

THE ULTRASTRUCTURE OF MOUSE LUNG

A NOTE ON THE FINE STRUCTURE OF MITOCHONDRIA AND ENDOPLASMIC RETICULUM OF THE BRONCHIOLAR EPITHELIUM*

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PLATE 42

A few aspects of the fine structure of bronchiolar epithelium have already been presented (4). The two types of cells, ciliated and non-ciliated, differed in their cytoplasmic structure. The ciliated cells contained only a few mitochondria, and a few vesicles of the endoplasmic reticulum, whereas non-ciliated cells showed numerous large mitochondria and a very well developed endoplasmic reticulum. It was also shown (4) that the mitochondria of non-ciliated bronchiolar cells appeared either as long and filamentous or as spherical, even within one and the same cell, and that the endoplasmic reticulum could assume the form of paired double membranes as well as of vesicles or tubules. The difference in appearance of the endoplasmic reticulum in ciliated as compared with non-ciliated cells and the varying forms of the reticulum in the non-ciliated cells had been recognized earlier by other authors (1).

The present brief report further illustrates the spherical mitochondria and the endoplasmic reticulum of non-ciliated bronchiolar epithelial cells. The methods of tissue processing and the technique used to select a small bronchiole for sectioning are the same as in earlier reports (2, 3, 4).

OBSERVATIONS

The *mitochondria* appear as large (up to 1μ diameter) dense bodies (*M*, Fig. 1) limited by a double membrane. In sections they all are approximately round or slightly elongated. For this reason as well as because of the rather frequent occurrence of tangentially sectioned mitochondrial profiles (*Mt*, Fig. 1) it is concluded that three-dimensionally these mitochondria are of approximately spherical shape. The mitochondrial matrix (5, 6) or ground substance (9, 10) appears uniformly dense and structureless. The slight graininess of this substance (Fig. 1) is considered as an artefact. Within the matrix are seen the very dense, small (about $40\text{ m}\mu$) mitochondrial granules (5, 6) (*Mg*, Fig. 1). The

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mitochondrial lamellae or cristae (5, 6) are scantily developed, and are arranged at the periphery of the mitochondria (*Ml*, Fig. 1). Because of this arrangement none are seen in the central portions of radially sectioned mitochondria, but they are readily visualized in tangentially sectioned mitochondrial profiles (*Mt*, Fig. 1). The lamellae appear in the section as two parallel dense membranes which are separated by a less dense layer of the width of about 10 μ . The membranes of the lamellae usually do not appear as dense as the outer mitochondrial double membrane or the membranes of the endoplasmic reticulum.

The *endoplasmic reticulum* shown in Fig. 1 appears predominantly in the form of dense paired membranes (*Erm*), but a few ring-shaped profiles (*Ert*) suggest the presence of tubular components as well. It has been established in the course of as yet unpublished studies that the endoplasmic reticulum of non-ciliated cells regularly occurs in both of these morphological forms, which is in agreement with findings presented by other authors (1), and that either the double membranes or the tubular forms may predominate in different bronchiolar cells, or in different regions of one and the same cell. The paired membranes appear very dense, and are separated by a less dense layer of an average width of about 10 μ . Different membrane pairs are seen to be arranged roughly parallel (Fig. 1) with a considerably varying spacing (in Fig. 1 about 55 to 110 μ between the pairs). Although at first glance the membranes seem to be continuous over rather long stretches, on closer inspection they are seen to blur out at frequent intervals (arrow, Fig. 1), or to end at well circumscribed points at which the two units of a membrane pair fuse (double arrow, Fig. 1). The blurred portions of the membranes are considered to be a product of oblique sectioning, whereas the closed ends of membrane pairs are taken as an indication that the membrane pairs are in reality the walls of flattened sacs (11) or cisternae (8) of the endoplasmic reticulum. Since only very few of the numerous small (10 to 15 μ) dense particulates (7) that are scattered throughout the cytoplasm (*P*, Fig. 1) are seen attached to the outside of the paired membranes, the endoplasmic reticulum of bronchiolar epithelium may be called agranular (8).

REFERENCES

1. Harford, C. G., Hamlin, A., and Parker, E., *J. Exp. Med.*, 1955, **101**, 577.
2. Karrer, H. E., *Bull. Johns Hopkins Hosp.*, 1956, **98**, 65.
3. Karrer, H. E., *J. Biophysic. and Biochem. Cytol.*, 1956, **2**, 241.
4. Karrer, H. E., *Exp. Cell Research*, 1956, **10**, 237.
5. Palade, G. E., *Anat. Rec.*, 1952, **114**, 427.
6. Palade, G. E., *J. Histochem. and Cytochem.*, 1953, **1**, 188.
7. Palade, G. E., *J. Biophysic. and Biochem. Cytol.*, 1955, **1**, 59.
8. Palay, S. L., and Palade, G. E., *J. Biophysic. and Biochem. Cytol.*, 1955, **1**, 69.

9. Rhodin, J., Correlation of Ultrastructural Organization and Function in Normal and Experimentally Changed Proximal Convoluted Tubule Cells of the Mouse Kidney, Karolinska Institutet, Stockholm, Aktiebolaget Godvil, 1954, 1.
10. Sjöstrand, F. S., and Rhodin, J., *Exp. Cell Research*, 1953, **4**, 426.
11. Weiss, J. M., *J. Exp. Med.*, 1953, **98**, 607.

