BIOLOGIA PLANTARUM (PRAHA)

7 (4) : 293—307, 1965

The Electron Microscopic and Classic Golgi Apparatus

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Received December 4, 1964

Abstract. The relationship of the membrane structure, designated in electron microscopy as the Golgi apparatus, to the classic Golgi apparatus in the light microscope were studied with *Fagopyrum*. Comparison of these structures in plant cells with the same or similar structures in animal cells led to the following conclusions: there exist two groups of formations, impregnable with osmium or silver, considered as the classic Golgi apparatus. The first group contains the active membrane structures. These are the dictyosomes and the anastomosing form of the electron microscopic Golgi apparatus. To this group belongs also the endoplasmatic reticulum, which in plant cells forms dense vacuoles, having the appearance of the classic Golgi apparatus, and in animal cells occasionally has a similar arrangement as the anastomosing form of the Golgi apparatus. The second group comprises formation containing reserve and secretion material, i.e. predominantly products of the activity of the electron microscopic Golgi apparatus and of the endoplasmic reticulum (matter of the dense vacuoles, lipochondria, secretory granula etc.).

In the plant cells, especially of *Fygopyrum*, the dictyosomes contained in the structures of the first group are separated from the formations of a reserve character in the second group, formed in the lumen of the endoplasmic reticulum (dense vacuoles). The identity of the dictyosomes with the osmiophilic platelets, considered by some authors in the light microscope as the classic Golgi apparatus, has not been proved up to present, because of the one-sidedness of the methods used nowadays. With *Fagopyrum* no foundation has been observed for the assumed formation of net-form structures by grouping of the dictyosomes. Structures similar to the net-form of the classic Golgi apparatus in the animal cell form only dense vacuoles.

On the basis of the differentiation of both types of formations in the plant cell, the foundations were laid for the characterization of the classic Golgi apparatus in the animal cell. The net-form of the classic Golgi apparatus in the animal cell is obviously not artificial, but reflects the ultrastructural arrangement of the electron microscopic Golgi apparatus or of the endoplasmic reticulum.

The problem of the suitability and specification of the name Golgi apparatus in the animal and plant cell was also discussed. In contrast to the opinion of some authors, it does not appear useful to remove the name Golgi apparatus, designating the dictyosomes and the anastomosing forms of the smooth membranes.

In the root meristeme of *Fagopyrum* the special types of vacuoles observed in the light microscope were assumed to be the classic Golgi apparatus of the

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plant cell, being analogous to the classic Golgi apparatus of the animal cell (HRŠEL 1965a). At present, the special membrane systems discovered in studies of the ultrastructure of the animal and plant cell are generally designated as the Golgi apparatus. It has not been confirmed satisfactorily whether these structures in plant cells are identical with the formations of the classic Golgi apparatus of the animal cell impregnated with silver and osmium. The Golgi apparatus has been first described in the animal cell with the aid of electron and light microscopy. Since the solution of this problem in plant cells is closely connected with similarly directed studies in the animal cell, it will first be necessary to consider the state of this problem in animal cytology.

The Electron Microscopic and Classic Golgi Apparatus in the Animal Cell

After the discovery of the ultrastructure of the animal cell in the electron microscope, systems or bundles of so-called smooth membranes connected with vesiculare or small vacuoles have been described in the cells of the nervous system, as well as in other objects. DALTON and FELIX (1954) designated these membranes as corresponding to the structures of the classic Golgi apparatus impregnated with silver or osmium, when studied under the light microscope.

Confirmation of the identity of the systems of smooth membranes (electron microscopic Golgi apparatus) and of the classic Golgi apparatus was the object of the first electron microscopic investigation. Comparison was carried out on the basis of the methods and morphology of the Golgi apparatus in the light and electron microscope.

Methods

The impregnation methods used for the detection of the Golgi apparatus (Kolatschev, Aoyama) were employed. The objects were embedded into methacrylate and the ultra-thin sections were observed in the electron microscope (LACY and CHALLICE 1956, studied mouse pancreas, DALTON and FELIX 1956, the pancreas, epididymis and the duodenum of mice, LACY 1957, the neurons of *Patella vulgata*). The demonstrated microphotographs indicate that osmium and silver are localized at the sites, where the smooth membranes of the Golgi apparatus are positioned. However, the membrane formations themselves are not apparent in the cell.

In another work on nervous cells impregnated with osmium (THOMAS 1961) it is demonstrated that the classic Golgi apparatus is an artefact formed by the impregnation of several components (so-called metaplasmic substances connected with the so-called lipochondria and mitochondria). On the electron microphotograph (see THOMAS 1961) formations can be seen which in the light microscope can be part of the canalicule structure of the Golgi apparatus, their origin, however, is not clear. The membrane structures are missing and the identification of the mitochondria is also doubtful, since they do not have a clear internal structure. The appearance of the cytoplasma is strongly changed and it is difficult to determine whether the impregnated structures were formed in the way suggested by the author or differently.

The insufficient clarity of the membrane systems after the application of the classic impregnation methods, when observed under the electron micro-

scope, indicate certain changes during fixation and impregnation. These changes of artificial character may be due to the acidic pH with Champy's and other fixations, to long impregnation with OsO_4 at 37° C, etc. The electron microscopic methods, on the other hand, at comparatively short fixation with OsO_4 do not stain the Golgi apparatus in the form of the structures

