

Ultrastructure of a Mucous Gland Cell Found in the Tube Feet of the Starfish *Asterina stellifera*

In early studies by light microscopy¹, it has been recognized that more than one type of gland cell could be found in the tube feet of starfishes. HYMAN² described the epidermal cells as interspersed with 2 types of gland cells: mucous gland cells or goblets, with a finely granular content, and muriform cells, filled with coarse spherules. CHAET and PHILPOTT reported, in electron microscopic studies, that the tube feet of the starfish *Asterias forbesi* contain at least 2 types of secretory glands³; presenting, however, electron micrographs of only one of them⁴. In preceding papers⁵⁻⁷ descriptions of one type of mucous secreting cells, found in the tube feet of the starfish *Asterina stellifera*, was offered; one of them giving particular attention to the ultrastructure of its mucous granules⁷.

The present paper describes a second type of secretory mucous gland cell found in the tube feet of the starfish *A. stellifera*.

Material and methods. Starfish tube feet were fixed in a solution of 1.5% of potassium permanganate in filtered sea water for about 1 h at 5°C. After dehydration in a series of cold alcohols followed by propylene oxide, the material was embedded in a catalysed epoxy resin mixture, Epon 812, by a method similar to LUFT's⁸. Thin sections were cut on a Porter-Blum microtome equipped with glass knives. The sections were doubly stained, first

with uranyl acetate⁹ then with lead citrate¹⁰ aqueous solutions, and were examined in a Siemens Elmiskop I electron microscope, operating at 80 kV with a double condenser and a 50 μ objective aperture.

Results and conclusions. The tube feet of the starfish *A. stellifera* have the shape of a hollow tube, which expands distally to form a sucker. The second type of mucous gland cell, although also present in the stem, was mainly found concentrated at the sucker, sometimes neighbouring the first type of gland cells already described⁷. They are large, very long cells, presenting, in thin section, an elongated oval shape. The fine structure of these cells is illustrated in the electron micrographs in Figures 1 and 2.

A smooth double-layered cell membrane (cm) surrounds the entire cell. The nucleus (N) has a shape varying from round to lobated. The nuclear contents are formed by small particles, abundantly distributed uniformly all over the nucleus. A few mitochondria (m) are observed at the sides of the cells; they are rounded bodies containing a few, rather irregularly disposed inner membranes. The endoplasmic reticulum (er), well developed,

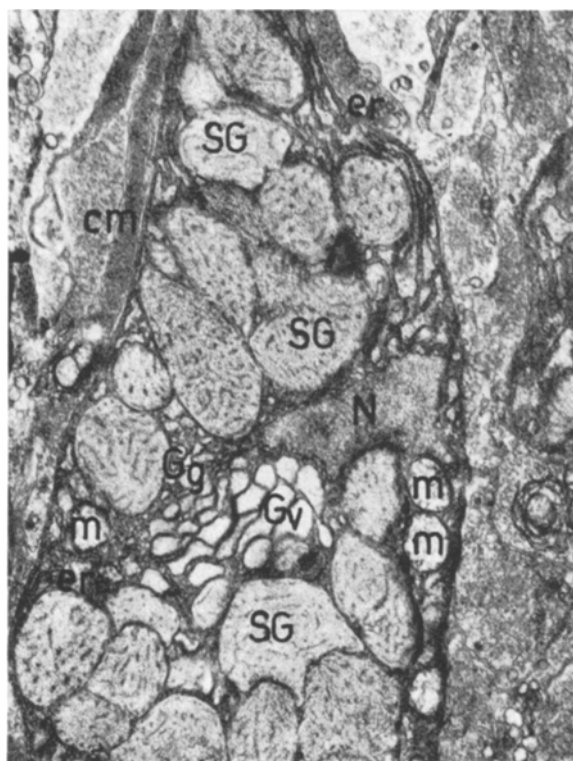


Fig. 1. Electron micrograph showing the second type of mucous gland cell found in the tube feet of *A. stellifera*. The nucleus (N), mitochondria (m) and a very remarkable Golgi complex (Gv, Gg) can be seen. The secretory granules (SG) present in its interior, structures shaped as small dense points or tiny threads. A very prominent endoplasmic reticulum (er) consists of long interconnected tubules. $\times 12,500$.

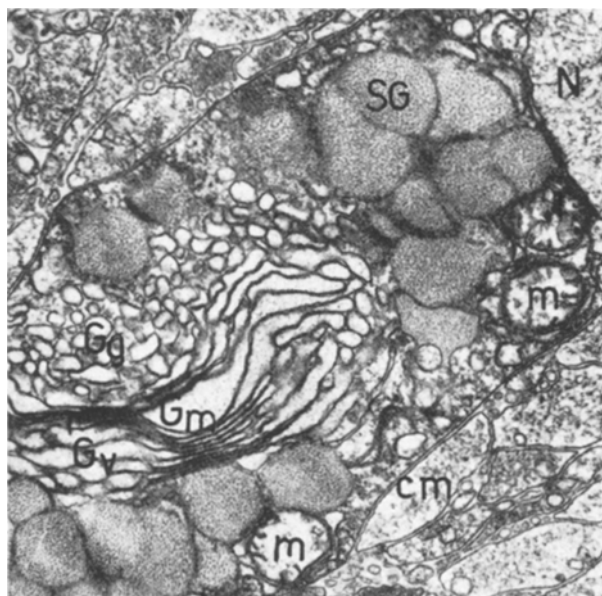


Fig. 2. Portion of a gland cell of the same type. One can see the nucleus (N), mitochondria (m) and the expanded Golgi complex (Gm, Gv, Gg). The ultrastructure of the secretory granules (SG) is also evident. $\times 14,000$.

