Synapses of the Ribbon Type in the Pineal Organ of *Lacerta vivipara* (Reptiles, Lacertilians)

The pineal organ of *Lacerta* has a dual function. Besides a neuro-humoral[1,2], and possibly a neuro-hormonal activity[3], it is characterized by remnants of a photoreceptor function[1,2] as evidenced by cytophysiological[1,2] and electrophysiological[4] investigations. With some few exceptions[2,5], characteristic synaptic connections have not been observed in the reptilian pineal organ just because this represents an important stage in the regression of direct pineal photosensibility occurring during the phylogenesis of vertebrates[1,2]. The present paper illustrates synaptic ribbons in the pineal organ of a lizard (Figures 2 and 3).

In a recent investigation of the pineal organ of adult *Lacerta vivipara* (Jacquin), performed during the summer, we have been able (see[2] for techniques used) to confirm the presence of a highly differentiated photoreceptor apparatus in the distal region of the organ. Quantitatively, however, this is little developed, the number of characteristic neurosensory photoreceptor elements being relatively small in comparison with that of rudimentary photoreceptor cells[2]. The former show morphological features similar to those of the photoreceptor cells in the pineal organ of *Lacerta muralis*, earlier defined[2]. In the basal part of the pineal sensory epithelium, some few sensory nerve cells could be determined[6]. In spite of their relative scarceness, about 30 characteristic synaptic connections could be observed forming junctions between the receptor

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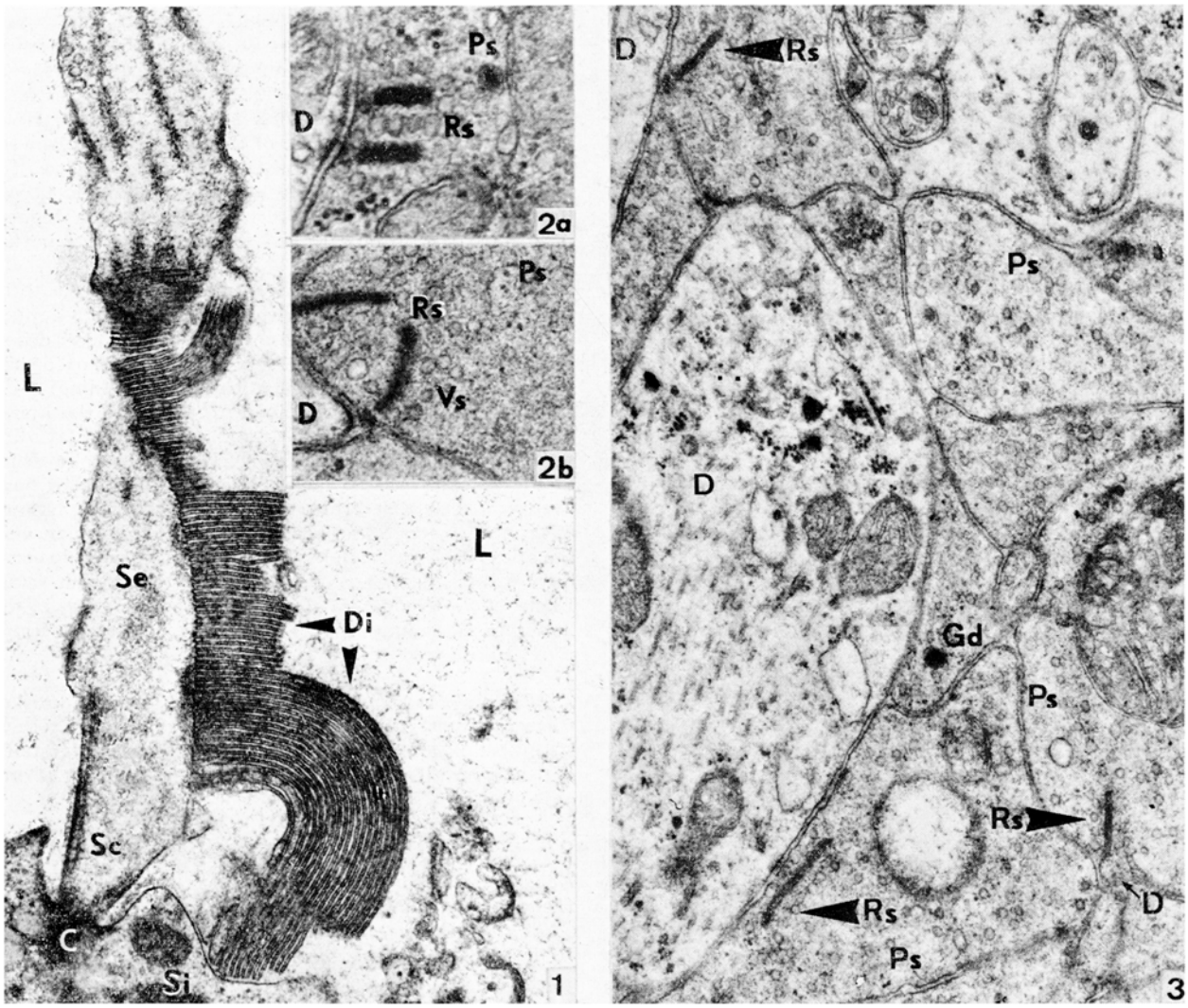

Fig. 1. Outer and inner segments of a typical photoreceptor. C, axial centriole; Di, discs; L, lumen of the pineal organ; Sc, connecting segment; Se, external segment; Si, internal segment. ×25,000.
Fig. 2a and b. Synaptic ribbons (Rs) in the processes (Ps) of photoreceptors in close proximity to dendritic processes (D) of nerve cells. Vs, synaptic vesicles. ×48,000; ×42,000.
Fig. 3. Demonstration of 3 synaptic contacts. D, dentritic process; Gd, dense granule; Ps, synaptic processes of the photoreceptor cells; Rs, synaptic ribbons. ×30,000.

and conductor elements of the photic stimuli. Studies of the middle region of the organ, now in progress, do not show these structures so far.