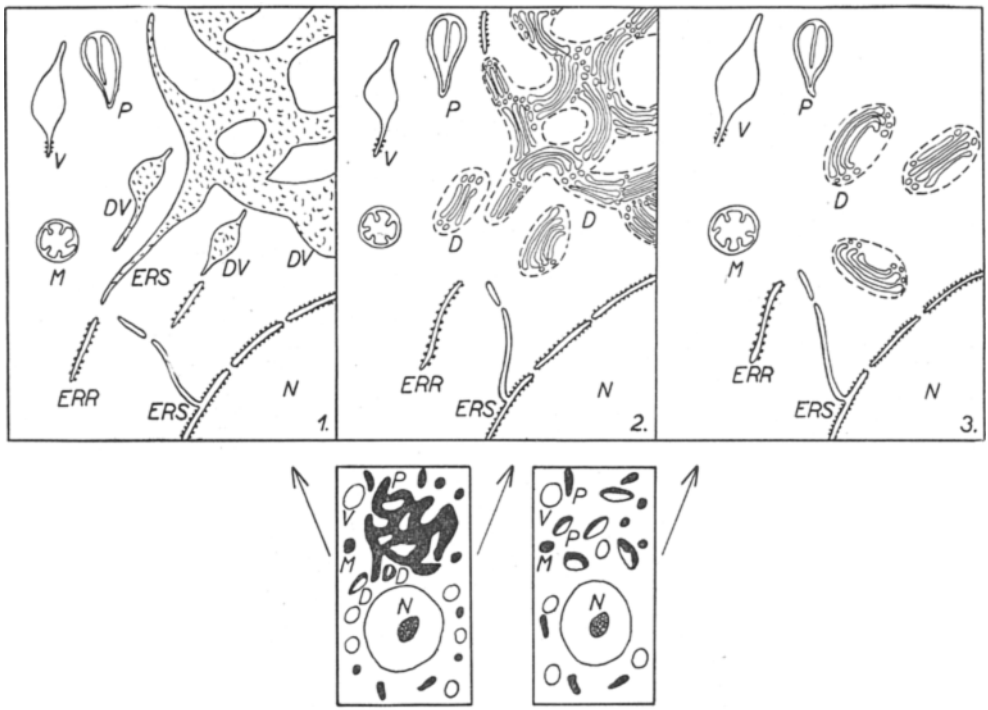

Fig. 1. Diagram of the ultrastructural arrangement in the plant cell, on the basis of which the net-like formations and osmiophilic platelets, impregnable with osmium or silver, are or could be formed.

V = vacuole; P = proplastid; M = mitochondria; DV = dense vacuole; ERS = endoplasmic reticulum "smooth"; ERR = endoplasmic reticulum "rough"; N = nucleus; D = dictyosome.

observed in the light microscope. None of the two types of methods mentioned, i.e. classic impregnation and electron microscopy, can, therefore, be used simultaneously for comparative proof of the Golgi apparatus in the light and electron microscope. Because of the one-sidedness of the present methods, no satisfactory direct methodic proof has been given hitherto on which ultrastructures of the cell silver and osmium are localized.

Morphology

The animal cell contains two groups of cytoplasmic formations assumed to represent the classic Golgi apparatus. To the first group belong the active structures forming various products. This is the electron microscopic Golgi apparatus and the endoplasmic reticulum.

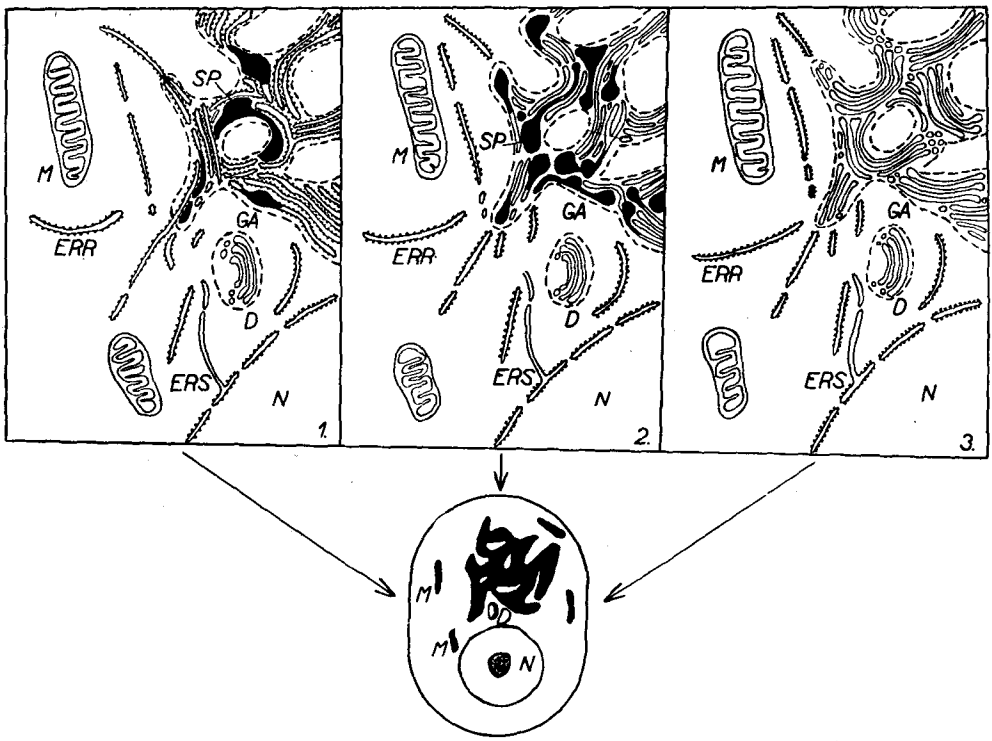

Fig. 2. Diagram of the ultrastructural arrangement in the animal cell, on the basis of which the net-like and other formations (osmiophilic platelets, lepidosomes etc.), impregnable with osmium or silver, can be formed.

SP = secretion product; GA = Golgi apparatus.

The electron microscopic Golgi apparatus consists of the smooth membranes having two forms: 1. Systems of long smooth membranes, for which interconnection by the anastomoses is assumed (anastomosing form). They form the so-called agranular reticulum (Fig. 2). Membranes of this type were observed by PALAY and PALADE (1955) and by LACY (1957) et al. in the neurons. They have also been described with gland cells, for example, pancreas, duodenum and epidermis (DALTON and FELIX 1956) and others. 2. Short bundles of agranular membranes without anastomoses (Fig. 2). DALTON and FELIX (1956), GRASSÉ, CARASSO and FAVARD (1956) and others described them in

the spermatids of *Lumbricus* and *Helix* and call them dictyosomes. The Golgi apparatus in the form of the dictyosomes has been found in several objects, especially in the sex cells and in lower animals (DALTON and FELIX 1956, AFZELIUS 1956, GRASSÉ 1956, GRASSÉ and CARASSO 1957 and others).

