REGULAR ORGANISATION OF MATERIAL IN CERTAIN MITOCHONDRIA OF NEUROGLIA OF LIZARD BRAIN

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During an investigation of the brains of cold- and warm-adapted lizards (*Lacerta viridis*) (1–3), bodies with a highly regular internal structure, presumably mitochondria, were found in the neuroglial cells of cold-adapted animals. These cells occur in a region referred to by Boycott, Gray, and Guillery (3) as the cochlear grey.

METHOD

The cochlear grey and surrounding tissue were removed and fixed for 3 hours at pH 7.4 in 1 per cent osmium tetroxide dissolved in mammalian Ringer. The temperature was maintained at about 4°C. After dehydration the tissue was stained for 3 hours in a solution of 1 per cent phosphotungstic acid in absolute ethanol and embedded in araldite for sectioning (see reference 5 for full details).

Received for publication, April 11, 1960.

OBSERVATIONS AND DISCUSSION

In the cochlear grey, neuroglia (astrocytes?) occur with irregularly shaped nuclei (Fig. 5) and

EXPLANATION OF FIGURES

a, type *a* mitochondria
c, type *c* mitochondria
cr, the intracristal extension of the outer mitochondrial compartment
cr_1, intracristal zone
g.f., neuroglial fibrils
ma, mitochondrial matrix
my, myelin sheath
nuc, nucleus

FIGURE 1

Type *a* and type *c* mitochondria in a glial process sandwiched between the myelin sheaths of two adjacent axons. × 120,000.

FIGURE 2

Type *c* mitochondrion (longitudinal section). × 36,000.

FIGURE 3

Type *a* mitochondrion in a neuronal process. × 67,000.

FIGURE 4

Type *a* mitochondrion showing the intracristal extension of the clear outer compartment. × 55,000.

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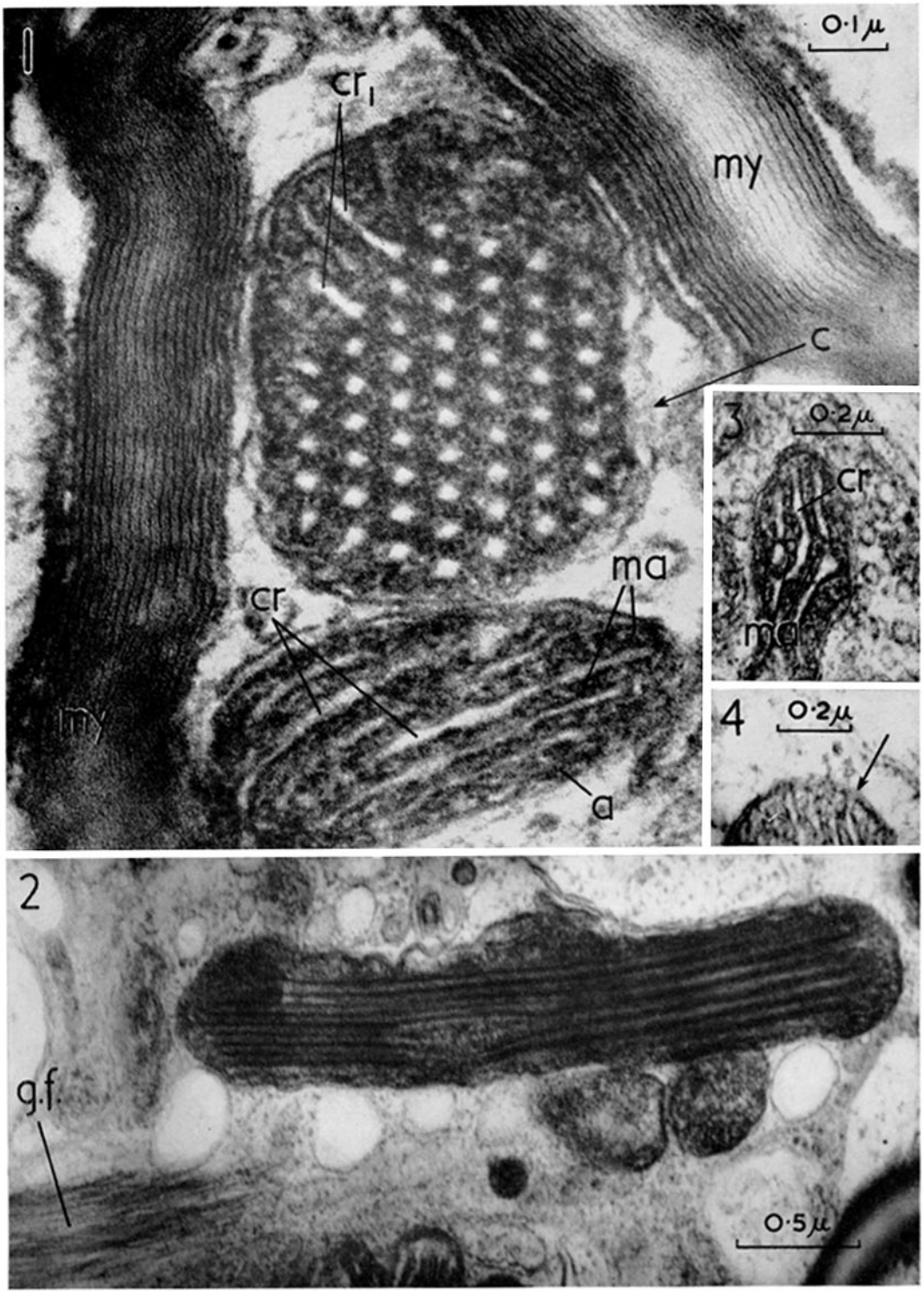

