Light and electron microscopy on plasma cells and Russell bodies in the iris of a chronic uveitis patient

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Slit-lamp examination of a 56-year-old woman showed many shiny spots in the iris of her right eye which had chronic uveitis and complicated cataract. A piece of iris was obtained by iridectomy at the cataract operation and was prepared for electron microscopy and studied with both light and electron microscopes. In the light microscopy of thick (2μm) sections stained with Giemsa, numerous plasma cells and dense-blue bodies were found in the iris stroma. The bodies, which were identified as the clinical shiny spots, were also intensely stained with fuchsin, periodic acid-Schiff (PAS), fibrin and Gram stains, indicating that they were Russell bodies. Electron microscopy revealed that the majority of the plasma cells were of mature type, with two forms of rough-surfaced endoplasmic reticulum (RER) and with cytoplasmic processes and islands. The flattened cisternae of RER were frequently arranged radially around the Golgi complex, which occasionally reached the cell surface. Single and multiple Russell bodies were contained in the plasma cells. They were various in size and shape, some being as large as 30 μ in diameter, and always embedded within the RER. The surrounding cytoplasm was usually intact, with occasional exceptions. "Lipidlike inclusions" and "dense inclusions" were also seen in the cytoplasm. Plasma cells often surrounded blood vessels. Although few in number, another type of cell which appeared to be akin to plasma cells was also found in the iris stroma. The ultrastructure of the above-mentioned cells and bodies is described, and discussed in relation to their possible functions and cell origin. It is suggested that the Russell bodies may be produced by a mechanism similar to the block which is assumed to be the cause of "intracisternal granules" in pancreatic exocrine cells.

Key words: iris, Russell bodies, uveitis, electron microscopy, light microscopy, histopathology, ultrastructure.

Plasma cell infiltrations in chronic inflammations are a well-known histologic feature in various tissues. Russell bodies in the proliferated plasma cells are also common findings in tissues of inflammatory, as well as of neoplastic, natures. In light microscopy of the iris, frequent plasma cell proliferations, often accompanied by Russell bodies, have been noted in various pathologic conditions, particularly in non-granulomatous uveitis.1, 2 This was em-

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Figs. 1 to 3. For legends see opposite page.
phasized recently in relation to the possible function of antibody production in such plasma cells.3

Electron microscopy of plasma cells of human and animal tissues in normal and pathologic states has been made by a large number of authors,4-27 and the ultrastructure of so-called Russell bodies has also been reported.7,8,12,15,17,20,21,28-30 However, there are still disputable problems to be clarified at an electron microscope (EM) level, such as the origin of plasma cells and the functional significance of their structures, including Russell bodies.

In the course of our EM studies of iris pathology,31 we encountered a patient whose iris showed many shiny spots in slit-lamp examination which were identified as Russell bodies by subsequent microscopy. To our knowledge, such large Russell bodies had not been studied with the electron microscope. A brief communication on this case was given at the French Ophthalmology Meeting 1988,32 and the purpose of this paper is (1) to report in detail the light and electron microscopy of the plasma cells and Russell bodies observed in the iris of this patient and (2) to discuss some problems raised, on the basis of our findings and also in comparison with earlier literature.

Case report

The patient, a 56-year-old woman who had had bilateral chronic uveitis for many years, had a secondary glaucoma with corneal edema in the left eye and a complicated cataract in the right eye. Slit-lamp examination showed the entire surface of the iris of the right eye to be covered with many small shiny spots. With higher magnification these were interpreted as very small spheres of an unknown birefringent substance. There were posterior synechiae and a dense, complicated cataract, but otherwise the anterior chamber did not show any irritation. The cytologic examination of the anterior chamber fluid did not give any clues as to the nature of the tiny spherules; no cells were detectable. A sector iridectomy was performed prior to the intraocular extraction of the lens of the right eye. The piece of iris was preserved for EM study.