The double form of the membranes of the Golgi apparatus in the electron microscope approximately corresponds to the double form observed also in the light microscope: the anastomosing form is analogous to the canalicule- and net-form structures in the light microscope (neurons and gland cells), the electron microscopic dictyosomes correspond to the dictyosomes, lepidosomes and osmiophilic platelets etc. observed in the light microscope (sex cells and cells of lower animals).

The existence of two forms of smooth membranes of the Golgi apparatus is denied (GRASSÉ and CARASSO 1957 and others) in some papers. The opinion has been expressed that the Golgi apparatus has only a single form, i.e. that of the dictyosomes. The formation of net-structures in the neurons and secretory cells is explained by the grouping or close vicinity of the arranged dictyosomes. The anastomosing form according to these authors originates from the wrong interpretation of the electron microscopic microphotographs*.

The anastomosing form besides the dictyosomes, on the other hand, has been observed very clearly in the spermatocytes of the guinea-pig in the area of the acrosome (MOLLENHAUER and ZEBRUN 1960). This finding confirms the existence of this form, however, on material which should contain dictyosomes according to light microscopic observations.

The animal cell contains another ultrastructure which could be the cause for the canalicule-form of the Golgi apparatus under the light microscope. This is the endoplasmic reticulum (Fig. 2). This structure could also form net- or canalicule-structures (see the formation of dense vacuoles, HRŠEL 1965a) at the low specifity of the impregnation methods and a special arrangement similar to that of the anastomosing form of the Golgi apparatus. MALHOTRA and MEEK (1960) assumed in their work on nervous cells that the endoplasmic reticulum is responsible for the canalicule-form deposition of silver and osmium of the classic Golgi apparatus in the nervous cells. The deposition of silver in the endoplasmic reticulum is not demonstrated in this paper. The existence of the Golgi apparatus in the form of dictyosomes with some objects in the light and electron microscope would not correspond to the net-form arrangement of the endoplasmic reticulum.

The other group of formations in the cytoplasm, considered as the classic Golgi apparatus, is not represented by active structures or organelles but by depositing reserve material, or secretion products. According to this opinion, these are substances produced by the cell predominantly through the activity of the electron microscopic Golgi apparatus and of the endoplasmic reticulum. Formations of this type are the so-called lipochondria (BAER 1953a, b, YOUNG

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* In a similar way, some authors on the basis of light microscopy consider the net- and canalicule-form of the Golgi apparatus as an artefact formed by fusion of the osmiophilic areas during fixation (see BAKER 1953a, b, KANWAR 1961 and others), contrary to other authors assuming the existence of the net form (see LACY 1954 and others).

1956), or the secretory granula (KANWAR 1961). The lipochondria are described as spheres, sometimes of light-yellow colour, containing phosphatides and other lipids (yellow pigments etc.). In the electron microscope the lipochondria after osmium fixation appear as homogeneous spheres of high electron density

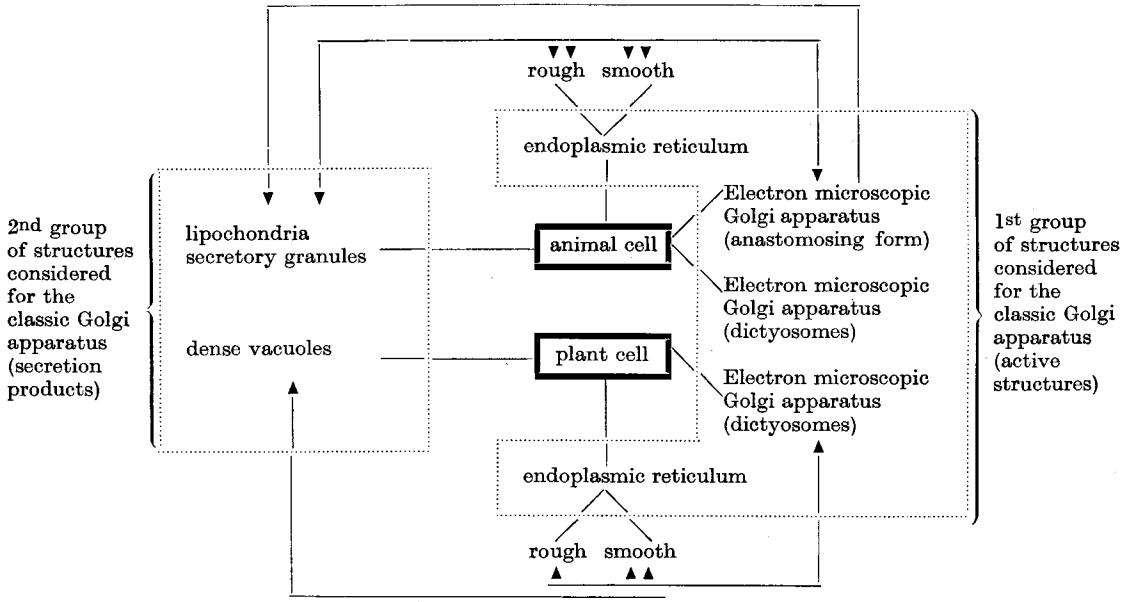

Fig. 3. Diagram of the relationship between the electron microscopic, the classic Golgi apparatus and related structures.

(YOUNG 1956). They do not possess membrane structure according to the microphotographs. In the author's opinion their origin is obscure. Their relationship to the nucleus and their arrangement in the vicinity of the endoplasmic reticulum has been observed. The lipochondria are probably present, according to the author, in all animal and plant cells. After fixation, the lipochondria can be changed artificially together with the other lipid structures to net-like and other formations of the classic Golgi apparatus (BAKER 1953a, b, YOUNG 1956, THOMAS 1961). The compressed secretory granula are also considered as formations able to form a net after impregnation with silver and osmium (KANWAR 1961).

