ELECTRON MICROSCOPY OF MITOCHONDRIA IN THE CENTRAL NERVOUS SYSTEM

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Mitochondria have been studied in thin sections of normal cerebral cortex from rat and man. As previously noted (1), there is little or no ultrastructural difference between the two species. The human material was obtained as surgical specimens which were fixed immediately. The surgical cases were mostly hypophysectomies, with nothing in the patients' histories to suggest abnormality of the nervous system. All material was fixed with the buffered osmium technique of Palade (2) as detailed by Farquhar (3).

In addition, the cerebral cortex from rats receiving cortisone has been studied in the electron microscope. The dosages were either 5 or 10 mg. of cortisone acetate daily for 10 or 20 days. Only one-half of the animals receiving the larger dosage survived for 20 days. Sections were cut with the Porter-Blum microtome (4) and examined in an RCA model EMU-2 microscope with a compensated objective.

As would be expected from the literature of light microscopy, as well as from the electron optical studies of a number of investigators, mitochondria are present in the perikaryon area of nerve cells as well as in the processes. In the perikaryon area, aside from being somewhat smaller than mitochondria of other cell types, they are quite typical in appearance with the mitochondrial crests transversely oriented. In axons and dendrites, however, the orientation of the crests may be transverse, longitudinal, or oblique. In all parts of the neuron, the crests are in general closely packed, particularly in synaptic areas. In the latter case, whenever the plane of section corresponds closely with the major diameter of a mitochondrion, it can be seen that the crests are longitudinally oriented.

It has been previously shown (5, 6) that mitochondria in motor nerve cells increase in number following section of their axons. Following administration of cortisone, increased numbers of mitochondria are not seen, but a vesicular transformation is observed. After small doses of cortisone (Fig. 1), there is a central vacuolation of the mitochondria in the perikaryon area with a concomitant diminution in the number of crests. Following the largest dosage, the mitochondria are swollen and nearly empty, with only a few short crests to distinguish them from simple cytoplasmic vacuoles (Fig. 2). Under the condi-

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tions of the experiment, the change in axonal and dendritic mitochondria does not proceed beyond the stage of central vacuolation.

Although the presence of centrally situated vacuoles in mitochondria can be observed as an artifact following prolonged fixation with osmium tetroxide, the tissues studied in the present work were judged not to have been overfixed because of the presence of structurally normal mitochondria in the adjacent neuroglial elements. It is not known at present whether the mitochondrial changes observed are due to the action of cortisone *per se* or are a reflection of general debilitation in animals receiving large or prolonged doses of the drug. However, the fact that neuroglial mitochondria retained a normal appearance in this experiment suggests at least that nerve cells may be more sensitive to cortisone (or to debilitating agents) than are the glial elements. Experiments designed to provide information on this question are in progress.

With respect to mitochondria in neuroglia, it is of interest to note that they are present in all glial elements of the cerebral cortex. The positive identification of mitochondria permitted by the electron microscope does not support the recurring statement in the light microscope literature that these organelles are absent from microglial cells (7, 8). Mitochondria are very numerous in protoplasmic astrocytes, and appear in a high proportion of the processes of such cells in a given field. An interesting structural feature of marginal glial cells is the presence in their processes of elongated, electron-dense bodies, approximately one-half micron in width. These are of indeterminate length (up to 3 micra in a given section) and show a longitudinal layering of regular spacing (approximately 100 A). It seems likely that these structures may represent unusual forms of mitochondria.

