

**A Crystalline Body Found in the Rod Inner Segment of the Frog's Eye.\*** BY EICHI YAMADA.†  
(From The Rockefeller Institute.)§

The rod portion of the rod cell in the frog's retina is divided into two parts; namely inner and outer segments. The latter is mainly occupied by the pile of so called rod-sacs which are arranged perpendicularly to the long axis of the rod (1-3). The inner segment is connected with the outer segment by a short slender stalk (or connecting cilium) (4, 5), which has a columnar shape and extends from the level of the outer limiting membrane of the retina. The internal organization of the inner segment shows a remarkable polarity. Within the distal portion of the segment are found numerous mitochondria packed very closely and forming a large compact mass. This portion of the segment has been known to light microscopists as the ellipsoid. The mitochondria within this mass show a tendency to be oriented with their long axes parallel to the long axis of the segment, and directed toward the basal body of the connecting cilium. Beyond this portion no mitochondria are seen in the inner segment.

Embedded in the mass of mitochondria, a peculiar structure is occasionally found that has been described as "a long straight rod-like body of high electron density" (3). In sections, the body has a sharp angular outline, and is surrounded very closely by numerous mitochondria. Under high magnification (Figs. 2 and 3), highly ordered inner structure can be recognized. Dense lines about 45 Å wide separated by lighter interspaces about 50 Å wide run parallel to the long axis of the body. Some dense lines may show a beaded appearance, in which case, the beaded granules of adjacent lines

are often arranged in phase so as to give the body a closely striated appearance. This may be an effect of the angle of sectioning, which introduces an additional cross-striation to the inner structure of the body but in any case describes the body as a highly ordered structure. The surface of the body is defined by a denser line of about 80 Å wide. Its shape and internal structure lead us to consider this structure as some sort of crystalline body, possibly protein or lipoprotein in nature.

As described before, the body is surrounded by closely packed mitochondria, so densely packed, in fact, that one can hardly recognize the cytoplasmic ground substance in this part of the cell body. There are also some indications that the dense line bounding the body is continuous with the limiting membrane of the mitochondria (Fig. 2, arrows). These findings suggest that the dense body described here may be a structure within the mitochondria and may have some functional significance for these mitochondria.

A similar structure was reported by Napolitano and Fawcett (6) in the mitochondrial matrix of the brown adipose tissue although it was much smaller than the body reported in this paper. They described it as a structure suggesting a protein crystal.

The exact nature of this body and its possible role in or any relationship with visual function are at present unknown.

## REFERENCES

1. Sjöstrand, F. S., *J. Cell. and Comp. Physiol.*, 1953, **42**, 15.
2. De Robertis, E., *J. Biophysic. and Biochem. Cytol.*, 1956, **2**, 319.
3. Yamada, E., *Kurume Med. J.*, 1957, **4**, 127.
4. De Robertis, E., *J. Biophysic. and Biochem. Cytol.*, 1956, **2**, No. 4, suppl., 209.
5. Porter, K. R., *Harvey Lectures*, 1956, **51**, 175.
6. Napolitano, L., and Fawcett, D., *J. Biophysic. and Biochem. Cytol.*, 1958, **4**, 685.