The dense mass of the acrosome in the spermatocytes belongs also to similar components, which are stained intensively after impregnation, do not possess membrane structure and could interfere in the light microscope with identification of the classic Golgi apparatus. On the basis of these uniform observations two groups of authors exist in animal cytology, possessing different opinions on the classic Golgi apparatus. One group holds the opinion that the Golgi apparatus is an active structure, formed by structures of the electron microscopic Golgi apparatus (DALTON, LACY et al., see KANWAR 1962). The

other group assumes that the Golgi apparatus was formed artificially by fusion of the lipochondria, secretory granula and organelles containing lipids (BAKER, THOMAS, KANWAR et al., see KANWAR 1962).

Electron Microscopic and Classic Golgi Apparatus in the Plant Cell

In plant cells electron microscopy showed dictyosomes of the same appearance as in animal cells and was designated also as the Golgi apparatus. This gave rise to several papers (PORTER 1957, HODGE, MARTIN and MORTON 1957, PERNER 1957, 1958, BUVAT 1957, 1958, HEITZ 1957, 1958, SITTE 1958, WHALEY, KEPHART and MOLLENHAUER 1958, DRAWERT and MIX 1961—62 etc.) representing a continuation of preceding works on light microscope.

In contrast to the animal cell, the electron microscopic Golgi apparatus exists in the plant cell in a single form, i.e. that of the dictyosome.

Methods

The object again was the root meristeme of *Fagopyrum esculentum*. The relationship of the dictyosomes to the classic Golgi apparatus was first studied by the simplest method, i.e. impregnation of the objects with osmium for the detection of the classic Golgi apparatus according to Kolatschev (fixation for 2 hrs. in 1% OsO_4 in veronal-acetate buffer, and without rinsing placed for 48 hrs. in 2% OsO_4, rinsed and transferred into methacrylate or araldit, see HRŠEL 1965a). From the embedded objects thick sections were made for the light microscope, as well as ultra-thin ones for the electron microscope.

However, the results obtained by these methods were not satisfactory. Thick sections of the objects processed in this way in the light microscope show dense vacuoles in the dermatogene and peribleme cells (Fig. 4), in the other cells small spheroids of about the size of mitochondria were observed (Fig. 4, 5).

The electron microscopic microphotographs of the ultrathin sections, like those of animal objects, show strongly impregnated formations whose origin is difficult to explain (Fig. 6). Other formations contain a finely flocculated osmiophilic mass (Fig. 7). Apparently so-called dense vacuoles are predominantly concerned (see HRŠEL 1965a, see below). The membrane structures are very unclear, so that it cannot be decided whether the dictyosomes are impregnated or not (Fig. 6, 7).

With this object the method of fixation with potassium permanganate and embedding into araldit (see HRŠEL 1965a) can replace the impregnation method to a certain degree. In the light microscope dense vacuoles of the same type as after impregnation with silver or osmium can be observed with thick slices. This method is also more important than the others, since the plasmodesms can be observed in the light microscope after its application, which was not attained with the other impregnation methods (see HRŠEL 1965a, Fig. 8).

Electron microscopy of ultra-thin sections permits observations of dictyosomes besides dense vacuoles. The other membrane structures can also be seen (Fig. 9).

It is not quite clear yet whether the dictyosomes have been observed in the cells of higher plants with the light microscope. The size of the dictyosomes in electron microscope corresponds approximately to the size of spherical mitochondria (Fig. 10), so that in the light microscope the dictyosomes could apparently be visible as formations of these dimensions (MILOVIDOV 1962). DRAWERT and MIX (1962) found that in living and fixed cells of *Micrasterias rotata* the so-called caryoids of the Golgi apparatus are visible with the light microscope. JAROSCH (1962) observed "whorl-like chondriosomes", when studying *Micrasterias Thomasiana, Micrasterias rotata, Allium cepa, Symphoricarpus albus* and *Nitellopsis stelligera* in vivo with the light microscope. According to the author these structures are in agreement with the electron microscopic Golgi apparatus. In the light microscope bodies impregnable with osmium have been found previously (BOWEN 1927, 1928). Their size is close to that of the mitochondria, which were designated as osmiophillic platelets. GUILLIERMOND and co-workers (see MILOVIDOV 1957) assume that the osmiophillic platelets are degenerate elements of the chondriome, in contrary to the opinion of the author and other workers (see references given by HIRSCH 1939), who considered the osmiophilic platelets to be the Golgi apparatus in the form of dictyosomes.

With *Fagopyrum* the methods for the detection of polysaccharides proved the existence of spheroids in the cytoplasma (HRŠEL, JURÁKOVÁ and BENEŠ 1960), whose origin is still unclear. According to their size they could correspond to the osmiophilic platelets. The osmium methods for impregnating the Golgi apparatus under the light microscope show similar osmiophilic spheroids, having the dimensions of mitochondria (Fig. 5). The character of the osmiophilic platelets has not been investigated with the electron microscope, except in the work of PRESS (1957). PRESS does not consider the platelets identical with the Golgi apparatus, but as elaioplasts. However, the membrane structures are not clearly demonstrated in this work. The osmiophilic platelets are formations which by their size could correspond to the dictyosomes observed in the plant cell on electron microscopic microphotographs. Proof of their identity will apparently meet with the same difficulties as in the case of the animal cells, i.e. the one-sidedness of the methods used at present.

Morphology

In the animal, as well as in the plant cells there exist two groups of structures and formations considered as the classic Golgi apparatus.

The first group comprises the active structures forming certain products. These are the dictyosomes (Fig. 10) and the branched dilated endoplasmic reticulum (Fig. 16). They were described with several objects in the papers mentioned in the introduction to this chapter.

