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The Pulvinar Thalamic Nucleus of Non-Human Primates: Architectonic and Functional Subdivisions

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Chapter 2
Cytoarchitecture and Myeloarchitecture of the Pulvinar

Walker (1938) subdivided the pulvinar of the macaque monkey into three portions based on topography and cytoarchitecture. The *nucleus pulvinaris medialis* (PM) is the medial and larger portion of the pulvinar, with compactly arranged polygonal cells and only a few transverse fibers. The *nucleus pulvinaris lateralis* (PL) comprises the lateral portion of the pulvinar and blends with the PM without a clear demarcation border. PL cells are rather small, easily stained, polygonal in shape, and are segregated in clumps by the many horizontally crossing fibers. The *nucleus pulvinaris inferior* (PI) lies in the ventral posterior portion of the pulvinar, between the medial (MGN) and the lateral (LGN) geniculate bodies. Laterally, it is bordered by the PL and dorsally by the brachium of the (SC). It is composed of compactly arranged small, dark, polygonal-shaped cells. Olszewski (1952) extended the anterior limits of the pulvinar and added a subdivision to this nucleus, named *pulvinar oralis* (PO). PO appears between the *nucleus centrum medianum* (CM) and the *nucleus ventralis posterior lateralis* (VPL). The cells are small and lightly stained and exhibit irregular density being, in general, less cellular than the other portions of the pulvinar.

In New World marmoset (*Callithrix jacchus*), squirrel (*Saimiri sciureus*), and capuchin (*Sapajus apella*, formerly *Cebus apella*) monkeys, we observe a similar subdivision of the pulvinar (Eidelberg and Saldias 1960; Mathers 1972; Spatz and Erdmann 1974; Soares et al. 2001). Figure 2.1 shows the cytoarchitecture of the pulvinar of the capuchin monkey in four different coronal planes, spaced 0.5 mm apart.

Mathers (1972) studied the ultrastructure of the pulvinar of the squirrel monkey and showed two populations of neurons that were quite similar to those found in other thalamic nuclei. The first neuron type is the thalamocortical relay cell (TRC), averaging 26 μm in diameter and exhibiting radial dendritic pattern and thin dendritic appendages. The second type is the Golgi type II neuron, about 16 μm in diameter, with more complex dendritic appendages and an axon ramifying in the vicinity of the soma (Fig. 2.2). The TCR-Golgi type II ratio is about 7:3, in both PL

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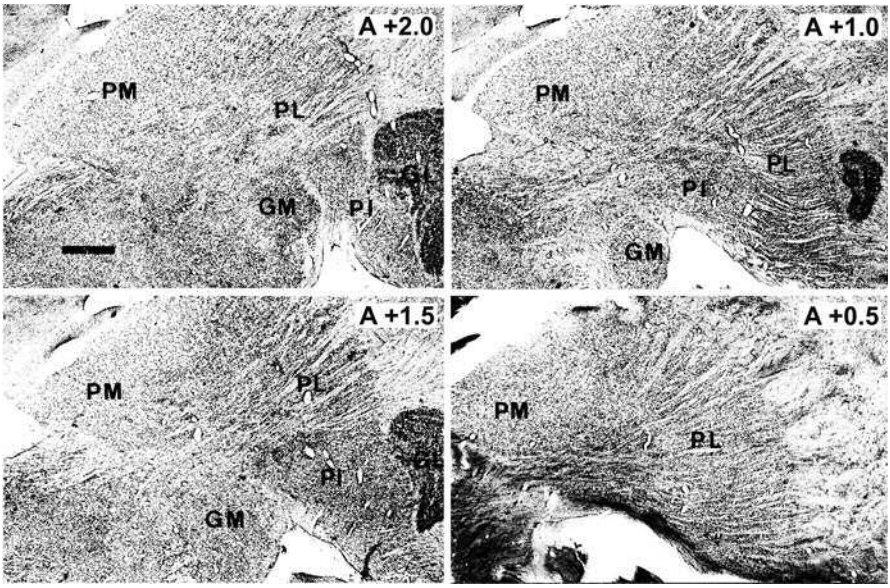

Fig. 2.1 Cytoarchitectonic subdivisions of the pulvinar according to Olszewski (1952). The cytoarchitectonic subdivisions are overlaid onto Nissl stained coronal sections of the capuchin monkey brain (right hemisphere), following the rostral (top left)-to-caudal (bottom right) extent of the pulvinar. The sections are spaced 0.5 mm apart, and they do not reach the caudal extent of the pulvinar. Abbreviations: *GM* medial geniculate nucleus, *GL* lateral geniculate nucleus, *PL* lateral pulvinar, *PM* medial pulvinar, *PI* inferior pulvinar. Scale bar = 1 mm. (Modified from Soares et al. 2001)

and PI, and 9:2 in PM. The most commonly found terminal is small with round vesicles (RS terminal). They are distributed throughout the neuropil, usually making contact with dendritic profiles. There are a significant number of axo-axonal synapses where a large terminal with round vesicles (RL terminal) is presynaptic to a terminal with flattened vesicles (F terminal). However, the large majority of the synapses are the usual axo-dendritic synapses. RL terminals nearly always make synaptic contact with more than one structure forming the so-called glomeruli.

