TUBULAR CONNECTIONS BETWEEN DICTYOSOMES AND FORMING SECRETORY VESICLES IN PLANT GOLGI APPARATUS

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The Golgi apparatus of most plant and animal cells occurs as a system of dictyosomes (4), often dispersed throughout a large portion of the cytoplasm. Each dictyosome consists of a stack of cisternae (usually 5 or 6) and associated vesicles. The central region of a typical cisterna is sac- or platelike and about ½ μ in diameter. Tubular proliferations extend from this central structure, uniting at intervals to form an anastomosing network of tubules (reference 1 and Figs. 1 and 2). In plant cells, two vesicle types consistently form part of the tubular network (reference 1 and Figs. 1 and 2). These vesicles represent regions of specialization different from the usual secretion granules or vesicles reported for maize root tip (5), slime-secreting cells of insectivores (8), and root hairs (9).

Secretion vesicles are generally lost during dictyosome isolation (6), but their relationship to the cisternal tubules can be visualized from sectioned material. Due to the usual cup-shape of the dictyosomes, tangential sections through an entire cisterna are rare. However, partial tangential sections are numerous and were used to clarify the mode of secretion vesicle attachment to the cisternal tubules.

Tangentially sectioned dictyosomes from glutaraldehyde-fixed, OsO_4-postfixed maize root tip have the same tubular cisternal form as isolated dictyosomes. The secretion product is contained in forming vesicles attached to the cisternae by one or more tubules (Figs. 3 and 4).

To clarify the tubular nature of plant dictyosomes and to preclude artifacts solely due to glutaraldehyde, we include results with tissues fixed in $KMnO_4$ (Figs. 5 and 6), confirming the above observation. The oft published (5, 10) cross-sectional view of a $KMnO_4$-fixed dictyosome is shown on the right in Fig. 6. Only in tangential section is the tubular nature of the structure clearly revealed (at the left of Fig. 6). Thus, the tubular character of the plant dictyosome is not restricted to cold-stored onion (1) and storage tissues (radish of Fig. 1 and cauliflower of Fig. 2) in which the dictyosomes might be expected to be relatively inactive. It is also present in dictyosomes of actively secreting cells. Preliminary observations on other tissues suggest that the tubular nature of dictyosome cisternae is widespread and not necessarily restricted to plant cells. That cisternal tubules are preserved by $KMnO_4$ fixation demonstrates that they are not artifacts attributable to glutaraldehyde stabilization.

A tubular attachment for 2 forms of secretion vesicles of cap cells of maize root tip has been demonstrated (Figs. 3 to 6). During formation of secretion vesicles, the cisternal tubules provide a channel for transfer of materials and possibly serve to segregate the activities of the cisternal lumen from those of the forming vesicles.