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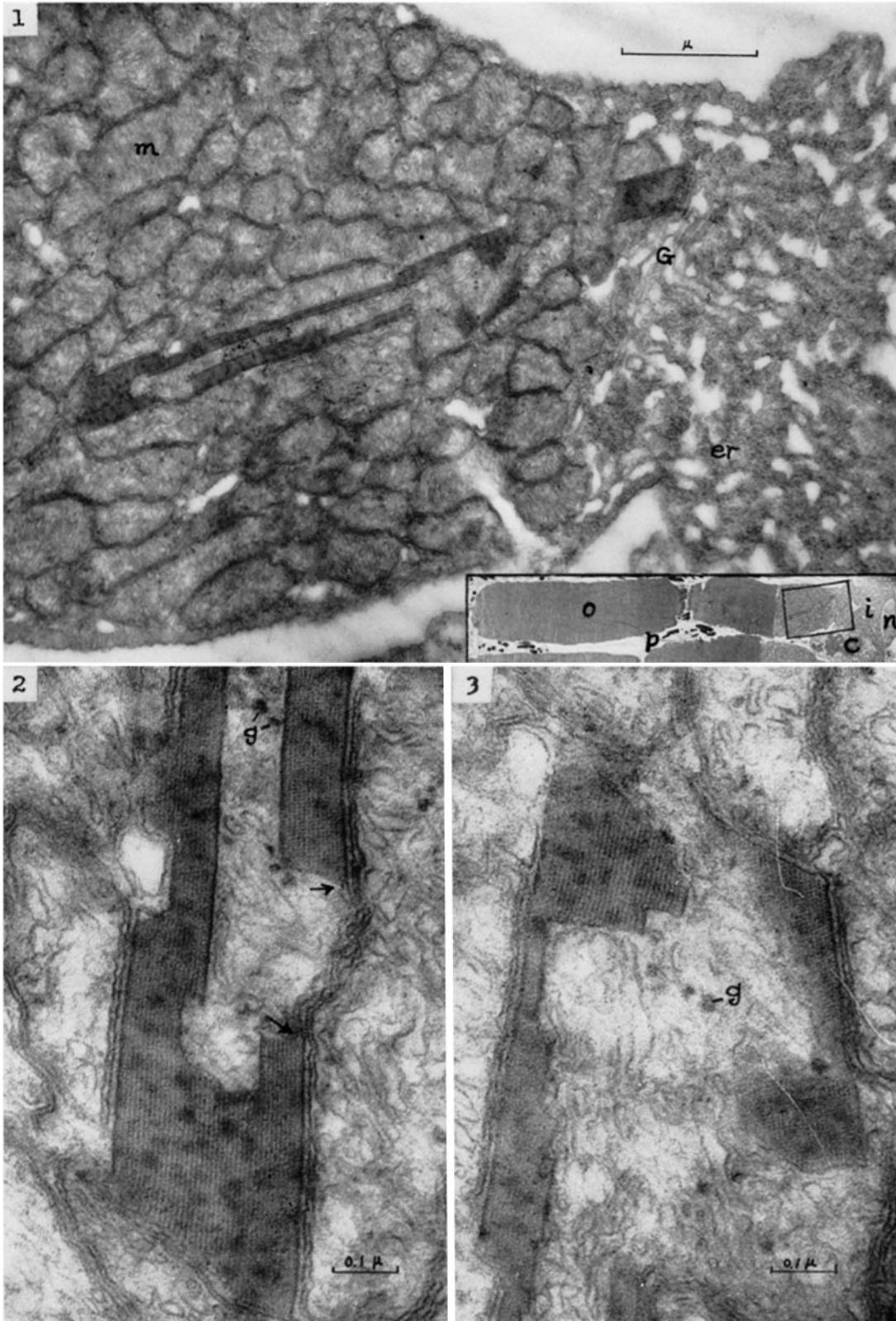
## EXPLANATION OF PLATE 251

All figures represent electron micrographs of retinal rods taken from light-adapted frog's retinae fixed with Caulfield's fixative (*J. Biophysic. and Biochem. Cytol.*, 1957, **3**, 827). The sections were stained with lead hydroxide solution according to the method described by Watson (*J. Biophysic. and Biochem. Cytol.*, 1958, **4**, 727).

FIG. 1. The picture shows a portion of the inner segment, which corresponds to the marked area in the insert of Fig. 1. The left two-thirds of the figure is occupied by a mass of numerous mitochondria (*m*), and to the right one can observe a part of the proximal portion of the inner segment showing a well developed rough surfaced endoplasmic reticulum (*er*) accompanied by many free RNP particles. Golgi bodies are also recognizable (*G*). A long bar-like crystalline body of high density surrounded by the compact mitochondrial mass, is prominent.  $\times 21,600$ .

*Insert.* The general view of the rod under low magnification. The marked portion represents the same area of Fig. 1. *o*, outer segment. *i*, inner segment. *n*, nucleus. *c*, cone. *p*, processes of pigment epithelial cells.  $\times 2,500$ .

FIGS. 2 AND 3. High magnifications of a part of Fig. 1, showing the internal structure of the dense crystalline body. Arrows in Fig. 2 indicate the probable continuity of the mitochondrial membrane with the surface layer of the crystalline body. Note the minute dense granules (*g*) in the mitochondrial matrix.  $\times 104,000$ .



(Yamada: Crystalline body in rod inner segment)