Material and methods

The material used for the descriptions and illustrations in this paper was confined to the iridectomized iris of the patient reported above. However, EM findings on four other irises, which were also iridectomized at operation, are briefly mentioned in the Discussion. Several normal human irises obtained by either enucleation or iridectomy at operation were used as controls for the electron microscopy.

The iris tissue of our patient was fixed with 4 per cent glutaraldehyde, postfixed with 1 per cent osmium tetroxide, and embedded in Durcupan ACM, following the same method reported previously.31 Both thick (2 μm) and thin sections were made with LKB Ultrotome. The 2 μm sections were stained for light microscopy with Giemsa, PAS, Gram, Weigert's fibrin, and fuchsin stains. All stainings were performed on glass slides prepared by the same technique as for Giemsa staining,31 and in each some modifications were made in the usual method; i.e., all stains were heated (between 80° and 100° C.), the time in individual steps was shortened, and all counterstains were omitted. The outlines of these modified procedures are as follows: Giemsa; the same as before.31 PAS; 0.5 per cent periodic acid solution (heated), washing (water), Schiff's reagent (heated), and washing (water). Fuchsin; Russell's fuchsin solution (heated), washing (water), and absolute alcohol.

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**Fig. 1.** Light micrograph of a section of the iridectomized iris. Arrows show Russell bodies. (Giemsa stain; x73). (All the light [Figs. 1 and 2] and electron [Figs. 3 to 18] micrographs illustrated here are from the iris of the patient with chronic iritis that is reported in the text. The line in each electron micrograph represents one micron unless otherwise indicated.)

**Fig. 2.** Light micrographs of variously stained Russell bodies. (A, Fuchsin stain, ×440; B, PAS stain, ×440; C, Giemsa stain, ×550; D, Gram stain, ×550.)

**Fig. 3.** A low-power electron micrograph of the iris, showing numerous plasma cells (P). They are located in the stroma (ST); however, those in the anterior border layer (ABL) are relatively few. AC, Anterior chamber. (×4,500.)
Figs. 4 and 5. For legends see opposite page.
Similar results were obtained with Ziehl-Neelsen stain; carbol fuchsin solution (heated), washing (water), 1 per cent acid alcohol, and washing (water). Gram; carbol gentian violet (heated), Lugol's solution, acetone-alcohol, and washing (water). Fibrin; crystal violet solution (heated), Lugol's solution, aniline xylene, and xylene. Eosin stain did not produce reliable results in our tissue.

Thin sections were doubly stained with 2 per cent uranyl acetate and lead citrate as elsewhere, and observed with an electron microscope—EM-9 (Zeiss).

**Observations**

**Light microscopy.** Marked changes were not seen in the pigment epithelium and dilator muscle layers, when judged from 2 μ sections cut at various depths and stained with Giemsa (Fig. 1). However, diffuse plasma cell infiltration was observed throughout the iris stroma, including parts of the anterior border layer. Some plasma cells were around small blood vessels. Most significant was the finding of round and variously shaped bodies stained dense blue with Giemsa (Figs. 1 and 2C). They were located among the plasma cells, and easily identified as the same bodies that were observed as shiny spots in slit-lamp examination. The bodies stained beautifully with fuchsin (Fig. 2A). PAS (Fig. 2B), Gram (Fig. 2D), and fibrin stains also produced strongly positive results in these bodies. Their general morphology, location among plasma cells, and the staining results indicate that they are Russell bodies (see Discussion).

**Electron microscopy.** The pigment epithelium, dilator muscle, and the superficial layer of the anterior border layer showed no significant changes, compared with normal human irises which were studied as controls. The whole iris stroma, including parts of the anterior border layer, was occupied by numerous plasma cells (Fig. 3). Small blood vessels were often surrounded partly or completely by plasma cells (Figs. 8 and 9), which confirmed the findings of the light microscopy. However, those plasma cells around the vessel walls were always outside the base- lamina, although a close contact of the cells with the lamina was observed in parts (Fig. 9).