In the cells of *Fagopyrum* the dictyosomes are distributed dispersely (Fig. 11). Sometimes two dictyosomes were found, adhering closely to each other, having the possibility of division (Fig. 12). A similar grouping in relation to division has been described by BUVAT (1958) and others. Groups of three and more dictyosomes (Figs 13, 14) have also been observed, forming the so-called Golgi zones (SITTE 1958). PERNER (1958) studied the Golgi apparatus of plant

cells and expressed the opinion that on the basis of the grouping and close vicinity of the dictyosomes net- and canalicule-form structures of the classic Golgi apparatus are formed (compare GRASSÉ and CARASSO 1957). In the *Fagopyrum* cells the net-like formations are formed by dense vacuoles (compare HRŠEL 1965a). No other net-like formations, originating on other foundations, have been observed besides the dense vacuoles, although the Golgi zones as well as the individual dictyosomes are often in close vicinity to dense and light vacuoles (Fig. 13, 14). If the net-like structures were formed from dictyosomes, they would have been served after impregnation even in the light microscope and in the cells not containing any dense vacuoles. However, no formations of this type were found in this case (Fig. 5) besides the osmiophilic spheroids of the size of mitochondria, although the dictyosomes are a universal structure of all meristemic cells.

The other group of formations, considered as the classic Golgi apparatus, like that of animal cells, is a secretion or depositing reserve material formed through the activity of the membrane structures.

Here belongs the matter of the dense vacuoles described in *Fagopyrum* (HRŠEL 1965a). The dense vacuoles are formed, as most plant vacuoles, by dilation of the endoplasmic reticulum. The endoplasmic reticulum attains branched net-form (Fig. 16) in the cells in which dense vacuoles should form. The branched net-form gradually dilates and fills with a dense substance (Figs 14, 15). Hereby the later net- or canalicule-appearance of the dense vacuole is given, which is preserved under the light and electron microscope (Fig. 8, 9). The dense vacuoles can also have the simple form of spheroids or drop-like formations (Figs 4, 8, 17). Their impregnability with silver and osmium and undifferentiable likeness to the classic Golgi apparatus of the animal cell in the light microscope instigated the assumption of the identity of both structures (MILOVIDOV 1957). Under the electron microscope they contain a homogeneous mass (Fig. 9, 17), or a light matrix with dark inclusions of various size and shape (Fig. 14, 15, 16).

In contrast to animal cells, the plant vacuoles and therefore also the dense vacuoles are part of complex vacuole systems which do not exist in the animal cell. The dense vacuoles differ also by several other properties from the structures and formations considered as the classic Golgi apparatus in the animal cell (compare HRŠEL 1965a).

The dense vacuoles have the following properties which are analogous to those of the structures of the animal cell: 1. The net- and canalicule-like form of the dense vacuoles formed on the basis of the endoplasmic reticulum agrees in principle with the opinion of MALHOTRA and MEEK (1960) on the formation of the net-like structure of the classic Golgi apparatus in neurons by the deposition of silver and osmium on the structures of the endoplasmic reticulum. 2. The content of the dense vacuoles, in spite of its chemical difference (see HRŠEL 1965a), is a material analogous with that of the lipochondria and the secretion products of the animal cell considered to be the basis of the classic Golgi apparatus (BAKER 1953a, b, KANWAR 1961, and others).

Discussion

The relationships between the membrane structures and the formations observed in the electron microscope on the one hand, and the classic Golgi apparatus on the other, are given in the diagram (Fig. 3). According to the results based on observations with the methods used at present it has not been possible to confirm or contradict unambiguously the identity of the electron microscopic Golgi apparatus with the classic one.

With plant cells, especially in the cells of the root meristeme of *Fagopyrum* with the aid of electron microscopy the dictyosomes can be observed separately besides the dense vacuoles, formerly considered as the classic Golgi apparatus.

As compared to animal cell, this advantage facilitates satisfactory orientation in the formations studied. Both types of formations have been observed in the same cell (Fig. 9, 14, 15) and sometimes in very close vicinity (Fig. 14, 15). The problem of the identity of the dictyosomes with the osmiophilic platelets remains open. The dense vacuoles are obviously part of the vacuome, formed by the activity of the endoplasmic reticulum. Their content has the character of reserve material. It belongs to the second group of formations, analogous with the lipochondria and secretion products.

The differentiation and observation of the properties of these two types of formations, i.e. the membrane and reserve formations in the plant cell facilitate the characterization of the principle of the classic Golgi apparatus in the animal cell with probability:

The impregnable formations should be based predominantly on the reserve or secretion products. The homogeneous mass of these formations, like that of the dense vacuoles of *Fagopyrum*, should have a more marked affinity to osmium or silver. However, it has to be pointed out, that although the membrane structures themselves are unclear in their total distribution in the plant cell after impregnation with osmium, still, the possibility cannot be excluded that on impregnation the dictiosomes can also accept osmium and assume the shape of formations similar to that of the dense vacuoles. However, the net-like formation should be formed hereby on the basis of the Golgi zones, formed by grouping of the dictyosomes in all cells (Fig. 13, 14), which has not been observed. It, therefore, appears more probable that the products of the secretory activity of the electron microscopic Golgi apparatus, or also of the endoplasmic reticulum, according to the results obtained with *Fagopyrum*, are responsible for the staining of the classic Golgi apparatus after application of impregnation methods under the light microscope. These products are generally localized in the immediate vicinity or directly in these membrane systems.

The opinion on the artificial character of the net-like formation of the classic Golgi apparatus in the animal cells does not appear correct, since with *Fagopyrum*, and apparently also in other plant cells, exist canalicule- or net-like forms of dense vacuoles, originating from the similar structure of the endoplasmic reticulum (Fig. 9, 16, see HRŠEL 1965a). It can also be assumed that the net-form of the classic Golgi apparatus of the animal cell reflects the reticular arrangement of the ultrastructure in the cell, both of the anastomosing form of the electron microscopic Golgi apparatus and the endoplasmic

reticulum, which has been observed in the same form in the plant cell under the light microscope (PORTER and MACHADO 1960 and others). A survey of the possible origin of the net-like and other formations impregnated with osmium or silver in plant and animal cells is given in Fig. 1 and 2.

In studies of the vacuoles in the root meristeme of *Fagopyrum* with the light microscope abolishment of the name Golgi apparatus has been suggested in plant cytology, since it is "no special structure, but only an example for the uncertain and unspecific demonstration of the vacuole elements in certain cells". "It is a so-called historic artefact, causing unnecessary complications in cytology" (MILOVIDOV 1957). It has been proved electron-microscopically in cells of the root meristeme of *Fagopyrum* that actually concerns a special type of vacuole, i.e. dense vacuoles. Hereby the problem of the name of these formations is solved.