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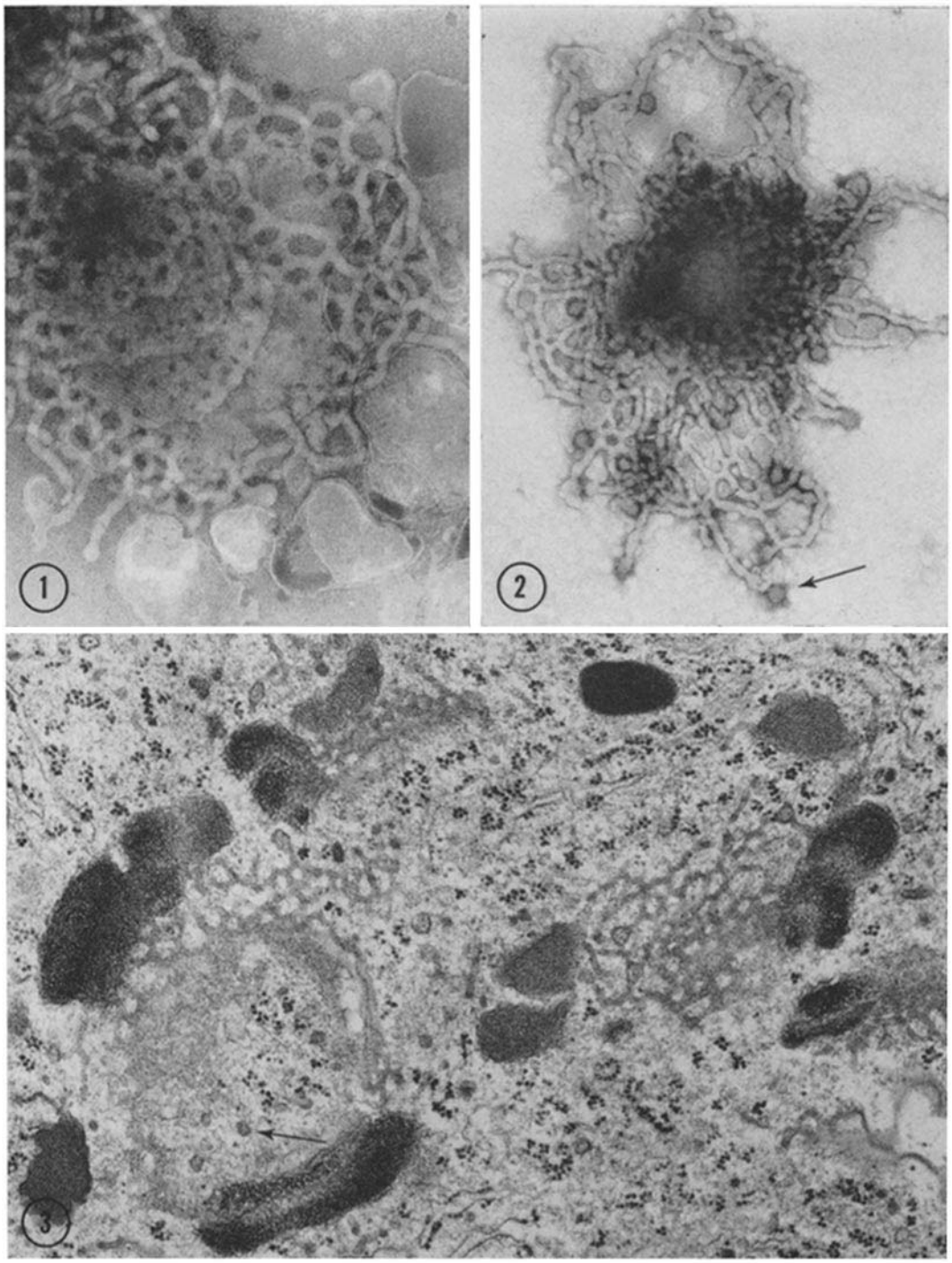
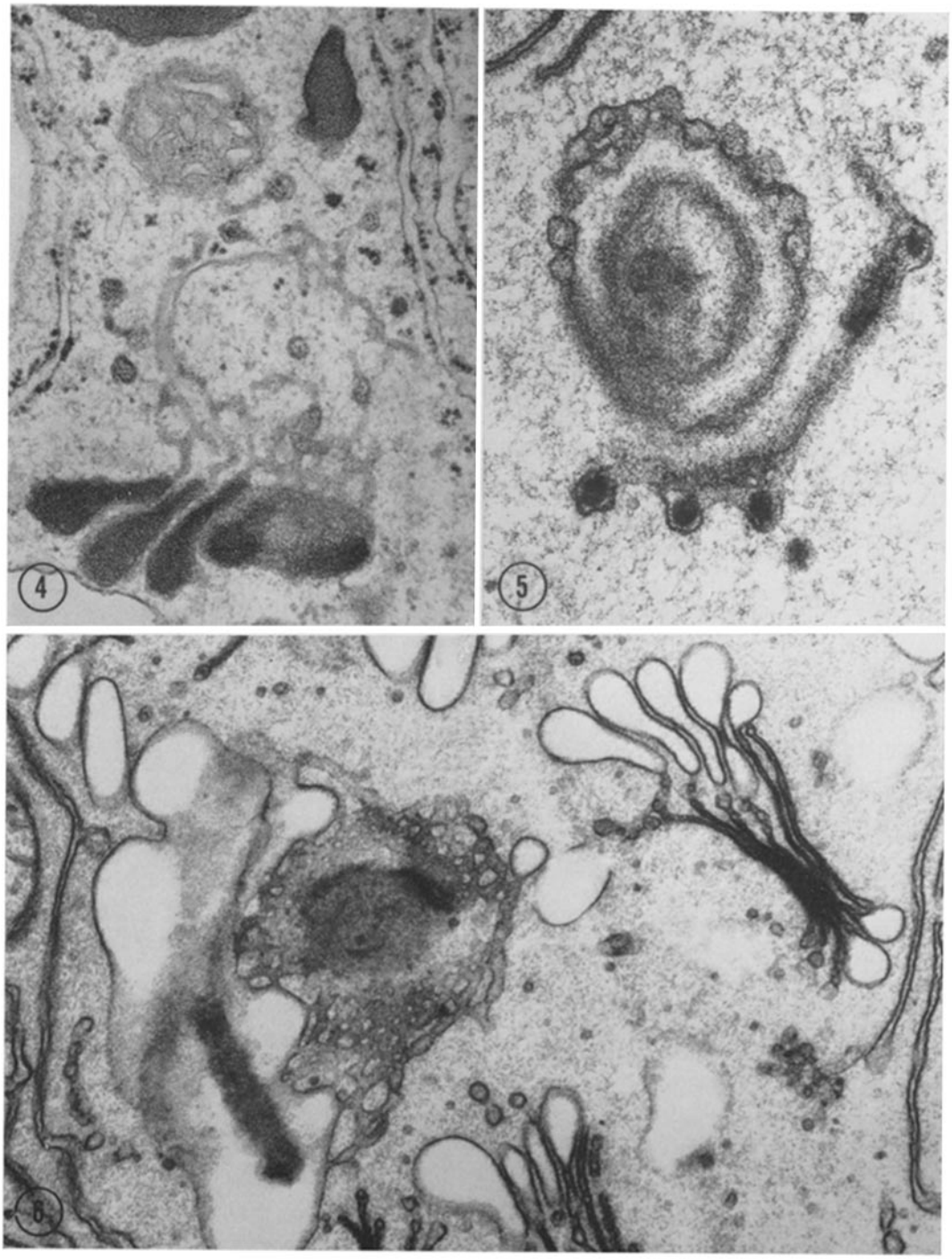


