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# Ultrastructural study of pericytes in the rat supraoptic nucleus

MIGUEL LAFARGA* AND GABRIEL PALACIOS

*Department of Histology, Faculty of Medicine, Autonomous-University of Barcelona, Hospital de San Pablo, Barcelona*-13, *Spain*

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## INTRODUCTION

Pericytes consist of a group of cells closely associated with capillaries. These cells are located on the external side of the capillary basal membrane and are completely included within an expansion of the capillary basal membrane (Rhodin, 1962, 1968; Majno, 1965).

Ultrastructural studies of pericytes in various areas of the central nervous system have been undertaken by Maxwell & Kruger (1965), Vaughn (1965), Mori & Leblond (1969) and Dodson (1973). Some authors have considered pericytes as representing an intermediary stage in the differentiation of microglia (Mori & Leblond, 1969; Baron & Gallego, 1972). According to these authors, these cells migrate into brain tissue and acquire the functions of the microglial elements.

The reactive and phagocytic capacity of pericytes when stimulated by different nervous tissue injuries has been investigated by Maxwell & Kruger (1965), Vaughn (1965) and Cancilla, Baker, Pollock & Frommes (1972).

This present work consists of an ultrastructural study of pericytes in the supraoptic nucleus. This hypothalamic region is characterized by a dense capillary plexus.

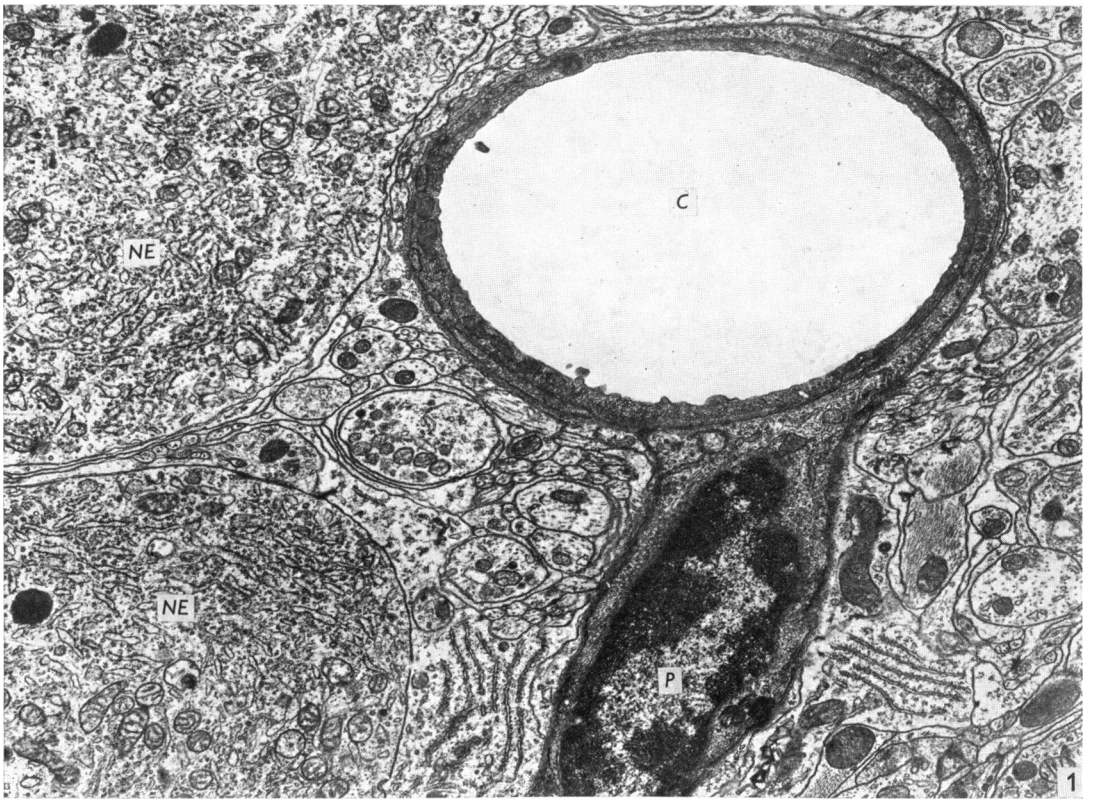
## MATERIALS AND METHODS

The ultrastructure of the capillaries of the hypothalamic supraoptic nucleus was studied in Wistar rats of both sexes. The rats were fixed by perfusion with 3 % glutaraldehyde and the hypothalamic blocks were post-fixed in 2 % osmium tetroxide. Both fixatives were maintained at pH 7·4 with 0·12 M phosphate buffer. The hypothalamic blocks were dehydrated in acetone and embedded in Durcupan (Fluka). Ultrathin sections were stained with 1 % aqueous uranyl acetate and then lead citrate, and examined in a Hitachi HU-12 electron microscope.

