Electron Microscopy of Neuroglial Fibrils of the Cerebral Cortex. By E. G. Gray. (*From the Department of Anatomy, University College London, England.*)*

The nature of neuroglial fibres, observed by light microscopy in silver and other preparations of the cerebral cortex, has for long been controversial. So has the question of whether these fibres are extracellular, intracellular, or the actual cytoplasmic processes of glia (2, 11). In this report the absence of extracellular fibres is confirmed by electron microscopy and fibrils that are embedded in the cytoplasm of neuroglial processes are described.

Method

The visual area of the occipital cortex of adult rats was fixed in 1 per cent osmium tetroxide buffed at pH 7.4, "stained" with 1 per cent phosphotungstic acid in absolute alcohol, and embedded in araldite for sectioning (see reference 5 for further details).

OBSERVATIONS

The surface membranes between the cell processes of the cerebral cortex lie about 200 A apart, although where three processes meet the distance may exceed 400 A. Fibrils cannot be observed in these extracellular regions. Collagen fibrils are only present in the walls of the larger blood vessels entering the cortex (8, 10) (Fig. 3).

Certain neuroglial processes usually appear clear or pale (8, 10), because they are of low electron density and do not contain synaptic vesicles, or tubules of the endoplasmic reticulum seen frequently in dendrites and occasionally in axons (3–5, 9). Two such processes are shown in Figs. 1 and 2. Arrows indicate their surface membranes. Often similar processes form end-feet on blood vessels (Fig. 3). The wall of a small arteriole is shown with endothelium and two smooth muscle cells. Basement membranes run between these structures (8). A glial end-foot (*g.e.*) is apposed to an outer basement membrane.

Frequently, but not always, intracellular bundles of fibrils (Fig. 2, *a*) are seen running in these processes. Each fibril is about 100 A or less in diameter, and the bundle shown here is 0.25 μ in diameter. The thickest bundle so far observed had a diameter of 0.5 μ. More frequently the bundles are much narrower and consist of only a few fibrils (*a*, Figs. 1 and 3). A bundle is seen in cross-section at *d* (Fig. 3). Elongated mitochondria (Fig. 2, *m*) also occur in these clear glial processes.

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Occasionally another type of elongated structure is observed in glial processes, appearing as rods of dense fibrous material. Longitudinal sections are shown in Fig. 1, *b* and Fig. 3, *e*, and transverse sections in figure 3, *f* and Fig. 4. In some places (Fig. 1) a thin cortical region can be seen with material orientated differently from the medulla. Membranes, consisting of two dense lines with a clear zone between, can be observed at the outer surfaces (*e.g.* Fig. 1 and Fig. 4, *a*), and the inner of the two membranes invaginates in places as do the cristae of mitochondria. The fibrous material sometimes appears as closely packed tubules, 150 to 200 A in diameter. Dense bodies with pale centres are sometimes contained in the rods (Fig. 1, *c*; Fig. 3, *h*). Hartmann (6) mentioned the occurrence of elongated dense structures in neuroglia, which he thought might be unusual forms of mitochondria, and are perhaps indentical with the fibrous rods described here.

DISCUSSION

At present it is not possible to decide whether these fibrils correspond to those seen with the light microscope. The diameters of the individual fibrils are, of course, well beyond the limits of optical resolution, but some of the larger bundles are not. Such aggregations have been traced for only a few microns so far.

These fibrils appear to resemble those described in processes of normal and pathological glia of the cerebral cortex and spinal cord by Luse (7). Fleischhauer (1) has described similar fibrils in reptilian glia. Schultz, Maynard, and Pease (8, 10), however, were unable to find in the cerebral cortex the type of fibrils described by Luse and described here. Elongated mitochondria in glia have been described previously (6, 10).

At present, no rigid criteria exist for the identification of the various types of neuroglia with the electron micrograph. This is not surprising since light microscope descriptions of these cells are many and varied (see reference 2). Microglia can usually be identified (7, 10), but there is disagreement about astrocytes and oligodendroglia.

The fibres seen by light microscopy are, of course, associated with the so called fibrous astrocytes. Since the clear processes described here often form end-feet on blood vessels, it seems

likely that the fibrils are astrocytic. Schultz, Maynard, and Pease (8, 10), on the one hand, describe astrocytes as having clear processes and describe their end-feet on blood vessels. However, oligodendroglia are also known to form end-feet on blood vessels, but less frequently (2). End-feet other than of the clear type have not yet been described by electron microscopy; so the situation is not fully understood at present.