In contrast to some other authors, we distinguish 'synaptic ribbons' from 'vesicle-crowned rodlets'[2]. Synaptic ribbons show an axo-dendritic localization. They are surrounded by clear vesicles and form part of a complex of other morphological features characterizing a true synaptic junction, such as free synaptic vesicles, a pre- and postsynaptic thickening, and possible filamentous material, present in the synaptic cleft. Synaptic ribbons are frequently observed in Anamniotes. Vesicle-crowned rodlets, on the other hand, show a somato-somatic position and are never associated with other structures, typical of a true synaptic connection. They are essentially present in Amniotes including mammals. So far, it is not known whether vesicle-crowned rodlets represent a form of synaptic regression or a functional mutation of the conventional ribbon-type synapses.

The elements described in the present paper have to be considered synaptic ribbons. They are strictly localized in the basal processes of the photoreceptor cells (Figures 2 and 3), which are typically characterized by the presence of external segments (Figure 1), and lie in close topographical relationship with nerve cells (Figures 2 and 3). Moreover, these structures show the same differentiation as those present in a highly differentiated photosensory pineal organ (*Lampetra planeri*[2]).

The synaptic ribbons are in close proximity to the following nervous constituents: processes showing mitochondria, microtubules, clear and dense-core vesicles[2], smooth or granular endoplasmic reticulum (Figure 3). In the case of *Lampetra*, all of these organelles are considered characteristic of dendrites of intrapineal sensory neurones[1,2]. Proximity of synaptic ribbons to cell bodies of nerve cells is only exceptionally observed.

In contrast to the processes of rudimentary photoreceptor elements, the synaptic process of typical photoreceptor cells contains, like the internal segment and the cell body, some rare dense granules of an average diameter of 1,000 Å (Figure 3). The terminal ending of the synaptic processes abounds in synaptic vesicles (Figures 2 and 3), contrary to the terminal of the basal process of rudimentary photoreceptor cells. At the level of the 'active zones', involved in synaptic transmission, the following structures can be observed (Figures 2 and 3): a) At the presynaptic side, in the terminal ending of the basal process of the photoreceptor cell: Synaptic ribbons associated with vesicles as well as free vesicles. The vesicles are clear and show an average diameter of 500 Å. A presynaptic dense zone, adjacent to the presynaptic membrane. b) At the postsynaptic side, in the dendritic process and in the cell body of the neurones: A postsynaptic dense zone, adjacent to the postsynaptic membrane. c) In the synaptic cleft, bordered by the pre- and postsynaptic membrane: filamentous material, most often directed parallel to the membranes.

It seems possible that several photoreceptor cells make synaptic contact with a single intrapineal neuron because, actually, a number of such direct contacts is established, not only with the dendritic processes, but also with the cell bodies. So far, we have not been able to demonstrate whether some photoreceptor cells make synaptic contact with dendrites exclusively, while others make such a contact with the cell body only, or whether a single photoreceptor element establishes synaptic junctions with both, the dendrites as well as the soma of a sensory nerve cell.

The demonstration of ribbon-type synaptic connections between photoreceptor cells and nerve cells conducting photic stimuli in the pineal organ of *Lacerta* is an argument in favour of the conversion of radiating energy into nervous impulses at the level of the characteristic photoreceptors (Figure 1). This is in accordance with the achromatic response obtained in the pineal organ of *Lacerta sicula*[4] in electrophysiological investigations.

Résumé. Un appareil photorécepteur et neuroconducteur est hautement différencié mais quantitativement peu développé dans l'organe pinéal de *Lacerta vivipara* adulte. L'existence de rubans synaptiques typiques, à la jonction des photorécepteurs et des cellules ganglionnaires est démontrée.

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[7] Acknowledgment: our thanks are due to Mrs S. Vernerey for her excellent technical assistance.

Action tératogène des altérations vasculaires

L'action tératogène de l'hypoglycémie[1,2], de l'anémie[3], de l'hypoxie[4,5], du CO_2[6,7], etc., est attribuée généralement à l'action directe de ces agents sur les cellules de l'embryon. Cependant, dans diverses des expériences, nous avons constaté que les perturbations vasculaires consécutifs à l'action de certains tératogènes sont, aussi, un facteur important dans la genèse de certaines malformations.

Au cours de travaux précédents[8,9], nous avons décrit les altérations vasculaires qui apparaissent après l'hémorragie experimentale chez les embryons du poulet, altérations qui sont responsables des malformations caudales.

Plus récemment nous avons étudié les altérations vasculaires qui se présentent après l'hypoxie et des interventions sur les somites. Les embryons soumis à l'hypoxie (causée par le revêtement de la coquille avec de la paraffine, après 32 h d'incubation, en laissant $^1/_3$ de la chambre à air, ou $^1/_2$, selon les cas, sans revêtement), présentèrent, 30 h après, les altérations suivantes:

1. Une notable dilatation des vaisseaux extra et intra embryonnaires, proportionnelle à la surface paraffinée de la coquille.

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