## RESULTS

Examination of numerous sections of capillaries in the supraoptic nucleus demonstrated that the majority of the capillaries of this region were partially or completely enveloped by pericytes and their cytoplasmic processes. The pericytes were situated on the external side of the capillary basal membrane and were completely covered by

* Present address: Department of Anatomy, Laboratory of Histology, Faculty of Medicine, University of Santander, Spain.



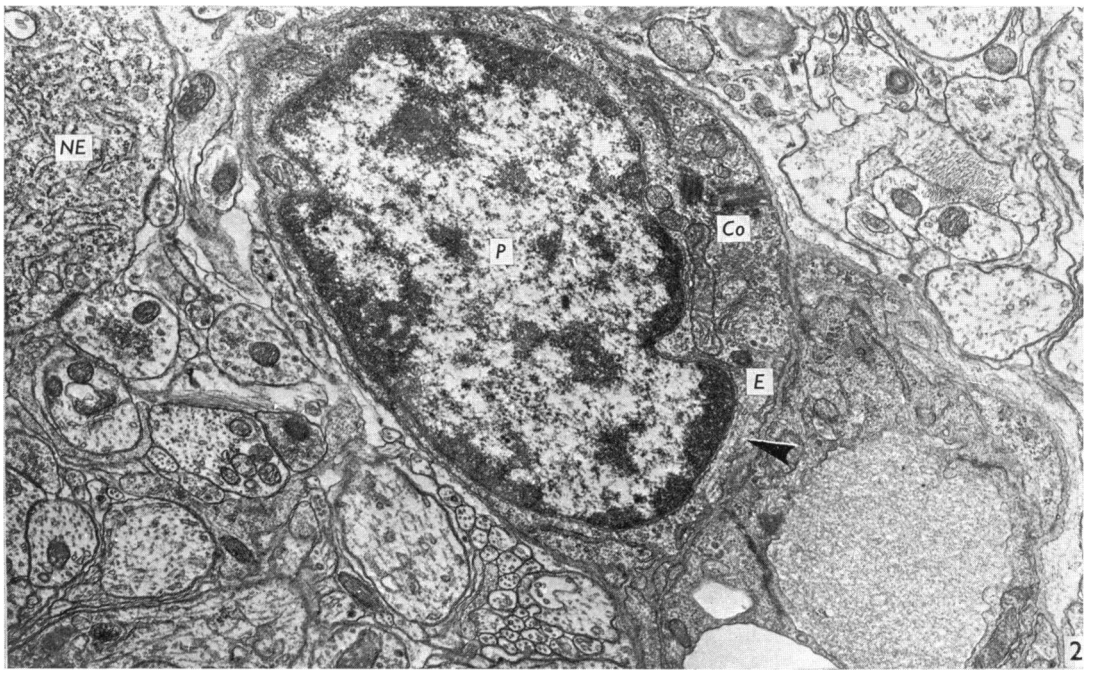




Fig. 1. Pericyte (*P*) with a thin cytoplasmic process which partially surrounds the capillary (*C*). The pericyte is enclosed within the basal membrane. The somas of two neurosecretory neurons (*NE*) can be seen. × 10500.

Fig. 2. The cytoplasm of the pericyte (*P*) shows two centrioles (*Co*) and microtubules (arrow); *E*, endothelial cell; *NE*, neurosecretory neuron. × 12000.

basal membrane surrounding the capillary endothelium (Figs. 1, 2, 3). Usually these cells presented a cellular soma which contained the nucleus and cytoplasmic processes which were quite variable in size and form. The nucleus contained aggregates of heterochromatin which were normally lined up along the nuclear envelope. The nucleoplasm was less densely granulated than in endothelial nuclei (Fig. 3).

Generally the cytoplasm presented an electron density which was inferior to that of the endothelial cell cytoplasm (Fig. 3). The quantity of cytoplasmic organoids was variable but was always superior to that of the endothelial cells. Usually the pericyte cytoplasm contained numerous free polyribosomes, isolated cisternae of granular endoplasmic reticulum containing a flocculent material, various dictyosomes of the Golgi complex, isolated microtubules, but very few mitochondria (Figs. 2, 3, 4). Pinocytotic and coated vesicles appeared irregularly dispersed in the cytoplasm (Figs. 3, 4). Occasionally a diplosome with two centrioles arranged at right angles was observed (Fig. 2).