The authors, defending the artefact theory of the Golgi apparatus (see KANWAR 1962), consider the term Golgi apparatus unfounded also with plant cells, provided it concerns the artificial complex formed from the so-called metaplasmic substances, the lipochondria and mitochondria impregnated with silver (THOMAS 1961 and others). BAKER (1953a, b) suggested the name lipochondria instead of the Golgi apparatus.

The results obtained with the electron microscopic method facilitate the most satisfactory differentiation of cytoplasmic structures at the present state of microtechniques. It will, therefore, be necessary to adjust the older nomenclature according to that used in electron microscopy. The name Golgi apparatus for the dictyosomes as well as its anastomosing form (bundles or systems of smooth membranes, i.e. the gamma-cytomembranes according to SJÖSTRAND 1956) is so deep-rooted in plant and animal cytology that it would not be suitable to change it (see DRAWERT and MIX 1961—1962). A change of name would not be useful even if it were proved that the classic Golgi apparatus of plant and animal cells is not formed exclusively or at all by the smooth membranes of the Golgi apparatus, designated by this name in electron microscopy. For plant cells the name Golgi apparatus is suggested only for the whole complex of cellular dictyosomes (DRAWERT and MIX 1961 to 1962). Although this suggestion is acceptable, the possibility of the existence of a single dictyosome in the cells of lower organisms will have to be taken into consideration, which then would represent the whole Golgi apparatus. Hereby the designations would be identical. With the anastomosing form of the Golgi apparatus in the animal cell the name dictyosome cannot be used either. However, the main nomenclature viewpoint mentioned here is not affected by these remarks.

Acknowledgements

I am indebted to Mrs B. Wolfová for her assistance in this work, to Prof. J. Fiala for making the microphotographs in the light microscope and to Dr. H. Mohelská and employees of the Institute for Apparatus Design (Ing. Drahoš) for the electron micrographs, and to Miss J. Veverková.

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Fig. 4. Section through the root meristeme of *Fagopyrum* below the vegetative peak in the area between the dermatogene and the peribleme. Dense vacuoles of net- and spherical form (DV) after impregnation with osmium (Kolatschew) and embedding into methacrylate. Thick section in the light microscope. Magnification 1000×.

Fig. 5. The same. Cell without dense vacuoles. Embedded in araldite. Magnification 2000×.

Fig. 6. The same. Ultrathin section under the electron microscope. O = osmiophilic formations; W = cell wall. Embedded in methacrylate. Magnification 21 000×.

Fig. 7. The same. Magnification 21 000×.

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I. Hršel, Ústav experimentální botaniky, Československá akademie věd, Praha: **Golgiho aparát elektronově mikroskopický a klasický.** — Biol. Plant. **7** : 293—307, 1965.

U *Fagopyrum* byly studovány vztahy membránových struktur, označovaných v elektronové mikroskopii jako Golgiho aparát, ke klasickému Golgiho aparátu v světelném mikroskopu. Na základě srovnání těchto struktur v buňce rostlinné se stejnými nebo podobnými strukturami v buňce živočišné vyplynuly tyto závěry: Jsou dvě skupiny útvarů impregnovatelných osmiem nebo stříbrem, pokládaných za klasický Golgiho aparát. V první jsou činné membránové struktury. Jsou to dictyozómy a anastomozující forma elektronově mikroskopického Golgiho aparátu. Kromě toho sem náleží endoplazmatické retikulum, které vytváří v rostlinných buňkách husté vakuoly, mající vzhled klasického Golgiho aparátu a má někdy v živočišných buňkách podobné uspořádání jako anastomozující forma Golgiho aparátu. V druhé skupině jsou útvary obsahující zásobní a sekreční materiál, tj. z největší části produkty činnosti elektronově mikroskopického Golgiho aparátu a endoplazmatického retikula (hmota hustých vakuol, lipochondrie, sekreční granula apod.).

U rostlinných buněk sp. u *Fagopyrum* jsou odděleny od sebe dictyozómy obsažené v strukturách první skupiny od útvarů zásobního charakteru v druhé skupině vznikajících lumen endoplazmatického retikula (husté vakuoly). Identita dictyozómů s osmiofilními ¦destičkami, pokládanými některými pracovníky v světelném mikroskopu za klasický Golgiho aparát, nebyla zatím prokázána pro jednostrannost dnes užívaných metod. U *Fagopyrum* nebyl nalezen podklad pro předpokládaný vznik síťovitých útvarů seřazováním dictyozómů. Útvary, podobné síťovité formě klasického Golgiho aparátu v živočišné buňce, tvoří zde jenom husté vakuoly.

V živočisné buňce vzhledem k umístění elektronově mikroskopického Golgiho aparátu v blízkosti jeho produktů a možnosti interference podobně uspořádaného endoplazmatického retikula, se nepodařilo zatím přesvědčivě rozhodnout, který z těchto elementů je odpovědný za barvení stříbrem nebo osmiem při impregnaci klasického Golgiho aparátu.

Na základě provedeného rozlišení obou typů útvarů v rostlinné buňce byly uvedeny předpoklady pro charakteristiku klasického Golgiho aparátu v živočišné buňce. Síťovitý tvar klasického Golgiho aparátu v živočišné buňce není patrně arteficiální, ale je odrazem ultrastrukturálního uspořádání elektronově mikroskopického Golgiho aparátu nebo endoplazmatického retikula.

Byla rovněž diskutována otázka vhodnosti a specifikace názvu Golgiho aparát v buňce rostlinné a živočišné. Proti názorům některých pracovníků název Golgiho aparát, označující dictyozómy a anastomozující formy hladkých membrán, se nezdá účelným odstranit.

И. Гршел, Институт экспериментальной ботаники ЧСАН, Прага: **Электронмикроскопический и классический аппарат Гольджи.** — Biol. Plant. **7** : 293—307, 1965.