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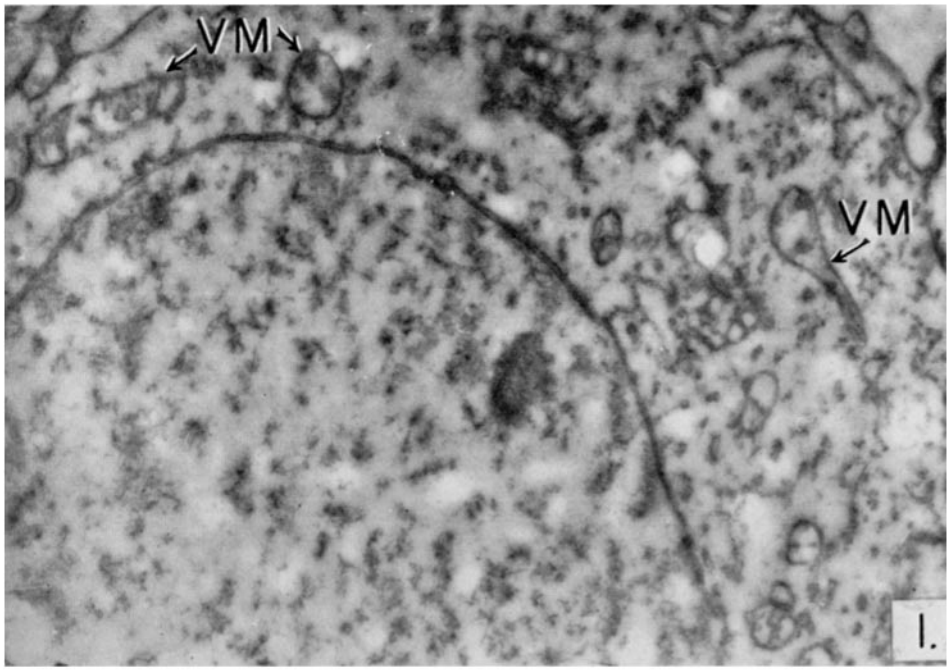
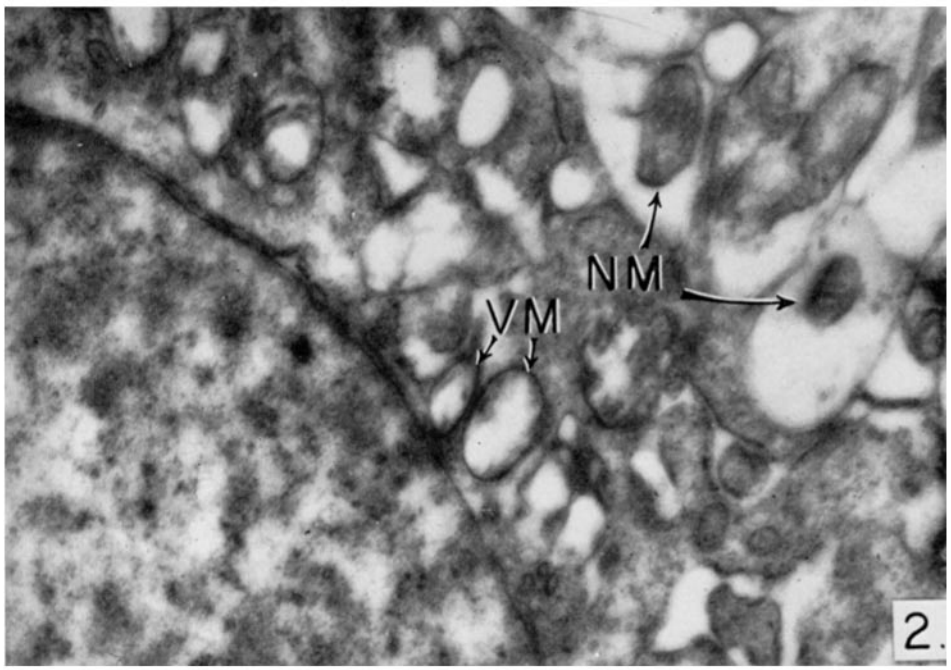
PLATE

EXPLANATION OF PLATE 128

FIG. 1. Part of a nerve cell from the cerebral cortex of a rat that had been given 5 mg. cortisone daily for 10 days. Vacuolated mitochondria (*VM*) can be seen. × 22,600.

FIG. 2. Part of a nerve cell and adjacent glial processes from the cerebral cortex of a rat following administration of 10 mg. cortisone for 20 days. The extremely vacuolated mitochondria (*VM*) in the nerve cell constrast with the normal appearing mitochondria (*NM*) in the glial processes. × 31,800.





(Hartmann: Mitochondria in central nervous system)