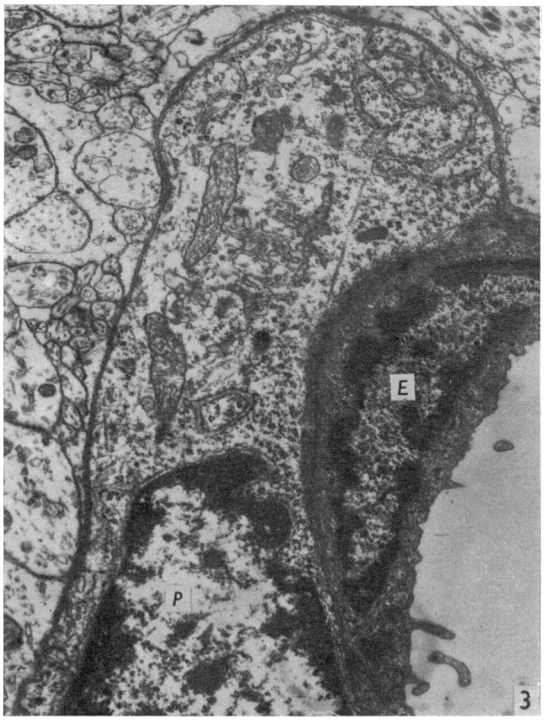
Although the majority of the pericytes presented very few lysosomes, some had a well developed lysosomal complex. These pericytes contained lysosomes with a dense, homogeneous matrix, probably primary lysosomes. They also contained large lysosomes with a polymorphic matrix which included dense granulations and clear vacuoles (probably of a lipid nature). These latter could well be secondary lysosomes (Figs. 5, 6).

The cytoplasmic processes of the pericytes surrounded the vessel wall and were enveloped by the basal membrane (Fig. 1). Some pericytes were, at the same time, partially covered by cytoplasmic processes of other pericytes (Fig. 4). Astrocytic processes were commonly observed adjacent to the external surface of pericytes, but areas of pericytes devoid of astrocytic processes were associated with other elements of the neuropil. The pericytes were not joined to each other or to the endothelial cells by junctional complexes.

## DISCUSSION

Pericytes could be easily differentiated from endothelial cells by their being totally included in a basal membrane, and by the lesser electron density of their cytoplasm. The pericytes in the supraoptic nucleus presented an ultrastructure comparable to that described by other authors for other areas of the central nervous system (Maxwell & Kruger, 1965; Vaughn, 1965; Mori & Leblond, 1969; Dodson, 1973).

The differentiation of pericytes in the rat central nervous system begins at the end of gestation and progresses in the immediate postnatal period (Donahue & Pappas, 1961; Hannah & Nathaniel, 1974). Some authors have proposed that pericytes migrate into brain tissue proper, where they are transformed into microglial cells (Mori & Leblond, 1969; Baron & Gallego, 1972). This is in agreement with the point of view of Del Rio Hortega (1932) and Penfield & Cone (1950), who postulated that the microglia entered the brain from connective tissue or blood, especially in inflammatory processes. In these present observations on normal rats the pericytes were always located in the capillary wall and no evidence was found which would suggest the migration of these cells into brain tissue. The studies of Cancilla *et al.* (1972) on the reaction of pericytes of the central nervous system to exogenous protein demonstrated that, even under conditions of brain injury, the pericytes remained fixed within the blood capillary wall.

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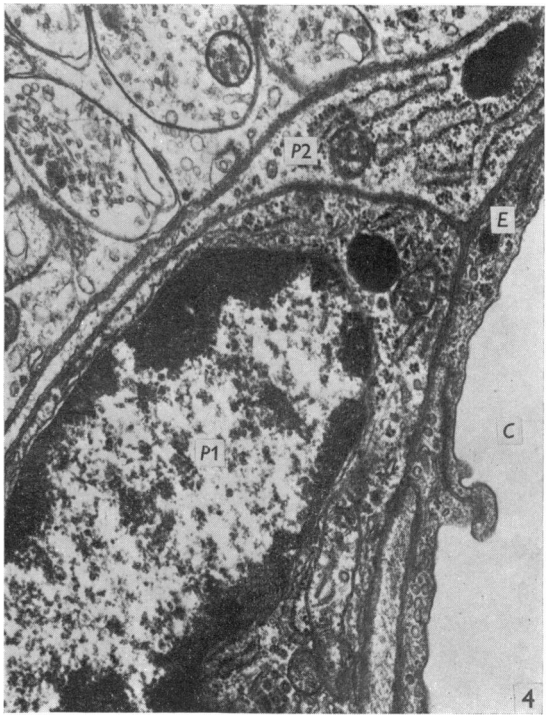