FIGURE 1 Isolated radish dictyosome stabilized with 0.1% glutaraldehyde (7) and stained with phosphotungstic acid (1). The component cisternae have separated, revealing a central region consisting of discs or flattened sacs about ½ μ in diameter. × 73,000.

FIGURE 2 Isolated dictyosome of cauliflower Golgi apparatus stabilized with glutaraldehyde and stained as described for Fig. 1. Tubular proliferations often extend a considerable distance from the central region. Arrow points to a "shaggy" vesicle (1). × 42,000.



FIGURES 3 and 4 Micrographs from tangential sections through maize root cap dictyosomes, showing the tubular interconnections between dictyosomes and forming secretion vesicles. Tissue fixed in glutaraldehyde, postfixed in OsO_4, and embedded in No. 1 epoxy resin mixture of Mollenhauer (2). Fig. 3. Arrow points to a "shaggy" vesicle (1). × 32,000. Fig. 4. × 41,000.

FIGURES 5 and 6 Micrographs from tangential sections through maize root tip dictyosomes, showing the tubular nature of the cisternae and the tubular connections to the forming secretion vesicles. Tissue fixed in 2% aqueous $KMnO_4$ and embedded in No. 1 epoxy resin mixture. Fig. 5. Annular region of root cap (3). Approximately × 45,000. Fig. 6. Root cap mantle region (3). × 40,000.

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