На материале *Fagopyrum* изучались взаимоотношения мембранных структур, обозначаемых в электронной микроскопии как аппарат Гольджи, к классическому аппарату Гольджи, наблюдаемому в световом микроскопе. На основе сравнения этих структур в растительной клетке с одинаковыми или похожими структурами в животной клетке вытекают следующие выводы: существуют две группы образований, импрегнирующихся осмием или серебром, которые считают классическим аппаратом Гольджи. Первую группу составляют действенные мембранные структуры. Это — диктиосомы и анастомозирующая форма электронмикроскопического аппарата Гольджи. Кроме того сюда принадлежат эндоплазматический ретикул, образующий в растительных клетках густые вакуоли, имеющий вид классического аппарата Гольджи и похожий иногда в животных клетках на анастомозирующую форму аппарата Гольджи. Во второй группе образования, содержащие запасной и секреционный материал, т. е в большей части продукты деятельности электронмикроскопического аппарата Гольджи и эндоплазматического ретикула (вещество густых вакуолей, липохондрии, секреционные гранулы итд.). У растительных клеток, в частности у *Fagopyrum* взаимно отделены диктиосомы содержащиеся в структурах первой группы от образований запасного характера в другой группе возникающих канальцев эндоплазматического ретикула (густые вакуоли). Идентичность диктиосом с осмофильными дощечками, считаемыми некоторыми работниками в световой микроскопии классическим аппаратом Гольджи, пока не доказана вследствие односторонности используемых ныне методов. У *Fagopyrum* не найдены доказательства для предполагаемого возникновения сеткообразных образований построением дикстосом в ряды. Образования, похожие на сеткообразную форму аппарата Гольджи в животной клетке, образуют здесь только густые вакуоли.

В животной клетке из-за того, что электронмикроскопический аппарат Гольджи находится и вблизи своих продуктов и вследствие возможности интерференции похожим образом построенного эндоплазматического ретикула не удалось пока убедительно решить, который из этих элементов отвечает за окрашивание серебром или осмием при импрегнации классического аппарата Гольджи. На основании проведенного разграничения обоих типов образований в растительной клетке приведены предпосылки для характеристики классического аппарата Гольджи в животной клетке. Сеткообразная форма классического аппарата Гольджи в животной клетке, повидимому, не артефакт, а является отражением ультраструктуры электронмикроскопического аппарата Гольджи или эндоплазматического ретикула. Также обсуждается вопрос удовлетворительности и спецификации термина «аппарат Гольджи» в растительной и животной клетке. В отличие от взглядов некоторых ученых нам не кажется выгодным устранить название «аппарат Гольджи», обозначающий диктиосомы и анастомозирующие формы гладких мембран.

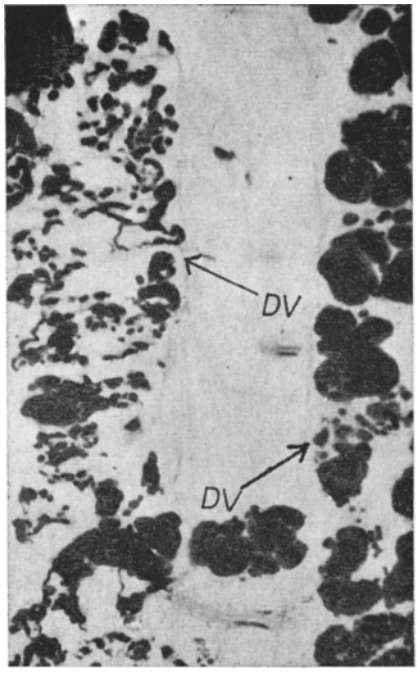

Fig. 4.

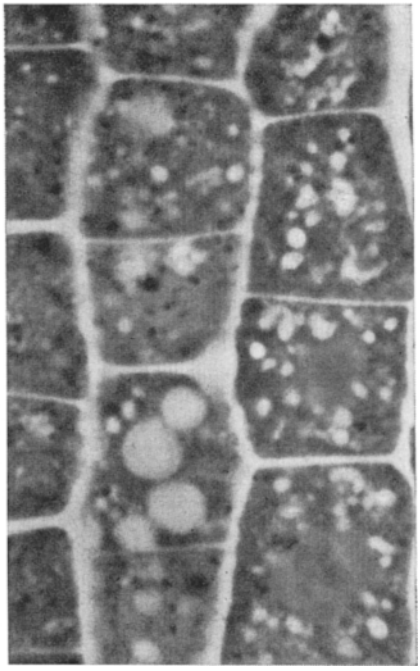

Fig. 5.

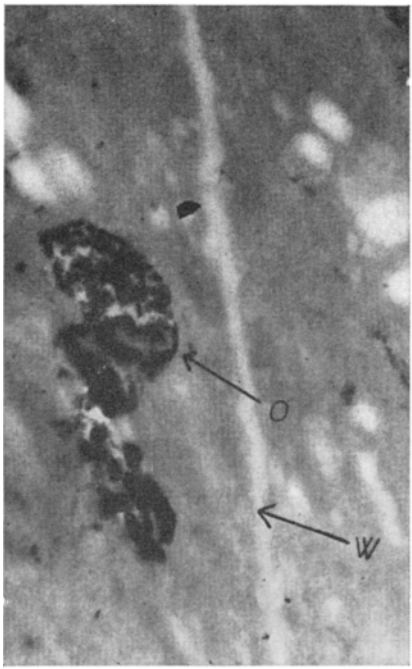

Fig. 6.

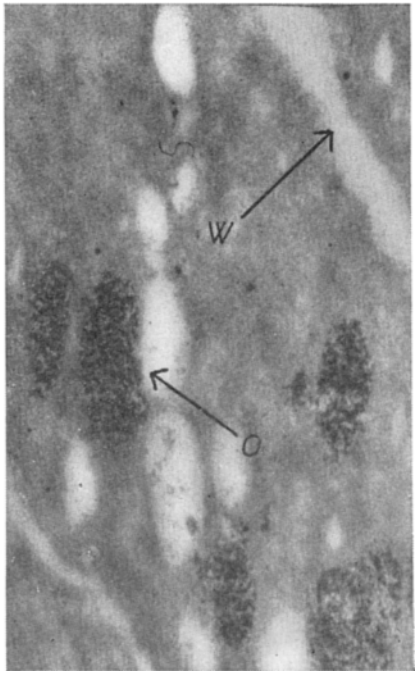

Fig. 7.