The majority of plasma cells were of a mature type (Figs. 4 and 5). The nuclei contained highly condensed chromatins in the periphery, and frequently exhibited a cartwheel-like pattern (Fig. 4). A nucleolus was also seen in the nucleus (Fig. 4). The cytoplasm was filled with rough-surfaced endoplasmic reticulum except where mitochondria and Golgi complex were located (Figs. 4 to 6 and 9). When observed, the Golgi complex, which consisted of flattened sacs and vesicles, usually occupied the central region adjacent to the nucleus. However, occasionally a part of the Golgi area reached the cell surface (Fig. 6). Centrioles were often found within the Golgi complex (Fig. 6). There were two forms of cells with respect to the structure of the rough-surfaced endoplasmic reticulum, one with long flattened cisternae (Fig. 4) and the other with dilated cisternae (Fig. 5) (a

Fig. 4. Plasma cell in the iris stroma. Flattened cisternae of rough-surfaced endoplasmic reticulum (ar) fill the cytoplasm. They are arranged concentrically around the nucleus (n), and contain moderately dense material. The chromatin of the nucleus shows a cartwheel-like pattern. m, Mitochondria; n, nucleus. Note many cytoplasmic processes (p); some appear to have been pinched off, forming isolated small cytoplasmic islands (i). Both the processes and the islands contain rough-surfaced endoplasmic reticulum. (×16,200.)

Fig. 5. Plasma cell in the iris stroma. The cisternae of rough-surfaced endoplasmic reticulum (a, b) are all dilated, and contain moderately dense material which reveals finely granular structure in higher magnification (inset). Some cytoplasmic islands (i) possess the same endoplasmic reticulum as in the cell body. n, Nucleus. (×16,200.) Inset: High magnification of the portion marked b. (×77,400.)

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Figs. 6 and 7. For legends see opposite page.
few cells contained both types). The flattened cisternae of the endoplasmic reticulum were often arranged concentrically around the nucleus (Fig. 4), while there were those which showed no regularity. However, when they surrounded a large Golgi complex, the orientation was frequently radial (Fig. 6). The cisternae always contained a moderately dense material which revealed a granular structure in higher magnification (Fig. 5). Many cytoplasmic processes were seen on the cell surface, some of which appeared to be pinched off, forming cytoplasmic islands (Figs. 4 and 5). Among these typical plasma cells, a different type of cell was sometimes observed (Fig. 7). The nucleus contained a nucleolus, and the chromatin was not so highly condensed as in the mature plasma cells. The cytoplasm was characterized by a Golgi complex, an appreciable number of flattened cisternae of rough-surfaced endoplasmic reticulum, some free ribosomes, and particularly numerous mitochondria. The cisternae of the endoplasmic reticulum were usually short and irregularly orientated. However, occasionally they showed a partial arrangement similar to that of plasma cells (Fig. 7, arrow). Prominent cytoplasmic processes were also noted.

Single and multiple Russell bodies were observed in many of the plasma cells (Figs. 10 to 13). They were various in shape and size, and always located within the cisternae of rough-surfaced endoplasmic reticulum (Figs. 10B and 12 to 14). Occasionally several bodies were within one cisterna (Fig. 12). Those cisternae with Russell bodies also contained a moderately dense material which appeared to be the same as that seen in the other cisternae (Figs. 10B, 12, and 13). In general, the structure of the Russell bodies was dense and homogeneous (Figs. 10 to 16). However, a wrinkling pattern (Fig. 11F) and concentric lines (Fig. 16) were seen infrequently in the central region. The surface of the body was usually smooth and always sharply demarcated from the surrounding medium (Figs. 10 to 12 and 14 to 16). Some large single Russell bodies appeared to be formed by fusion of several smaller bodies (Figs. 11A, 11C to E, and 15). Only rarely a body with rugged surface was seen (Fig. 13). Russell bodies were frequently very large (Fig. 11C to F); the diameter of some of them amounted to as much as 30 μ (Fig. 11E). Even such an enormous Russell body was surrounded by a membrane of rough endoplasmic reticulum, although the cytoplasm outside the membrane was extremely stretched—up to the thickness of 40 μ (Fig. 14). It was only occasionally observed that the surrounding cytoplasm was partially disrupted (Fig. 15). However, even such an uncovered area of the body surface was still sharply delimited (Fig. 15, arrow). In addition to the Russell bodies, structures which we tentatively called "lipidlike inclusions" (Figs. 9, 12, and 18) and "dense inclusions" (Figs. 6, 9, 17, and 18) were observed in the plasma cell cytoplasm, including the Golgi area. The "lipidlike inclusion" consisted of low-density material with a denser rim, and had no limiting membrane (Fig. 18). The "dense inclusion" was an aggregation of