Ogren and Hendrickson (1979) studied the structural organization of PI and PL of the macaque monkey pulvinar and described two neuronal types. The projection neurons (PN) vary in cell body (15–40 μm) and dendritic tree (150–600 μm) diameters but bear the same variety of dendritic appendages, namely, spine-like, hairlike, and knot-like. The local circuit neurons (LCN) have smaller cell body diameters (10–20 μm) but can have very large dendritic field diameters (150–600 μm). They are best distinguished from PN by their elaborate dendritic appendages, which have been identified as presynaptic dendrites under electron microscopy (EM). They also described four types of synaptic terminals. RS and RL terminals both contain round synaptic vesicles and make asymmetric synaptic contacts. RL contact larger-caliber dendrites and frequently form synaptic

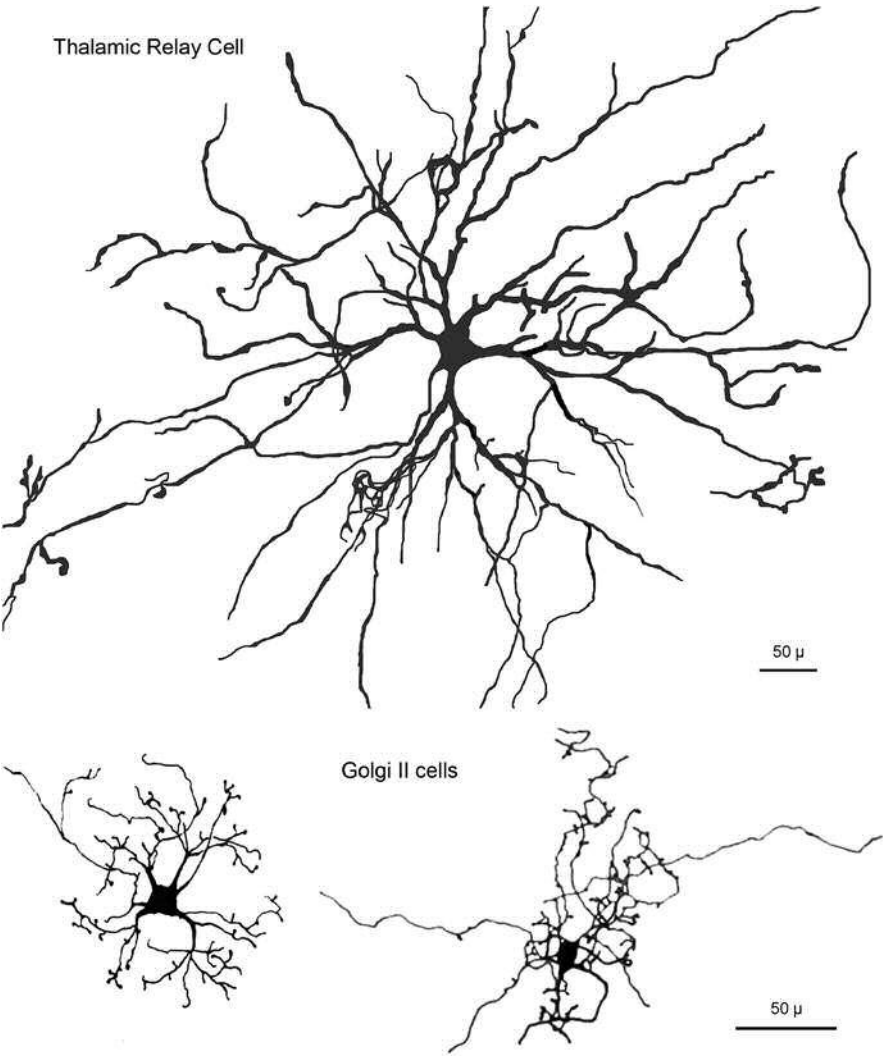

Fig. 2.2 Reconstruction of one thalamocortical relay cell (TRC) and two Golgi Type II cells from the PI (inferior pulvinar) and PL (lateral pulvinar) subdivisions of the pulvinar. The neurons were impregnated using the Golgi-Kopsch method. Top: TCR cell with the radial dendritic arbor, and some of the filiform spines that typify this neuronal type. Bottom: Drawings of two Golgi type II neurons with their more complex dendritic appendages. Scale bars = 50 µm. (Based on data from Mathers 1972)

complexes with presynaptic dendrites of LCN, while RS contact fine-caliber dendrites and only rarely take part in synaptic complexes. F terminals and P boutons both contain flat and pleomorphic vesicles and make symmetric synaptic contacts. The quantitative distribution of each type is very similar in both subdivisions, averaging 85% for RS, 5% for RL, 0.3% for F, 8% for P, and 2% unidentified.

Based on architectonic characteristics, Lin and Kaas (1979) distinguished three distinct nuclei in PI of owl monkeys that are separated from each other by encapsulating fiber zones and are distinguished by differences in the size and distribution of its neurons. The medial nucleus, IPm, is distinguished from the central, IPc, and posterior nucleus, IPp, by a denser packing of cells. Neurons in IPm are largely spindle shaped, while neurons in IPc and IPp are mainly round shaped. IPc occupies about 70% of PI, while IPm occupies about 20% of PI and extends dorsally across the brachium of the SC.

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