SOME OBSERVATIONS ON THE FINE STRUCTURE OF CENTRIOLE IN THE MITOTIC CELL*

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In previous papers (Yamada (1), (2), (3)), the fine structure of the centriole and its associated structure in the interkinetic cell of various types (white blood cell, megakaryocyte, ovarian follicular and interstitial cell) were described. Almost simultaneously and independently, Bernhard and De Harven (4), (5) reported similar finding in other cell types. Recently, Amano et al. presented the papers about the same subject (6), (7), (8). They offered, however, the assumption that the centriole within the mitotic cell shows somewhat different finding from that of the interkinetic cell. This paper presents the evidence that the centriole found in the mitotic cell shows the same structure with that of interkinetic cell and in this connection, it confirms the reports by Porter (9) and by Bernhard et al. (4), (5).

MATERIALS AND METHODS

The specimens were prepared in the same manner described in previous papers (1), (2). The RCA-2B or JEM-4c microscope was used for observation.

OBSERVATIONS AND INTERPRETATION

Considering the thinness of the sections used, it is comprehensible that the centriole in the mitotic cell is recognized in a few occasions under the electron micrographs. Occasionally, one encounters sections of the mitotic cells which represent both centriole and chromosome. All figures in this paper represent the structures being regarded as the centriole and the chromosome. The stages of the mitosis in these cases are not always obvious.

Two (Figs. 1-7) or one (Figs. 8-10) profiles of centrioles are shown in respective picture. Each centriole represents a round or quadrangular profile and shows lighter core within the denser cortex. The dense cortex of the tube- or hollow cylinder-like

*Some of the pictures which this study based upon, were taken at the Department of Anatomy, School of Medicine, University of Washington, Seattle, and Dr. Porter's Laboratory, the Rockefeller Institute for Medical Research, New York, while the author was there as a visiting investigator from 1954 to 1956.

centriole consists of filaments (possibly 9 paired or tripled filaments running longitudinally in parallel) being embedded in the dense matrix. These findings are similar to those of centrioles found in the interkinetic cells which were reported previously and hence, it seems to be reasonable to assume that the structure of the centriole is essentially the same in both cases.

Fig. 1 represents the mitotic cell found in the mouse spleen. Portions of the chromosomes are bounded by the double membranes, probably the nuclear membrane. From a dense body (C), numerous filaments spread towards the chromosomes in spindle fashion. This part of the picture is shown in higher magnification in Fig. 2. The detail of the dense body is not clear due to the thickness of the section, but one can barely recognize two centrioles in this mass. One (C 1) is cut in longitudinal manner and the other (C 2) is shown as oblique profile. Hence, two centrioles seem to locate each other at the direction of right angle. The numerous filaments running from the centriolar mass towards the chromosomes may constitute one part of the so-called spindle apparatus, and the structure shown in this picture is similar to the spindle filaments of De Harven and Bernhard (5). These filaments seem to derive from the side wall of the centrioles and shows tubular nature of about 150 Å in diameter. Similar filaments are also recognized in other figures (Figs. 4-10). On the other hand, Porter (9), (10), demonstrated very clearly the paired tubular filaments in his pictures and he considered them as the spindle fibers. They are bigger and denser than the filaments reported here and previously by other workers. The number of the former filaments may be much smaller than the latter since many workers reported only the latter. It may mean that these two filaments are different from each other in nature and that the spindle apparatus may consists of two different components. The structure shown by arrows in Figs. 9 and 10 is somewhat similar to those described by Porter. The nature of the spindle apparatus and the exact relation between the centriole and these filamentous structure remain for further investigations.

Fig. 3 represents a mitotic cell found near the tracheal cartilage of the mouse embryo. A centriole (C 1) shows, a profile of the longitudinal section. The other (C2) is barely visible close to the former. The consecutive section (insert) shows the fact that the latter centriole (C 2) being locate almost at right angle to the former (C 1). Similar arrangement of two centrioles (diplosome) is also observable in Figs. 4-7. This kind of arrangement is also encountered frequently in the interkinetic cells. The significance and nature of such a arrangement of centrioles are not known yet.

SUMMARY

The centriole in the mitotic cell shows essentially the same structure to that of interkinetic cell.

The tubular filaments of about 150 Å in diameter are recognized running from the centriolar mass towards the chromosome and may be one of components of the spindle apparatus.

In the case when two centrioles are observed, they usually locate at right angle each other.