Fig. 6. Plasma cell in the iris stroma. A large Golgi complex (g) which consists of flattened sacs (I) and vesicles (v) occupies the central region of the cytoplasm, and reaches the cell surface at its lower portion (arrow). A multivesicular body (mv), "dense inclusions" (d), and two centrioles (c), of which one is very long, are within the Golgi complex. The endoplasmic reticulum (er) around the Golgi complex is arranged radially. Nucleus is not included in this section. (x13,600.)

Fig. 7. A cell occasionally encountered in the iris stroma. n, Nucleus; g, Golgi complex; er, rough-surfaced endoplasmic reticulum; r, free ribosomes; m, mitochondria. For details, see text. (x13,800.)
Figs. 8 and 9. For legends see opposite page.
dense granules surrounded by a unit membrane without accompanying ribosomes (Fig. 17), and was found more frequently in the Golgi region than in the other cytoplasmic area. Partial crystalline array was observed in one dense inclusion (Fig. 18C). A similar dense substance was also seen in the flattened sacs of the Golgi complex (Fig. 9). The lipidlike inclusions were occasionally embedded within the dense inclusions (Fig. 18B and C).

**Discussion**

Plasma cell proliferation and Russell bodies in the iris have been frequent findings in light microscopy.1-3 The shiny spots observed clinically in the iris of our patient were identified as Russell bodies in plasma cells by subsequent light and electron microscopy, as discussed below. These bodies were contained in a relatively small proportion of cells as compared with the numerous plasma cells which occupied almost all the iris stroma in the iridectomized tissue. Since the spots were seen all over the iris, the plasma cell infiltration in this patient may have been entirely diffuse throughout the whole iris stroma.

Most of the plasma cells in the iris were of the mature type when judged from their nuclear nature. Their ultrastructure was essentially the same as that reported in various other tissues.17, 20, 22 Two forms of plasma cells had often been observed, and the form with flattened cisternae of rough-surfaced endoplasmic reticulum was said to be an earlier phase than that with dilated cisternae.15-17 The flattened cisternae were often arranged concentrically around the nucleus, as seen elsewhere.10 However, in our study, arrangement in radial orientation was also frequently noted around the Golgi complex. The Golgi area, which usually occupied the central region of the cell, adjacent to the eccentric nucleus, was sometimes connected directly with the cell surface. Most plasma cells possessed many cytoplasmic processes, some of which appeared to be pinched off to form small cytoplasmic islands. Such islands were often found around the cell bodies, and occasionally formed a large group. Similar "clasmato"s18, "fragmentation,"17, 24 and "blebbing"26 was also seen by others. "Dense inclusion" and "lipidlike inclusion," as we have tentatively called them, were frequently seen in the cytoplasm. Similar (but not identical) structures located mostly in the Golgi complex have been observed in the plasma cells elsewhere,6, 10, 20 and other small bodies in the plasma cells, also resembling our "dense inclusions," were regarded as early forms of mitochondria,18 probable microbodies or lysosomes,20 and iron particles.20 The true nature of these "inclusions" is not clear. However, it is possible that the "dense homogeneous globules" and "dense bodies" observed by Movat and Fernando20 correspond to our "dense inclusions" in the Golgi region and those in the other cytoplasmic area, respectively.