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granular cytoplasm. Their processes form numerous folds that make sheaths round dendrites and axon terminals. This relationship will be described in detail elsewhere. These glial processes, and the cell cytoplasm from which they originate, contain bundles of glial fibrils (Figs. 2, 5, and 6, *g.f.*) and mitochondria that fall into three categories.

(*a*) The majority of mitochondria have a dense granular or vesicular matrix (Figs. 1 and 3, *ma*), while the content of the outer chamber including its intracristal part (*cr*) appears pale (Fig. 4, arrow). Palade (7) has previously described a pale content in the outer chamber and dense material in the inner chamber and Watson (8) has shown that this material can be rendered denser by staining.

(*b*) Less frequently mitochondria are observed with fewer cristae and the contents of their inner and outer chambers appear equally pale and in both cases non-granular. Types *a* and *b* can both be observed in the same section, and they occur in neuronal as well as glial processes. Type *b* has not been figured here, since it fits the description given by many workers on various tissues.

(*c*) Mitochondria of the third type are restricted to neuroglial cells and their processes. They usually appear much larger than normal and contain material that is partly or wholly organised into a surprisingly regular structure. In sections (*e.g.* Figs. 1 and 2 and 5 to 9 the observed pattern consists of dense material surrounding clear zones that have a regular hexagonal spacing of 500 to 600 A from centre to centre. These clear zones are interpreted as being continuous with the outer compartment, for in Figs. 1 and 9 the intracristal zones (cr_1) can be followed inwards to connect with the clear zones on the edge of the pattern. From these and the longitudinal sections (Figs. 2 and 5) it seems that the intracristal extensions of the outer compartment develop into equidistant and parallel channels orientated longitudinally in the mitochondrion. The dense matrix forms a regular packing, situated around and between the channels. In this state no distinct cristal membrane can be seen separating a space from the matrix.

The matrix itself is extremely dense and seems to be organised into vesicular or granular particles. They are about 100 A in diameter and are tightly packed together. A suggestive but less clear particulate appearance in the dense matrix of type *a* mitochondria was noted above.

Napolitano and Fawcett (6) and Yamada (9) have reported crystalline structures within mitochondria, but it is not known whether they are related to the structures described here.

In the glial cells of both lizards (cochlear grey) and rats (cerebral cortex) (4) there seems to exist the dual system of large atypical mitochondria and bundles of glial fibrils. At present, however, there is no evidence to suggest a relationship between the two.

The author is indebted to Professor J. Z. Young, F.R.S., and Dr. J. D. Robertson for advice and to Mrs. R. Wheeler, Mrs. R. Tilly, and Mr. A. Aldrich for technical assistance.

REFERENCES

1. Boycott, B. B., and Guillery, R. W., Environmental temperature and the reptilian nervous system, *Nature*, 1959, **183**, 62.
2. Boycott, B. B., Gray, E. G., and Guillery, R. W., A theory to account for the absence of boutons in silver preparations of the cerebral cortex, based on a study of axon terminals by light and electron microscopy, *J. Physiol.*, 1960, **152**, 3–5 p.
3. Boycott, B. B., Gray, E. G., and Guillery, R. W., Synaptic structure and its alterations with environmental temperature; a light and electron microscope study of the central nervous system of lizards, *Proc. Roy. Soc.*, in press.
4. Gray, E. G., Electron microscopy of neuroglial fibrils of the cerebral cortex, *J. Biophysic. and Biochem. Cytol.*, 1959, **6**, 121.
5. Gray, E. G., Axo-somatic and axo-dendritic synapses of the cerebral cortex, *J. Anat.*, 1959, **93**, 420.
6. Napolitano, L., and Fawcett, D., The fine structure of brown adipose tissue in the newborn mouse and rat, *J. Biophysic. and Biochem. Cytol.*, 1958, **4**, 685.
7. Palade, G. E., An electron microscope study of the mitochondrial structure, *J. Histochem. and Cytochem.*, 1953, **1**, 188.
8. Watson, M. L., Staining of tissue sections for electron microscopy with heavy metals, *J. Biophysic. and Biochem. Cytol.*, 1958, **4**, 475.
9. Yamada, A., A crystalline body found in the inner segment of the frog's eye, *J. Biophysic. and Biochem. Cytol.*, 1959, **6**, 517.

