

## **A somato-somatic synapse between amacrine and bipolar cells in the cat retina**

It is generally accepted that chemically transmitting synapses can be identified in the electron microscope by observing increased electron density on apposed areas of neuronal cell membranes; an accumulation of synaptic vesicles close to the membrane densification on one (presynaptic) side of the junction; and often a slight increase in width of the extracellular space at such points<sup>3,4,7</sup>. Such synapses are usually classified according to the nature of the pre- and postsynaptic structures; and thus, axosomatic, axodendritic, or axoaxonic synaptic junctions are routinely described. Synapses in which the soma is the presynaptic structure have been classified as 'atypical'. However, several accounts of somato-dendritic synapses have been presented in the literature<sup>7,8</sup>. Hopsu and Arstila<sup>5</sup> described somato-somatic synapses in the rat pineal gland and suggested that they were unique to the modified cells of the pineal. LeVay gives an account of one possible somato-somatic synapse in the rhesus monkey lateral geniculate<sup>6</sup>. In vertebrate retinas, axodendritic, axosomatic, and axoaxonic synapses have all been described<sup>1</sup>. I report here a somato-somatic synapse found in the inner nuclear layer of the retina of the cat.

These unusual synaptic arrangements were found in adult retinas which had been fixed by immersion in 2.5% glutaraldehyde buffered with 0.67 *M* sodium cacodylate. The tissue was postfixed in 2% osmium tetroxide buffered with veronal acetate, dehydrated in alcohol and embedded in Araldite. Serial sections for electron microscopy were placed on formvar films on slot grids for examination. Electron microscope sections were stained with 1% uranyl acetate in distilled water for 20 min, and Reynold's lead citrate stain for 10 min. Sections were examined in JEM 100B and Siemens Elmiskop I electron microscopes. Somato-somatic synapses have also been sought in adult cat retina fixed in 2% osmium tetroxide buffered with veronal acetate alone.

Eight somato-somatic synapses have been found in the glutaraldehyde-osmium tetroxide fixed cat retinas. In all cases an amacrine cell body was found to be presynaptic to a bipolar cell body (Fig. 1). Seven of the 8 synapses occurred deep in the inner nuclear layer (Fig. 1). In one case the synapse was near the inner plexiform border of the amacrine cell, close to the point of exit of the bipolar axon. In the glutaraldehyde-osmium tetroxide fixed retina of the cat cell types are readily distinguishable on the basis of nuclear and cytoplasmic morphology. Most of the 7 synapses were found by recognizing amacrine and bipolar perikarya lying next to each other with an apposed area between the cells free of glial (Müller) cell processes. In many cases, such an area, when followed in serial sections, eventually led to the observation of a somato-somatic contact. Somato-somatic synapses were not seen in cat retina fixed with osmium tetroxide alone, possibly because of the inability to distinguish between amacrine and bipolar somata with this fixation. Since osmium tetroxide alone is the fixative most often used with vertebrate retina, it is not known whether a glutaraldehyde-osmium tetroxide fixation will reveal somato-somatic synapses in other retinas as well.