Russell20 was the first to describe in detail the "fuchsin bodies" which were later
Fig. 10A. A plasma cell with a large, round Russell body (R). A few lipid-like inclusions (I) are also seen in the cytoplasm. Small, cytoplasmic processes are on the cell surface. (×5,400.)

Fig. 10B. Higher magnification of a portion (a) in Fig. 10A. Many long, flattened profiles of rough-surfaced endoplasmic reticulum (er) and a few mitochondria (m), which are characteristic of plasma cells, can be seen in the cytoplasm. Russell body (R) is homogeneously dense, and has a sharply demarcated, smooth surface. The body is completely surrounded by a membrane studded with ribosomes (arrow), and between the membrane and the Russell body there is a thin layer of moderately dense material which appears identical with that contained in the other cisternae of rough endoplasmic reticulum. (×25,000.)
Fig. 11. Russell bodies with various sizes and shapes. A to F are all shown at the same magnification. (x2,900.) Some density patterns seen in C, D, and E are artifacts. In B a plasma cell contains multiple small Russell bodies, and in the others either a huge, round Russell body (F) or single but irregularly shaped Russell bodies are seen. Those bodies with irregular shapes (A, C, D, and E) appear to have been produced by confluence of two to several round Russell bodies. The nucleus (n) of the plasma cell containing a Russell body is visible in A. In E the maximum diameter (from arrow to arrow) of the Russell body amounts to as much as 30 μ. A wrinkling pattern is observed in the central region (r) of the body in E; whether this is an artifact or not is not clear. Portions marked with a, b, and c are magnified in Figs. 16, 15, and 14, respectively. (x2,900.)
Figs. 12 and 13. For legends see opposite page.
called Russell bodies. Subsequent histochemical studies showed that these bodies were probably muco- or glycoprotein. There may still remain some arguments as to whether all the structures reported under various terms, such as "Mott cell," "grape cell," and "plasma cell droplet" stained blue with Giemsa, are essentially the same element as Russell bodies. In our material, which was prepared originally for electron microscopy, eosin staining was not successful—probably because of the different fixation and embedding. However, our bodies, which stained dense blue with Giemsa, were well in accord with those commonly referred to as Russell bodies in their microscopic structure and other staining properties; i.e., they were intensely positive in PAS, Gram, fibrin, and fuchsin staining. Electron microscope studies on so-called Russell bodies were also reported in various tissues as mentioned, and the ultrastructure of our bodies was very similar to that of those by other workers, although these earlier reports did not include such large, single Russell bodies as we saw in the iris. In our study, essential ultrastructural differences were not found between large single bodies and the smaller multiple bodies, of which the latter may correspond to those which constitute "Mott cells." Some authors stated that, in multiple myeloma and macroglobulinemia, dense spherules resembling Russell bodies could be seen in the nuclei of plasma cells, but we never encountered them in our tissue.

The origin of plasma cells is still obscure; various cells have been presumed to be precursors, e.g., the reticulum cell and its possible derivatives, including the hemocytoblast, lymphocyte, macrophage, and perivascular adventitial cell. The fact that we saw many plasma cells surrounding the iris blood vessels seems to support their adventitial origin. However, they were always located outside the basement lamina, and no cells which clearly indicated transition from pericytes to plasma cells were seen in our study. Among the numerous plasma cells in the stroma, we encountered some cells such as those shown in Fig. 7, which were not seen in our normal control irises. It is not clear to which category they belong, but they appeared similar to one of the cells observed in plasmocytic myeloma.

