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Movement in a ganglion

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SUMMARY

It is known that laser light scattered from small particles in Brownian motion is noisy. When locust ganglia are illuminated by laser light we find that the scattered light is particularly noisy and the ganglia appearing to twinkle in that light, when the bathing medium is K^+-rich. The effect is dependent on the presence of Ca^{2+} and it is suggested that K^+-rich solutions in the presence of Ca^{2+} permit presynaptic vesicles to undergo Brownian movement.

The image of scattered laser light appears granular: if the scattering centres are moving then the image appears to twinkle. Twinkling, or noise, in such laser light, scattered from small particles, arises essentially from Doppler shifts superimposed on the monochromatic laser frequency which cause 'light beats' analogous to the beats noticeable with sound waves[1].

Helium-neon laser light scattered by locust ganglia shows a slow movement of the granularity whilst the ganglia are immersed in their normal Ringer solutions; when, however, Na^+ of the Ringer solution is replaced by K^+ the ganglion shows a rapid shimmer or twinkle. The effect is reversible and we have analysed the power spectrum of the noise in the scattered light, detected by photomultiplier in the two circumstances; the results are shown in Fig. 1. In the absence of Ca^{2+} from the Ringer (and with 1 mM EGTA), K^+ causes less increase in noise output in the scattered light near 20 Hz.

Our tentative explanation of the phenomena is that light is scattered by presynaptic vesicles which are only free to move extensively when the nerve endings are depolarised in the presence of Ca^{2+}. The axoplasm, at least of giant nerve fibres, is a gel, which is liquefied by 0.5 mM Ca^{2+} (ref. 2) and regelled by a Ca^{2+}-free medium containing EGTA[3]. We suppose that depolarisation, allowing Ca^{2+} entry[4], liquefies the axoplasm in presynaptic nerve terminals thereby freeing the vesicles.

Abbreviation: EGTA, ethyleneglycol-bis-(β-aminoethyl ether)-*N,N'*-tetraacetic acid.

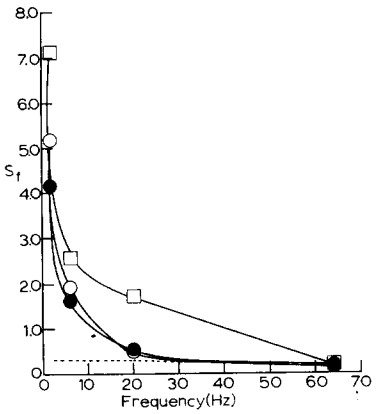

Fig. 1. Power spectra, ordinate (arbitrary units referring to photomultiplier current output), of noise recorded in light scattered at 90° from a beam of laser light directed into the neuropile of the third thoracic ganglion of locust (*Schistocerca gregaria*). Abscissa: frequency (Hz). ○—○ and ●—●, ganglion immersed in normal Ringer; readings taken, respectively, before and after immersion in isoosmotic Ringer containing 57 mM K^+ (□—□). - - - - indicates the noise recorded from a small Teflon block immersed in Ringer. All records for same mean light intensity on photomultiplier. Power spectra calculated for a fixed bandwidth; laser 0.5 mW; 632 nm.

If our explanation is correct it provides a simple basis for explaining the release of synaptic transmitter substances. We note, in any case, that the method of light beats, using laser light, provides a powerful tool for biologists to explore the movements of structures otherwise detected in the electron microscope.

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