Luse (7), on the other hand, considers the clear processes to be oligodendroglial and considers astrocyte end-feet to consist of a series of folded processes applied to the blood vessel wall. The author has not observed such processes. Schultz, Maynard, and Pease (10) identify oligodendroglia as having moderately dense cytoplasm forming a narrow rim round the nucleus, while astrocytes have more abundant clear (watery) cytoplasm. Luse (7) takes the opposite view. The author agrees that often these two distinct types can be observed, but since neuroglial cells can be observed with the electron microscope that fit into neither of the categories given by these authors, it seems premature to be dogmatic about the classification of neuroglia.

SUMMARY

Fibrils, which occur in bundles, are described in neuroglial processes of the cerebral cortex. These processes appear "clear" and often form end-feet on blood vessels.

This feature adds a further clue to the identification of the cell processes seen in thin sections of the cortex, the criteria for which are at present gradually emerging (3–10).

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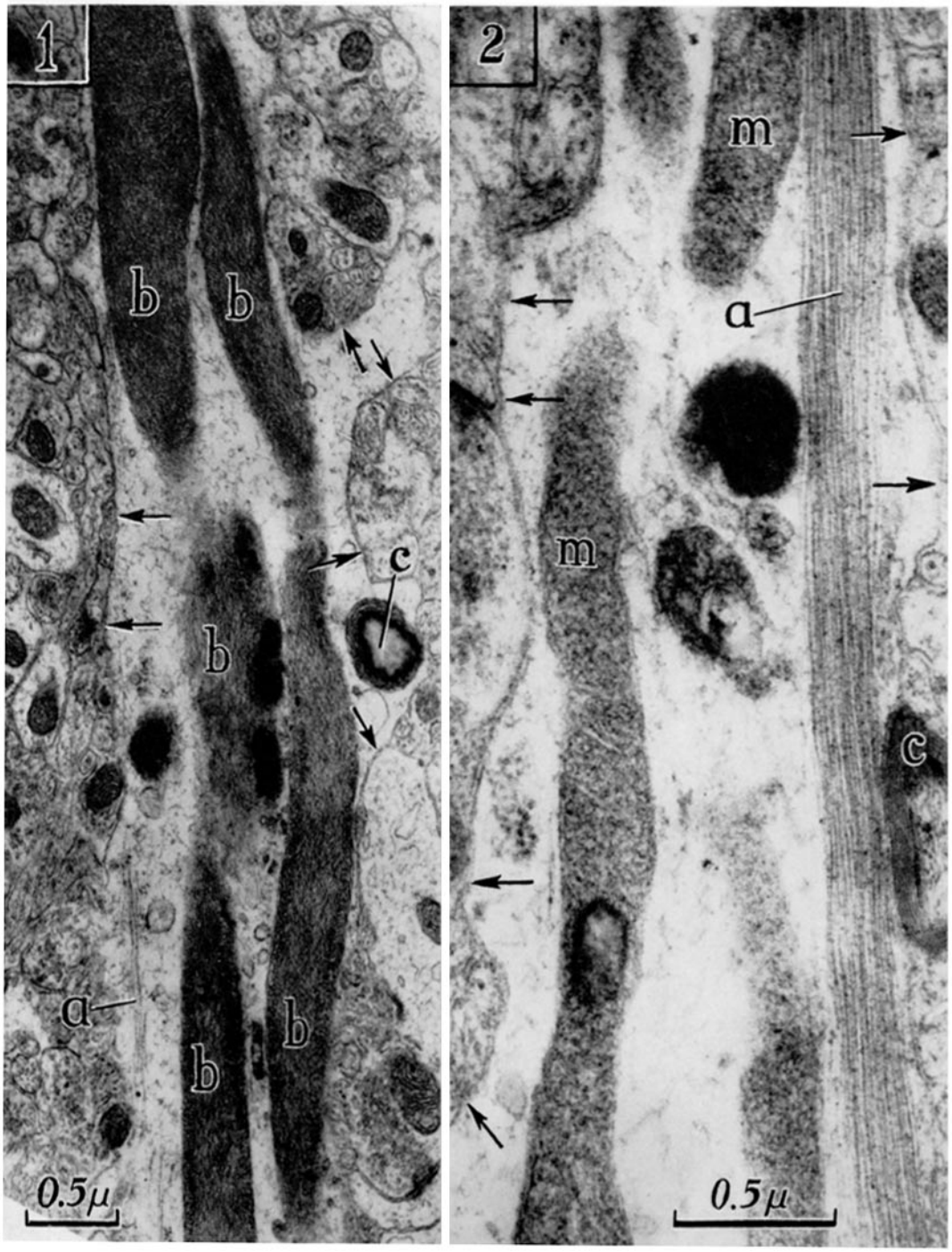
EXPLANATION OF PLATES

PLATE 77

FIG. 1. Electron micrograph of a neuroglial process of the rat visual cortex. Its surface membrane is indicated by arrows. A small bundle of glial fibrils occurs at *a*. Long rods (*b*) and (*c*) of fibrous material lie in the cytoplasm. × 27,000.