Cells with well-developed, rough-surfaced endoplasmic reticulum, such as plasma cells, pancreatic cells, and other gland cells, are believed to be concerned with protein production. In addition, many findings have strongly suggested a probable function of the plasma cell as a producer of antibody or gamma globulin, although there are questions of how the antigenic informations enter the cell. A possibility that Russell bodies contain gamma globulin or antibody has also been suggested. Some crystalline structures were observed

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Fig. 12. A plasma cell with several relatively small round Russell bodies. All the bodies are within the cisternae of rough-surfaced endoplasmic reticulum. Three bodies (a, b, and c) are contained in one cisterna. Dilated cisternae of endoplasmic reticulum (er) fill the rest of the cytoplasm, and a few empty vacuoles (v) are also visible near the cell surface. Whether or not such vacuoles resulted from discharge of the contents of the cisterns is not clear; those vacuoles were observed only rarely. In the cytoplasm a lipidlike inclusion (I) is also seen, and its upper portion appears to be uncovered. (x13,500.)

Fig. 13. A Russell body (R) with rugged surface. It is conceivable that this minute irregularity of the body surface resulted from fusion of numerous smaller Russell bodies. In this high magnification the Russell body itself appears to be composed of extremely fine grains (ca. 30 Å); however, the value of describing such fine granularity in detail may be questionable, because this could be caused by the embedding plastic or other artifacts. (x52,200.)
Figs. 14 to 16. For legends see opposite page.
within plasma cells in other tissues. Although we did not see such crystals in our cells, a somewhat similar crystalline array was found in one "dense inclusion."

The mechanism of presumed secretion and excretion of the above substances in plasma cells is quite obscure, and the following discussion concerning this subject includes some hypotheses. Recent studies of pancreatic exocrine cells seem to strongly support the view that the proteins synthesized at the ribosomes are transported through the rough-surfaced endoplasmic reticulum to the Golgi complex, where they are condensed and finally excreted. Since, as has been known, the structural elements, particularly the endoplasmic reticulum of the plasma cells, resemble those of the pancreatic exocrine cells, it is conceivable that the same mechanism as in exocrine cells may be applicable to plasma cells. If so, one possible interpretation is that the moderately dense material observed in the cisternae of rough endoplasmic reticulum, which may represent proteins, is carried to the Golgi area and condensed to form "dense inclusions," as a somewhat similar possibility had been presumed. Actually, the dense inclusions were most often seen in the Golgi region. In addition, some of them appeared to be moving toward the cell surface (Fig. 17B);

this was reminiscent of the movement of zymogen granules in the pancreatic cells. However, no pictures indicating their excretion out of the cells were obtained. A similarity between Russell bodies and "dense homogeneous globules," the latter of which might correspond to our "dense inclusions" in the Golgi region, has been pointed out, and a close relation in their occurrences has also been suggested. However, our "dense inclusions" so far studied possessed a granular structure, which was common to those in both the Golgi complex and the other cytoplasmic area, and were always surrounded by limiting membranes with no accompanying ribosomes, whereas the homogeneously dense Russell bodies were always encircled by ribosome-studded membranes. No clear transition between the two structures has been seen, although it was noted that the grade of condensation of the granular substances in the "dense inclusions" was not constant, some appearing more condensed than others (Figs. 17C and D and 18B and C). Some authors thought that Russell bodies were produced by direct condensation of the moderately dense cisternal material. As to how the Russell bodies are produced, our EM findings on the other four human irises seem to warrant a brief description. An
Figs. 17 and 18. For legends see opposite page.
appreciable degree of plasma cell infiltration was seen in three of them; two had a possible herpetic infection, and one was from a heterochromic cyclitis. Many of these plasma cells contained “dense inclusions” but no Russell bodies. The last patient was being treated for glaucoma, but the iris appeared normal clinically. A small number of plasma cells, however, were observed in this iris, and most of them possessed large Russell bodies identical with those reported in this paper. These few experiences appear to coincide with a light microscopic finding in other tissues, in which the occurrence and number of Russell bodies were not dependent upon the number and density of plasma cells. These also seem to be compatible with an assumption that Russell bodies are products of some unusual functional condition of the plasma cells. Again, in the pancreatic exocrine cells, so-called “intracisternal granules,” which could be compared to the Russell bodies in the plasma cells, were presumed to be the result of a block during the course of protein transport from the rough endoplasmic reticulum to the Golgi complex. It is very tempting to assume that Russell bodies may be produced by a mechanism which is similar to the block in the pancreatic exocrine cells. In experimental animals Russell bodies occurred when a specific antigenic stimulus was given. Plasma cells with Russell bodies were often regarded as a degenerative phenomenon by earlier histologists. In our study the cells themselves usually appeared intact, even when the included Russell bodies were enormously large; this confirms other findings. Apparently degenerated changes of those cells were observed only occasionally and partially, allowing an interpretation that this probably resulted from too much expansion of the included bodies. Even in such portions where the Russell bodies were uncovered, the bodies retained their unchanged structure with sharply demarcated surfaces, and the possibility that the Russell bodies might be dissolved out to the surrounding medium seemed unlikely. No signs indicating that the

