Chapter V

The Small Neurons

In the present chapter, the cytology of the small neurons in the dentate nucleus of the rat and monkey will be reviewed with special attention paid to the organization of synapses upon them.

1. Rat: Small Neurons in the Lateral Nucleus

a) Perikarya

Profiles of the perikarya of small neurons in electron micrographs are readily recognized by their overall size; the somatic profile usually includes a nucleus and measures 10–12 μm or less in diameter. The nucleus is usually very lobulated and the creases are so deep that they may extend well into the interior of the nucleus from side to side. The chromatin is finely dispersed throughout, but because of the smaller size of this nucleus, the chromatin appears more concentrated or more flocculent than it does in nuclei of larger neurons. A thin rim of chromatin with occasional patches of heterochromatin occurs under the nuclear envelope. The nucleolus is prominent and is centrally situated. The deep creases in the nucleus house small numbers of polysomes. The amount of cytoplasm in the cell body of the small neuron is limited, but not meager. Like many small neurons elsewhere in the central nervous system, these cells have little Nissl substance. It usually consists of only scattered cisternae of the endoplasmic reticulum lying in stacks two or three deep and small collections of polysomal arrays. A prominent Golgi apparatus rings the nucleus. No hypolemmal cisternae have been observed in the small cells.

Two varieties of small perikaryal profile are seen in the electron micrographs, cells with and without axosomatic synapses. In a total of 187 profiles of small cells examined in electron micrographs 52% showed no axosomatic synapses, while the rest, 48% bore many axosomatic synapses. Of these axosomatic synapses, 78% were made with axons belonging to Purkinje cells and the remainder, 22% with axons of other small neurons (Chan-Palay, 1973c, f). Thus, all axosomal contacts made on small neurons in the rat’s lateral nucleus come from inhibitory sources—the corticonuclear afferents and an intrinsic local circuit neuron.

Like the large cells, the smaller neurons have either smooth or irregular somata. In the light microscope, Golgi preparations show that the small irregular neurons have protuberances suggestive of small spines on somatic surfaces as well as along the dendrites. The fusiform small neurons, particularly the bridging neurons of the columnar zone, are generally smooth, while the multipolar small neurons in the medial hilus zone and rostral and caudal poles are usually more spiny.

b) Dendrites

The small neurons emit three or four dendrites, which emerge as gentle, slim prolongations of the cell body, and the processes are more slender and tortuous than the dendrites of the larger neurons. At the junction between the cell body and the base of the dendrite, there is a sudden transition from the perikaryal cytoplasm, with its mat of haphazardly oriented microtubules, mitochondria, polysomes, and smooth endoplasmic reticulum, to the dendritic cytoplasm, with its funnel of longitudinal microtubules and mitochondria and small clumps of polysomes.

In electron micrographs in which only disconnected segments of dendrites are visible, it is diffi-
ult to distinguish dendrites of small neurons from the thinner dendritic branches of large neurons. Distal dendritic segments are recognized by their narrow caliber and their content of microtubules (Figs. 11a and b in CHAN-PALAY, 1973c), and neurofilaments. Synapses with axon terminals of several varieties and in small numbers have been encountered on the surfaces of distal dendritic segments. These synaptic terminals usually occur singly or in pairs, and they do not cluster in large numbers around the dendrite as they do on primary dendrites of larger caliber. Of the axodendritic synapses examined, 31% are made by the axons of Purkinje cells from the cortex, 25% by axons of other small neurons, 10% by axons of large neurons, 28% by the collaterals of mossy fibers and, 6% by collaterals of climbing fibers (CHAN-PALAY, 1973f, g). Recent evidence shows that the somata and dendrites of small neurons in the medial hilus zone receive a significant number of synaptic terminations from axons containing serotonin (Chap. XV). These axons, labeled by the uptake of exogenous tritiated serotonin in autoradiographic procedures and electron microscopy are distinctive, since they contain considerable numbers of large 900 Å granular vesicles.

These results are summarized in the circular frequency histograms of Figure 5-1 which compare the percentages of the axon type synapsing upon the somata and dendrites of large and small neurons in the rat. As these data show, the afferent inputs to these neuron types are comparable both as to source and approximate numbers.

c) Axon

The axon initial segments of the small neurons have been distinguished from those of the large cells on the basis of their size. Usually they are about 1 µm or less in diameter and have all of the features typical of initial segments. Their surfaces are also wrapped in neuroglial cytoplasm. Synapses however have not been observed. Synapses on the initial segments of small cerebellar nuclear neurons have been reported by O’LEARY et al. (1972) in the rabbit.

2. Monkey: Small Neurons in the Dentate Nucleus

Measurements of numerous neuronal somata showed that the neurons of the dentate fall naturally into two classes. Approximately half of them are small neurons with areas under 270 µm², lengths between 8 and 25 µm, and widths between 5 and 20 µm; the other neurons are larger in

---

**Fig. 5-1.** Comparison of types of axonal terminations on the somata and dendrites of the small and large neurons in the rat’s lateral nucleus. In both cell types Purkinje axons, axons of small neurons, and a full complement of other axons synapse on the soma as well as on dendrites. Purkinje axons (light stipple), mossy fiber collaterals (white), large cell axons (dark stipple), small cell axon (black dots), and climbing fiber collaterals (white circles) are represented. Recent studies with labeled amines show that monoamine axons make axosomatic synapses predominantly on the smaller neurons (see Chap. XV).

---

**Fig. 5-2a.** The perikaryon of a small neuron (Class A). This cell (sN) has a simple nucleus. The cytoplasm contains few organelles, including simple mitochondria (m), loose threads of the granular endoplasmic reticulum (ger), numerous polysomes, and a clump of proteinaceous material (arrow). There are no axosomatic synapses; an oligodendrocyte (O) lies in close proximity. Rhesus monkey dentate nucleus. x 24000

**Fig. 5-2b.** Somatic thorn on a small neuron (Class A). This small neuron (sN) has an oval nucleus, meager cytoplasm with few organelles, as is usual for this type of cell; its somatic surface is free of axosomatic synapses except for that made with an axonal profile (Ax) on the top of a somatic thorn (arrow, t). There is a satellite oligodendrocyte (O); the remaining cell surface is surrounded by processes of fibrous astrocytes (fA) and beyond these the perikaryon of a larger neuron (N) appears. Rhesus monkey dentate nucleus. x 14000