EXPLANATION OF PLATE 42

Key to Abbreviations

Erm, endoplasmic reticulum appearing in the form of double membranes.

Ert, endoplasmic reticulum appearing in the form of vesicles or tubules.

M, mitochondrion.

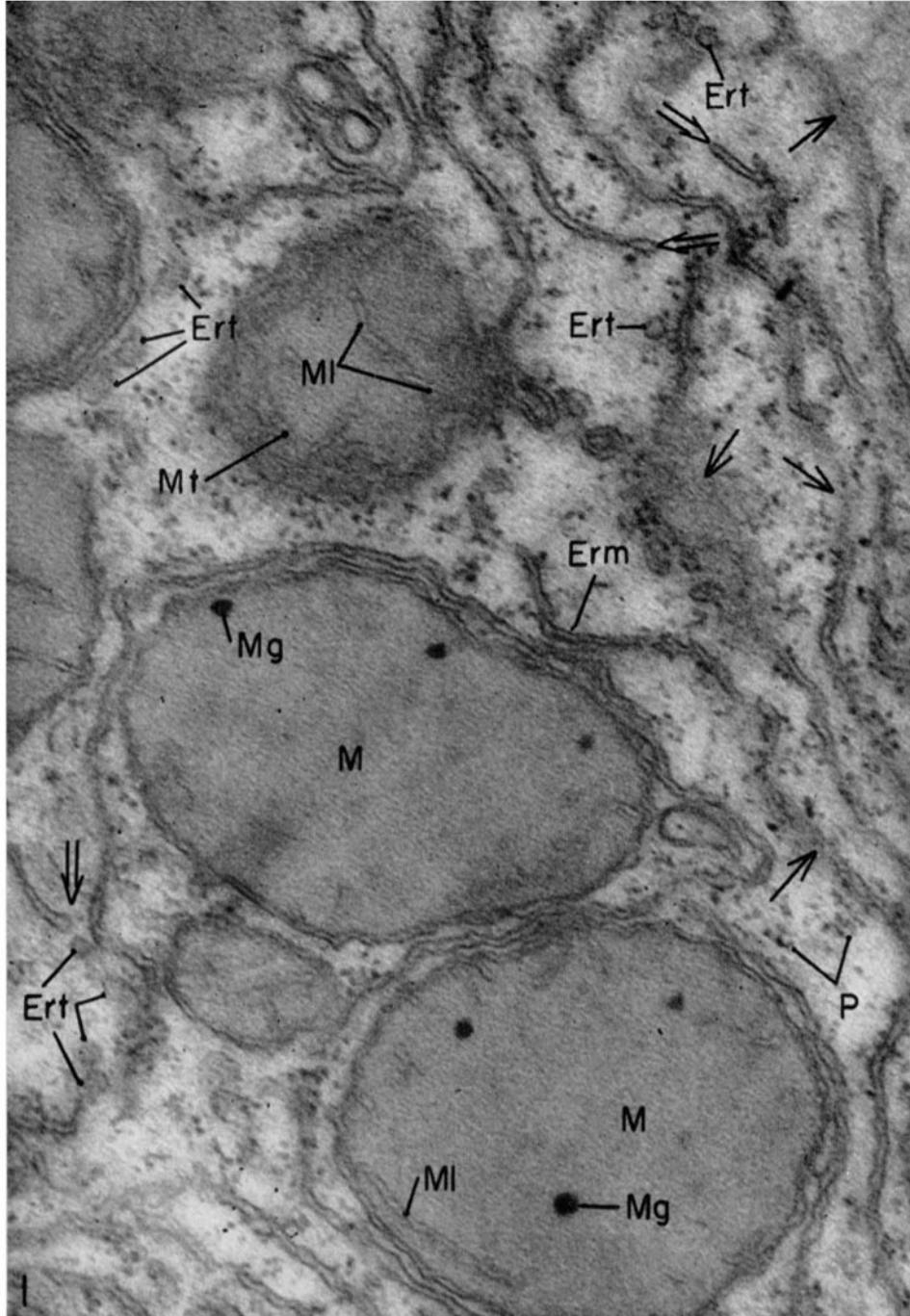
Mg, mitochondrial granule.

Ml, mitochondrial lamella.

Mt, tangentially sectioned mitochondrion.

P, particulates of cytoplasm.

FIG. 1. Electron micrograph showing the fine structure of spherical mitochondria and of endoplasmic reticulum of a bronchiolar epithelial cell. Most mitochondria appear as radially sectioned (*M*), and their outer double lining membrane is clearly recognized. In a tangential section through a mitochondrion (*Mt*) the outer membrane is indistinct, but the mitochondrial lamellae (*Ml*) show up quite well because of their peripheral arrangement inside the mitochondrion. The otherwise homogeneously dense mitochondrial matrix contains the dark mitochondrial granules (*Mg*). The endoplasmic reticulum shown by this micrograph appears mainly in the form of paired membranes (*Erm*), and only few profiles are indicative of tubular or vesicular structures (*Ert*). Rather frequently the membrane pairs appear blurred (arrows), and interconnections between the two units of a pair can be seen (double arrows). Numerous small dense particulates (*P*) are scattered throughout the cytoplasm. They tend to occur in small groups of two to four; only rarely are any particles seen adhering to the membranes of the endoplasmic reticulum. $\times 71,000$.



(Karrer: Ultrastructure of mouse lung)