Fig. 17. A, B, C, and D are all parts of the plasma cells found in the iris stroma, and show “dense inclusion.” A: Several “dense inclusions” (d) are observed in the periphery of the Golgi complex (g). Each is surrounded by a single smooth-surfaced membrane. er, Rough-surfaced endoplasmic reticulum. (×17,400.) B: “Dense inclusions” (d) are arranged in a row, between arrays of dilated cisternae of rough-surfaced endoplasmic reticulum. The rows of the cisternae and inclusions are oriented nearly radially, as if the dense inclusions are passing from the central Golgi area (g) to the cell periphery, c, Centriole within the Golgi complex. (×17,400.) C: Higher magnification of a region of the Golgi complex in a plasma cell, showing a “dense inclusion” (d). The inclusion is composed of dense, granular material and is surrounded by a triple-layered unit membrane (arrow). (×77,400.) D: Higher magnification of the cytoplasm of a plasma cell, showing a Russell body (R) and a “dense inclusion” (d). In this high magnification the Russell body seems to consist of extremely fine grains (see the explanation of Fig. 13). The “dense inclusion” is clearly composed of larger dense granules (ca. 100 Å.). The limiting membrane of the inclusion is not visible at the lower portion, probably due to tangential sectioning; in this region the constituent dense granules appear to be arranged in parallel rows (arrow). (×77,400.)

Fig. 18. A, B, and C are all parts of the plasma cells in the iris stroma, and show “lipidlike inclusions.” A: A lipidlike inclusion (l) in the cytoplasm of a plasma cell. It is of low density and homogeneous, except for the denser peripheral zone, and has no limiting membrane. (×54,000.) B: Two lipidlike inclusions (l) are embedded within the dense granular material (d) of a “dense inclusion” which has a limiting membrane (arrow). (×54,000.) C: A lipidlike inclusion (l) embedded within a “dense inclusion” (d). Dense parallel lines ca. 200 Å. apart are clearly seen within the dense inclusion (arrow); between the dense lines there are thinner, less dense, intermediate lines. These lines may have been caused by a crystalline array of the constituent particles of the dense inclusion. (×54,000.)
moderately dense contents of the rough endoplasmic reticulum are directly excreted from the cells have been seen, except for a few plasma cells which we interpreted to be artifact. Thus, in our study, no clear sign of excretion of the plasma cell contents has been obtained, with one doubtful exception of lipidlike inclusion (Fig. 12). However, while there is an assumption that the cytoplasmic processes or "villi" on the plasma cell surface could be concerned with uptake of substances, it seems more likely that the above-mentioned cytoplasmic islands, which usually contained cisternae of rough endoplasmic reticulum, may be concerned with excretion, as has been postulated. The unresolved problems discussed above remain to be clarified by future study.

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