FIG. 2. Electron micrograph of a neuroglial process of the rat visual cortex. Its surface membrane is indicated by arrows. *a* is a bundle of glial fibrils. *m*, elongated mitochondria. *c* is a neighbouring myelinated axon. × 48,000.

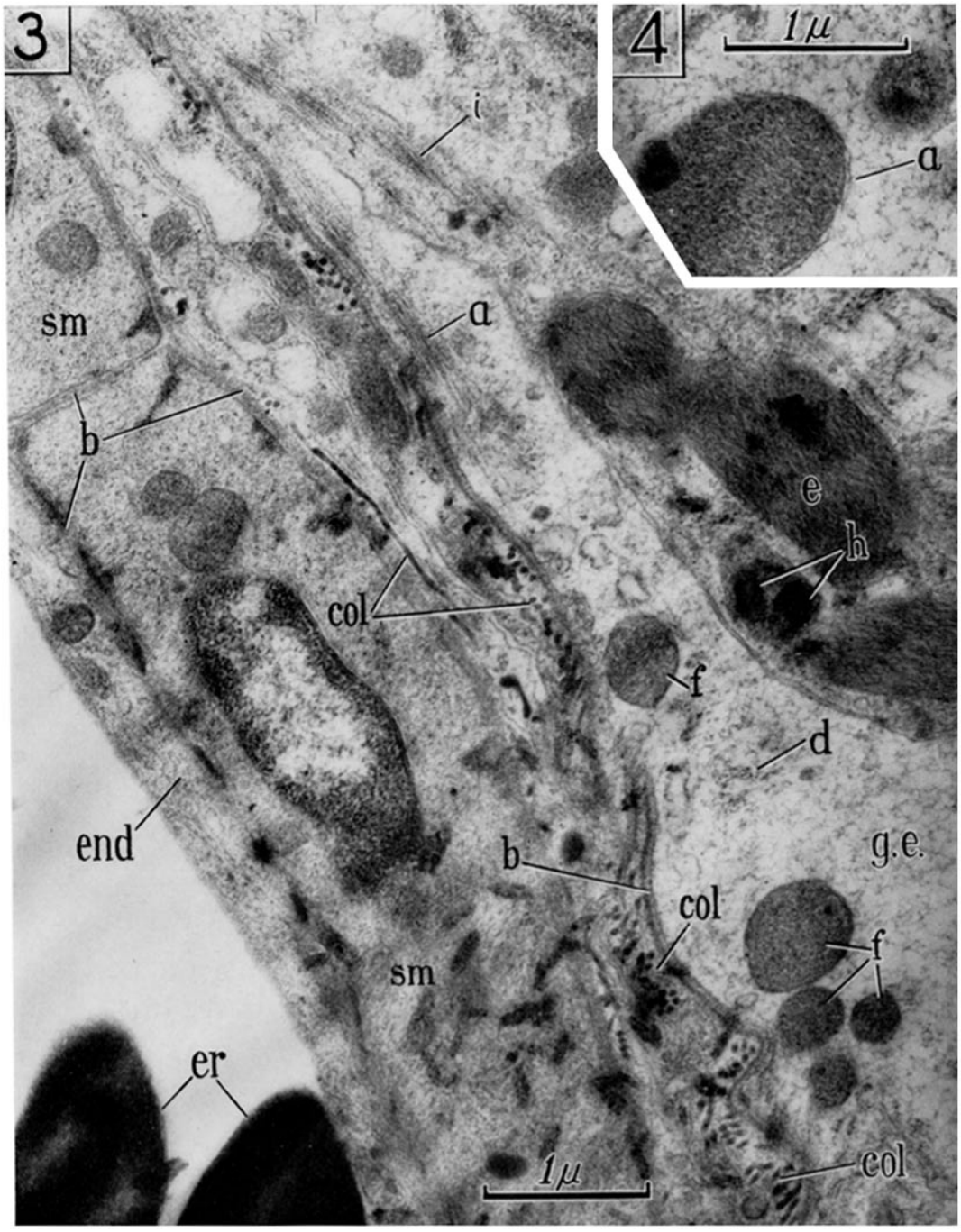


(Gray: Neuroglial fibrils of cerebral cortex)

PLATE 78

FIG. 3. A glial end-foot (*g.e.*) is seen apposed to the wall of a small arteriole. The end-foot contains glial fibrils (*a*) seen in longitudinal section and (*d*) in transverse section. A second adjacent end-foot contains glial fibrils (*i*). *b*, basement membrane; *col.*, collagen; *end*, endothelium; *er*, erythrocytes; *sm*, smooth muscle cells. × 24,000.

FIG. 4. Transverse section of fibrous rod, showing limiting membranes (*a*). × 27,000.



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