy transfer required to explain the insect data may be possible given a suitably close pair of sites.

Although not based on radically new data, the suggestion of a 'sensitising pigment' may be the solution to old problems. Further developments including a more direct attack on the protein chemistry involved should tell whether it is right. □

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