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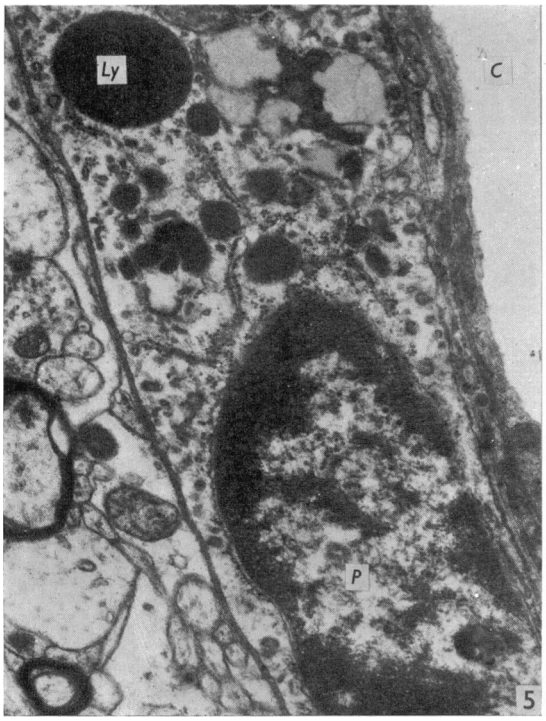


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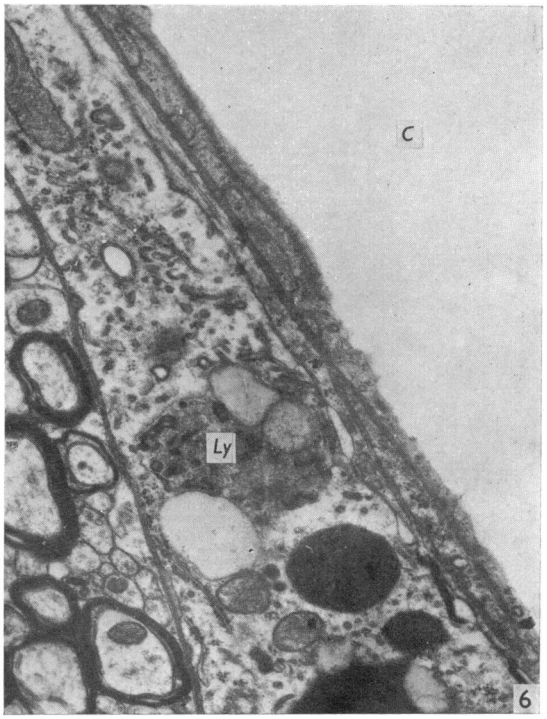


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Considering possible functions of pericytes, Rhodin (1968) suggested that they might be implicated in basal membrane synthesis. Phagocytosis in response to diverse neuropathologic processes was postulated by various authors (Torack, 1961; Maxwell & Kruger, 1965; Vaughn, 1965). Cancilla *et al.* (1972), utilizing horseradish peroxidase, demonstrated intense activity in pericytes, suggesting great phagocytic capacity. Although the majority of the pericytes studied in the present material contained few lysosomes, the finding of some pericytes containing numerous dense bodies with a structure similar to primary and secondary lysosomes suggests that phagocytosis goes on even under normal conditions. On the other hand, the variations encountered in the quantity of cytoplasmic organoids could be interpreted as variations in the metabolic activity of these cells. The presence of pinocytotic vesicles in the pericytic membrane may well indicate normal incorporation of various substances into the cell. Whether or not pericytes play some role in the blood–brain barrier remains an unresolved problem.

SUMMARY

Pericytes of the supraoptic nucleus of normal rats have been studied with the electron microscope. These cells are morphologically similar to those of pericytes in other parts of the nervous system. The pericytes and their cytoplasmic processes were surrounded by basal membrane. The nucleus contained large masses of heterochromatin. The cytoplasm, less dense than that of the endothelial cells, contained numerous free ribosomes, cisternae of granular endoplasmic reticulum, various dictyosomes of the Golgi complex, isolated microtubules, a few mitochondria, and, occasionally, a diplosome. The presence of numerous lysosomes in some pericytes suggested that the cells are phagocytic even in normal circumstances.

Fig. 3. In this section the differences between the cytoplasmic and nucleoplasmic components of a pericyte (*P*) and an endothelial cell (*E*) are shown. Numerous free ribosomes, granular endoplasmic reticulum cisternae and microvesicles are seen in the cytoplasm of the pericyte. × 12000.

Fig. 4. The pericyte (*P*1) is enveloped by a thin cytoplasmic process of an other pericyte (*P*2). The cytoplasm of the pericytes shows granular endoplasmic reticulum cisternae, pinocytotic vesicles, and lysosomes. *E*, endothelial cell; *C*, capillary channel. × 18000.

Figs. 5 and 6. Various types of lysosome (*Ly*) can be seen in the cytoplasm of pericytes (*P*). Electron-dense lysosomes with a homogeneous structure, and polymorphic lysosomes with light inclusions of a probable lipid nature, are shown. *C*, capillary channel. × 17000.

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