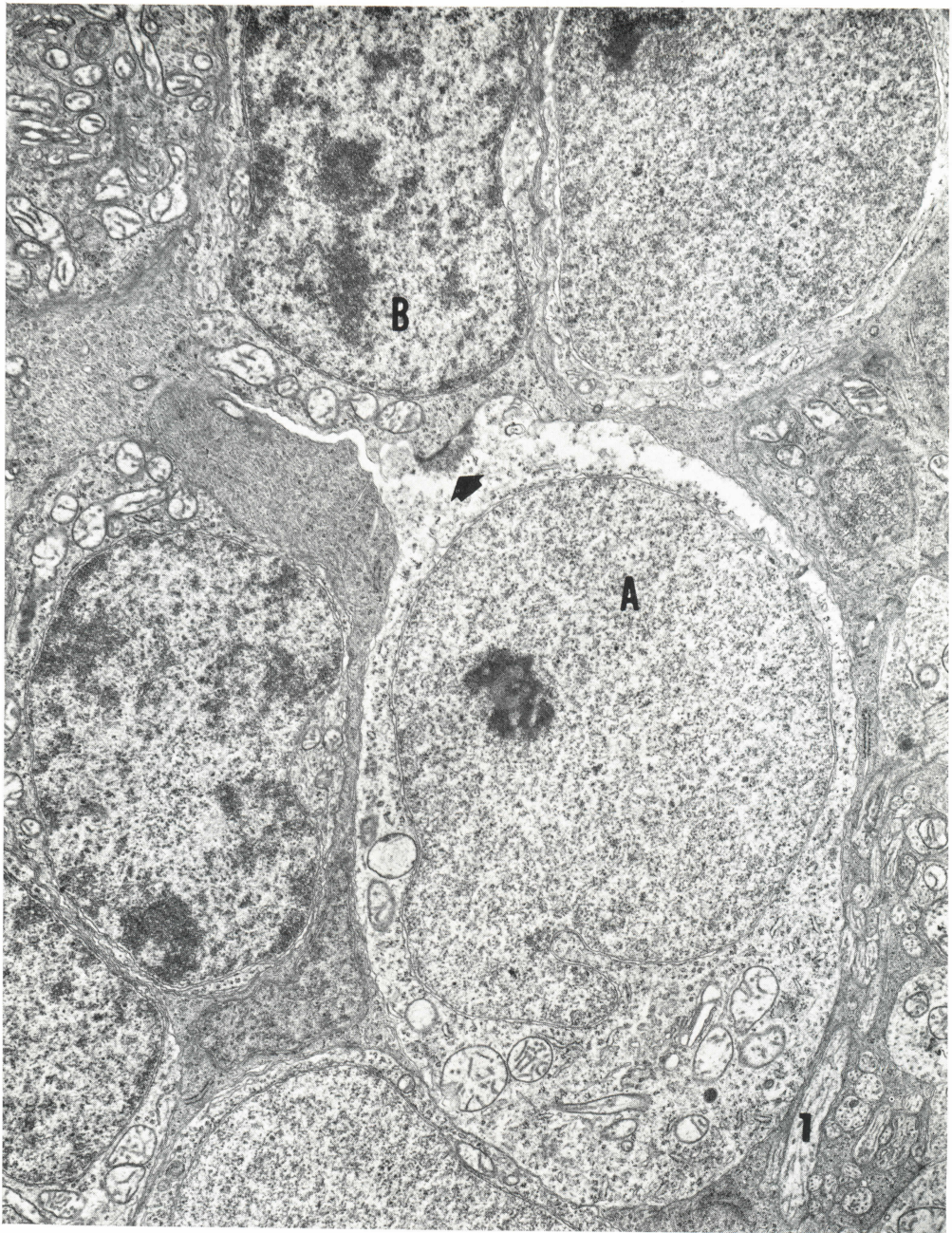


Fig. 1. An electron micrograph showing a somato-somatic synapse (arrow) between A, amacrine, and B, bipolar, cell bodies.  $\times 9,000$ .