¹ J. E. SMITH, L. Phil. Trans. R. Soc. B 227, 111 (1937).

² L. H. HYMAN, *The Invertebrates. Echinodermata* (McGraw-Hill Book Company, Inc., 1955), vol. IV, p. 268.

³ A. B. CHAET and D. E. PHILPOTT, Biol. Bull. 119, 308 (1960).

⁴ A. B. CHAET and D. E. PHILPOTT, J. Ultrastruct. Res. 11, 354 (1964).

⁵ H. SOUZA SANTOS, *Estudo da ultraestrutura dos pés ambulacrários de Asterina stellifera (Hupé)-Echinodermata-Asterioidea*. Doctoral thesis. University of São Paulo. November 1963.

⁶ H. SOUZA SANTOS, Boln. Fac. Fil. Ciên. Letr. Univ. S. Paulo, Zool. 25, 175 (1965).

⁷ H. SOUZA SANTOS, J. Ultrastruct. Res. 16 (1966), in press.

⁸ J. H. LUFT, J. biophys. biochem. Cytol. 2, 799 (1956).

⁹ M. L. WATSON, J. biophys. biochem. Cytol. 4, 475 (1958).

¹⁰ E. S. REYNOLDS, J. Cell Biol. 17, 208 (1963).

consists of long tubules, devoid of ribosomes, interconnected among themselves. The most remarkable feature of this cell is a sizeable Golgi complex, always surrounded by the secretory granules; it consists of several parallel paired membranes (Gm), numerous vacuoles (Gv) and smaller vesicles (Gg); often the membranes expand to form fusiform dilatations (Figure 2); the contents of the vacuoles are of the same density as the embedding medium, but sometimes, when enlarged, they display contents similar in density to the larger secreting granules, and apparently represent formative stages in the evolution of the secretory product. As already pointed out,

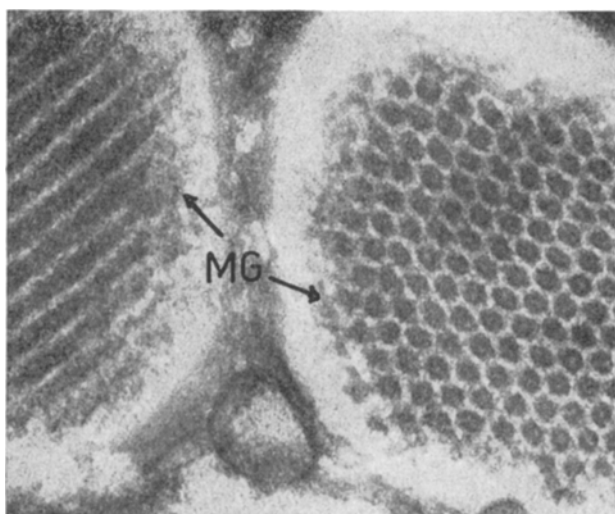


Fig. 3. Mucous granules (MG) belonging to the first type of mucous gland cells found in the same tube feet of *A. stellifera*. Their internal, highly organized structure can be recognized, the rods appearing cut, both transverse and obliquely. $\times 80,000$.



Fig. 4. The electron micrograph presents a group of secreting granules (SG) in the process of being secreted through the free surface of the epithelial cells between gaps of microvilli (Mv). $\times 18,000$.

surrounding the Golgi complex a varying number of closely packed secretory granules (SG) are observed. These secretory granules have a round or oval shape presenting a great interval of variation in their average diameter. Deviations from their basic shape occur when the granules are lying so closely packed that the neighbouring granules seem to compress one another. These granules, clearly delineated by a surface membrane, display at their interior a very fine texture, constituted by small, dense, dark points or tiny threads with various electron densities, which completely fills the entire granule. This texture lacks, however, an organized structure and has an aspect completely different from the mucous granules (MG) already reported⁷ for the same starfish species. The latter were described as granules with a circular or oval profile, delimited by very distinct membranes and presenting in their interior 2 distinct regions; an external one characterized by its low opacity to the electron beam, and a second central part showing a peculiar electron dense structure, which in longitudinal sections appears as a system of elongated parallel bars and in transverse sections as a regular hexagonal array of dense bodies (Figure 3); these structures could be interpreted as a bundle of hexagonal rods organized into a regular hexagonal array.

Histochemical studies¹¹ were able to differentiate the secretory products of these 2 morphologically distinct types of glands, identifying both of them as mucous cells. Figure 4 is an electron micrograph showing a group of intact secretory granules being discharged through the free surface of the epithelium, between gaps of the microvilli (Mv).

It was suggested in a preceding paper⁷ that the secretory product of the first mucous gland cell had the role of sealing lubrication which would help to make good contact in the tube feet for adhesion of the suckers in the process of locomotion. The extracellular material disposed in 2 layers, which cement together the microvilli covering the outer epithelium¹² (Figure 4), are formed by glycoproteins¹¹; probably the secretory product of the second gland cell present in the tube feet of *A. stellifera*, both in the sucker and stem, contribute to the formation of these cementing layers.

Resumen. Es descrita la ultraestructura de un segundo tipo de célula glandular mucosa que es encontrada en el pié ambulacrario de la estrella del mar *Asterina stellifera*. Los gránulos secretorios de esta célula tienen en su interior una ultraestructura en forma de pequeños puntos densos y delicadas fibrillas, mas faltando una organización, principalmente comparada con la organización del otro tipo de gránulo mucoso, también encontrado en el mismo pié ambulacrario.

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¹¹ H. SOUZA SANTOS and W. S. SASSO, unpublished studies.

¹² H. SOUZA SANTOS, Boln Fac. Fil. Ciên. Letr. Univ. S. Paulo, Zool., in press.