REFERENCES

1. YAMADA, E.: The fine structure of the megakaryocyte in the mouse spleen. *Acta Anatomica*. **29**, 267, 1957.
2. YAMADA, E.: The fine structure of the centriole in some animal cells. *Proc. 1st Conf. Electronmicroscop. in Asia and Oceania*. 1956, Tokyo. 247.
3. YAMADA, E.: Fine structure of ce'lls. *Fukuoka Acta Medica*, **47**, 1292, 1956. (in Japanese).
4. BERNHARD, W. AND DE HARVEN, ET.: Sur la présence dans certaines cellules de Mammifères d'un organite de nature probablement centriolaire. *Compt. r. Acad. Sci. Paris*. **242**, 288, 1956.
5. DE HARVEN, ET. AND BERNHARD, W.: Etude au microscope électronique de l'ultrastructure du centriole chez les vertébrés. *Z. f. Zellforsch.* **45**, 378, 1956.
6. AMANO, S.: The structure of the centrioles and spindle body as observed under the electron and phase contrast microscopes - a new extension fiber theory concerning mitotic mechanism in animal cells. *Cytologia*, **22**, 193, 1957.
7. TANAKA, H., HANAOKA, M. AND AMANO, S.: Observations on the centriole of interkinetic blood cells under the electron microscope by ultra-thin sections. *Acta Haem. Jap.*, **20**, 85, 1957 (in Japanese).
8. AMANO, S. AND TANAKA, H.: Dynamic structure of the nuclear membrane, with special reference to its disappearance and reappearance in mitosis as observed under the electron microscope. *Acta Haem. Jap.*, **20**, 319, 1957. (in Japanese).
9. PORTER, K. R.: The submicroscopic morphology of protoplasm. *Harvey Lectures. Series* **51**, 175, 1955-1956.
10. PORTER, K. R.: Changes in cell fine structure accompanying mitosis. In "Fine structure of cells." Noordhoff, Groningen. 1955.

EXPLANATION OF FIGURES

All figures are the electronmicrographs of sectioned mitotic cells fixed with buffered osmium tetroxide solution. The bar in each picture represents the distance of 1 micron except when otherwise indicated.

Fig. 1. A mitotic cell found in the mouse spleen. A portion of the cell surface is seen at left upper and lower corners (s). A part of the chromosome (ch) is bounded by the double membrane (nm). From the irregular-shaped body of high electron density (C), bundles of numerous filaments extend towards the chromosome. This part of the figure is shown in Fig. 2 at higher magnification. There are many vesicles and small particulate components scattering in the cytoplasm. Mitochondria (m) and unidentified structure, (shown by arrow) possibly paired filaments are also recognized. X 28,000.

Fig. 2. Detail of a part of the Fig. 1. Within the dense body (C) in the Fig. 1, one can recognize two centrioles (C 1 and C 2). C 1 is cut longitudinally and C 2 shows a oblique profile. The tubular nature of the filament is demonstrated. Note some sword-like structure extending from the centriolar mass (†). X 66,000.

Fig. 3. A mitotic cell found near the tracheal cartilage of mouse embryo. Large vacuoles are seen within the cytoplasm. A centriole (C 1) is shown in longitudinal section and the other (C 2) is barely visible to the left. Insert represents a consecutive section of the same cell and shows the fact that the latter centriole (C 2) locate at right angle to the former (C 1). X 22,000. Insert. X 20,000.

Figs. 4 and 5. The mitotic tapetum cell found in the kitten eye. A centriole (C 1) is shown at longitudinal section and the filaments within the cortex are clearly shown. The other centriole (C 2) represents a oblique profile. The finding of this picture also suggests that these two centrioles arrange each other at right angle.
m; mitochondria. f; filament. ch; chromosome. Fig. 4 X 23,000. Fig. 5 X 60,000.

Figs. 6 and 7. A mitotic cell found in the rat bone marrow. C 1 and C 2 represent the longitudinal and cross sectioned profiles of centrioles respectively.
m; mitochondria. f; filament. G; Golgi bodies. ch; chromosome. Fig. 6 X 24,000. Fig. 7 X 54,000.

Fig. 8. A portion of the mitotic cell found in the rat bone marrow. A centriole (C) is shown in longitudinal section. ch; chromosome. X 55,000.

Figs. 9 and 10. A mitotic cell found in the rat bone marrow, probably neutrophil leucocyte. A centriole (C) is cut in longitudinal manner, and the filaments within the cortex are visible. The dense material accumulates around the centriole. Note the tubular filaments with dense material running towards the chromosome (indicated by arrows).

m; mitochondria. V; vesicular conglomerate. g; possibly neutrophile granule. er; endoplasmic reticulum. Fig. 9 X 27,500. Fig. 10 X 63,000.