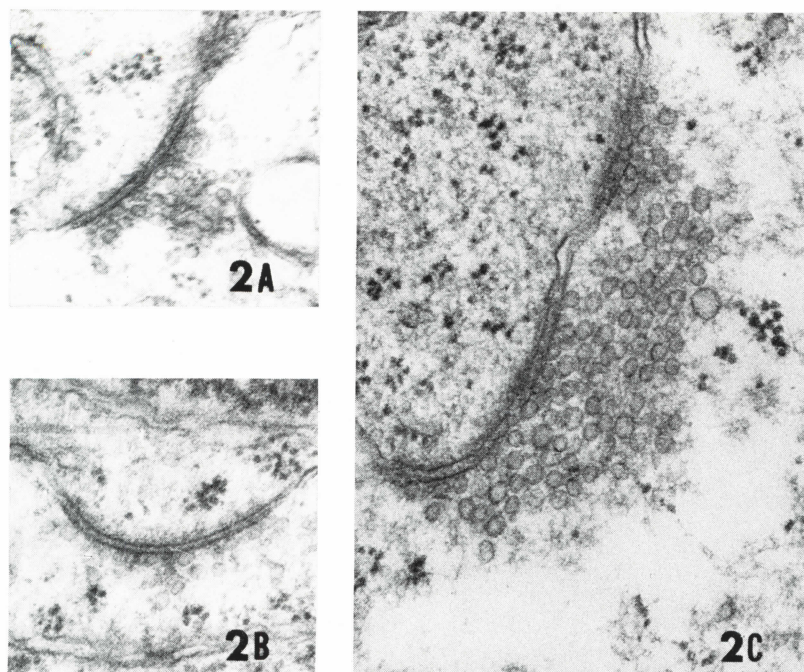


Fig. 2. Three somato-somatic synapses between amacrine and bipolar cell bodies. A, B, Sectioned in one plane, the area of membrane specialization occurs over at least  $0.5 \mu\text{m}$ . C, When sectioned in a plane perpendicular to the first, the area of specialization extends over at least  $1 \mu\text{m}$ .  $\times 60,000$ .

The somato-somatic synapses described here appear similar to other synapses of the amacrine cells<sup>1</sup> in that they have a widened synaptic cleft, symmetrical pre- and postsynaptic membrane densifications and a cluster of synaptic vesicles near the presumed presynaptic membrane (Fig. 2A, B, C). However, the synapse does differ from other retinal amacrine synapses in two respects. First, the area of membrane specialization always smoothly indents the amacrine cell perikaryon (Fig. 2A, B); and second, these appear to be unusually large synapses. When sectioned in one plane the distance across the area of membrane densification is at least as large as  $0.5 \mu\text{m}$  (Fig. 2A, B) and one synapse (Fig. 2B) was followed through 10 consecutive silver-gold sections, suggesting it was nearly  $1 \mu\text{m}$  in diameter. Fig. 2C shows a somato-somatic synapse which was sectioned through its long axis, and the distance across the area of membrane densification measures approximately  $1 \mu\text{m}$ . Conventional inner plexiform layer synapses have diameters ranging around  $0.2 \mu\text{m}$  with only a very few synapses having a diameter above  $0.4 \mu\text{m}$  (*cf.* ref. 2).

Present theories concerning the role of amacrine cells in the retina have not required the presence of a somato-somatic synapse between amacrine and bipolar cells, nor does the presence of this synapse make the explanation of amacrine function any clearer. Whether or not this type of synapse is found in other species, and whether or not it is limited to certain amacrine or bipolar cell subclasses must await further observations.

In summary, electron microscopic observations have revealed an unusual synaptic arrangement in the inner plexiform layer of the cat retina. This arrangement may be described as somato-somatic with an amacrine cell body presynaptic to a bipolar cell body.

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- 1 DOWLING, J. E., AND BOYCOTT, B. B., Organization of the primate retina: Electron microscopy, *Proc. roy. Soc. B*, 166 (1966) 80-111.
- 2 DUBIN, M., The inner plexiform layer of the vertebrate retina: A quantitative and comparative electron microscopic analysis, *J. comp. Neurol.*, 140 (1971) 479-506.
- 3 GRAY, E. G., AND GUILLERY, R. W., Synaptic morphology in the normal and degenerating nervous system, *Int. Rev. Cytol.*, 19 (1966) 111-182.
- 4 HAMA, K., Studies on fine structure and function of synapses. In T. TOKIZANE AND J. P. SCHADÉ (Eds.), *Correlative Neurosciences, Part A, Fundamental Mechanisms, Progress in Brain Research, Vol. 21A*, Elsevier, Amsterdam, 1966, pp. 251-267.
- 5 HOPPSU, V. K., AND ARSTILA, A. U., Apparent somato-somatic synaptic structure in the pineal gland of the rat, *Exp. Cell Res.*, 37 (1965) 484-487.
- 6 LEVAY, S., On the neurons and synapses of the lateral geniculate nucleus of the monkey, and effects of eye enucleation, *Z. Zellforsch.*, 113 (1971) 396-419.
- 7 SETALO, G., AND SZÉKELY, G., The presence of membrane specializations indicative of somato-dendritic synaptic junctions in the optic tectum of the frog, *Exp. Brain Res.*, 4 (1967) 237-242.
- 8 WONG, M. T. T., Somato-dendritic and dendro-dendritic synapses in the squirrel monkey lateral geniculate nucleus, *Brain Research*, 20 (1970) 135-139.

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