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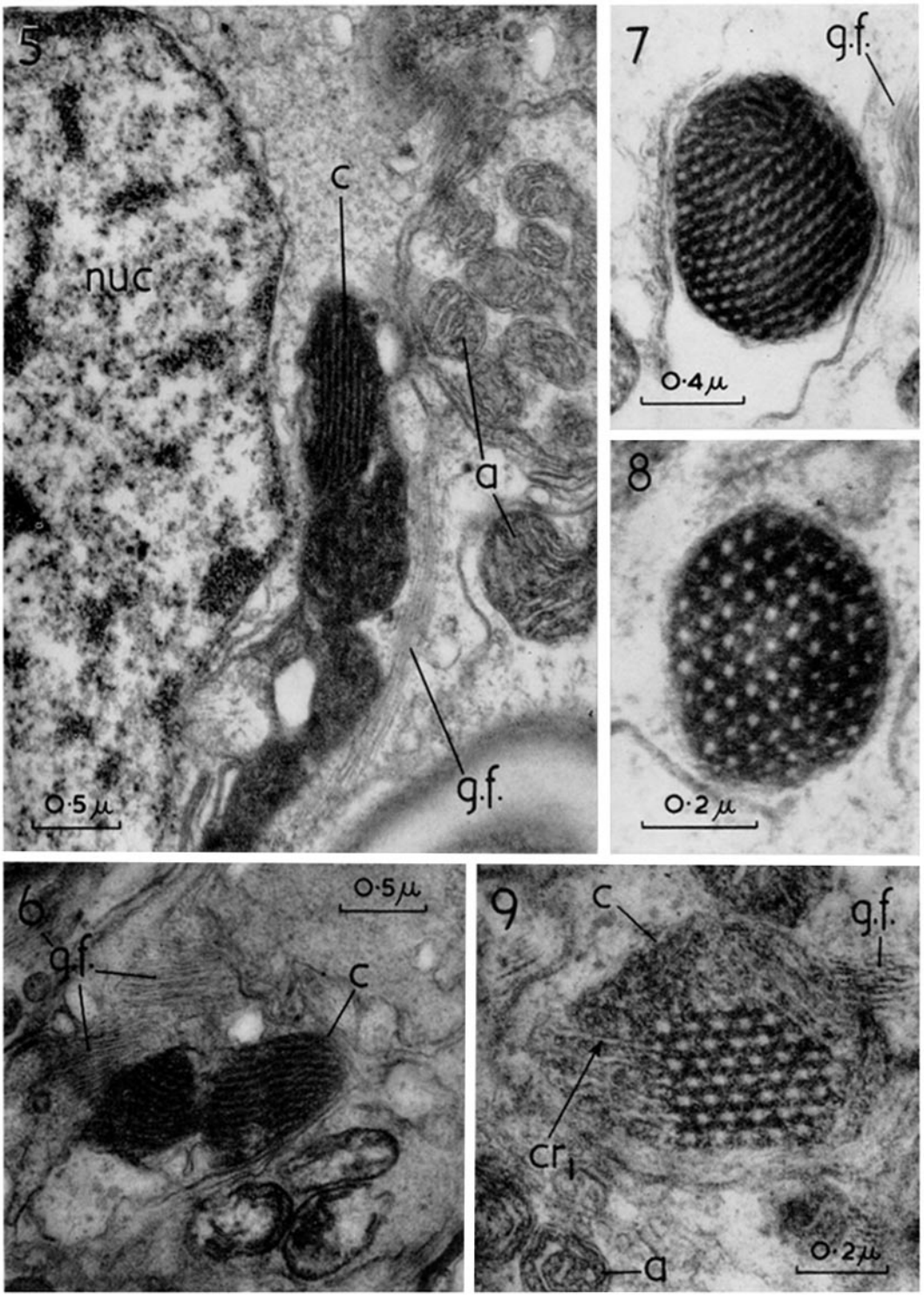

FIGURE 5 Glial cell containing type *c* mitochondrion and glial fibrils. × 26,000.

FIGURES 6 to 9 Sections of type *c* mitochondria. × 26,000, 38,000, 85,000, and 70,000.

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