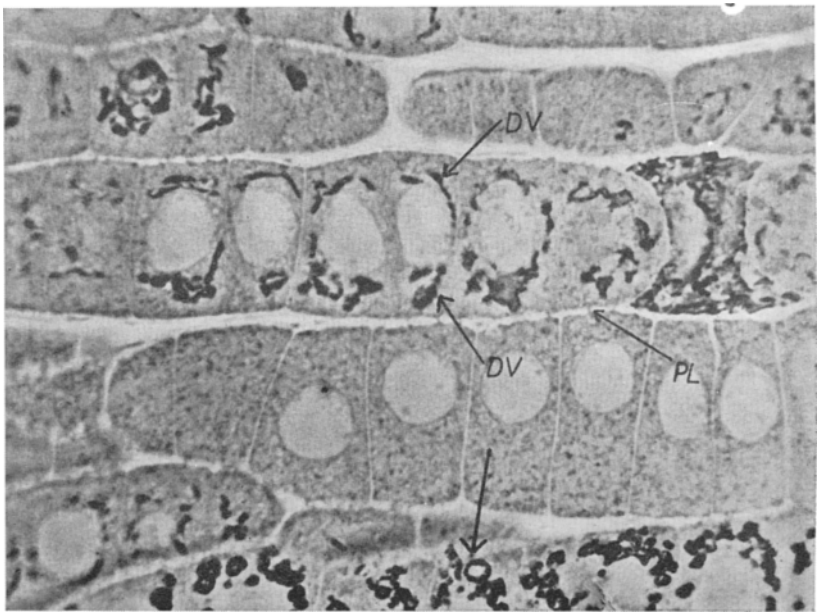

Fig. 8. This section through the root meristeme of *Fagopyrum* from the same area as in Fig. 4. Fixation with $KMnO_4$, embedded in araldite. DV = dense vacuoles; PL = plasmodesms. Arrow without mark indicates spherical types of dense vacuoles. Magnification 1200×.

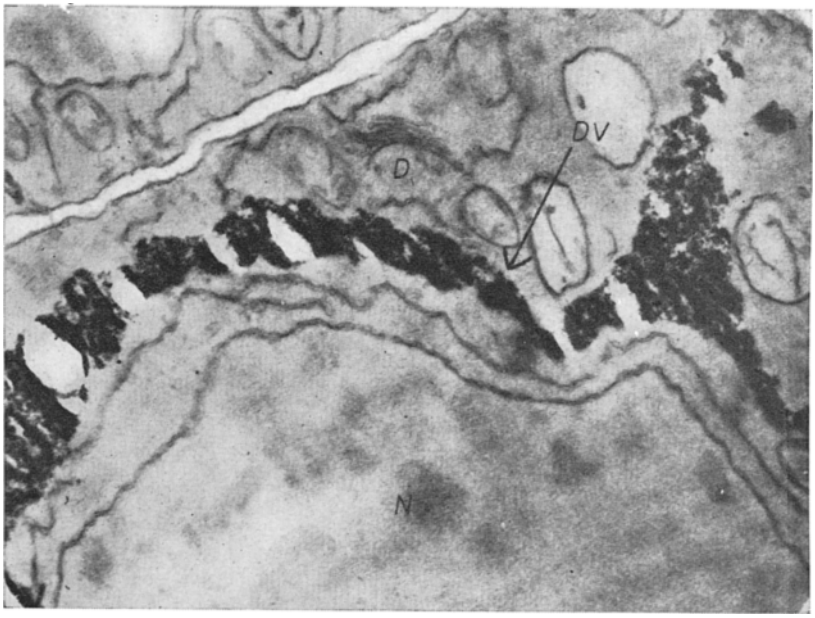

Fig. 9. The same in the electron microscope. D = dictyosome; DV = dense vacuole; N = nucleus. Magnification 14 500×.

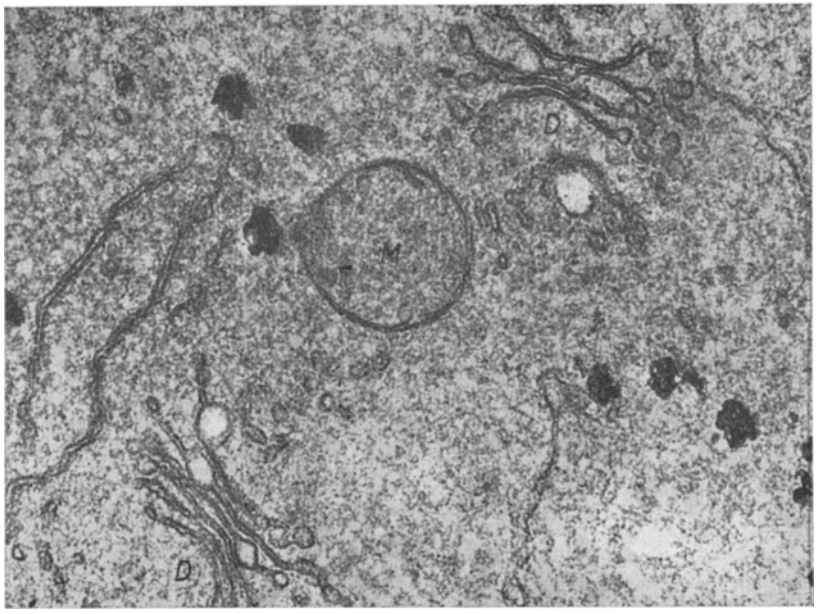

Fig. 10. The same; dictyosomes of *Fagopyrum* at greater magnification. D = dictyosome; M = mitochondria. Magnification 35 000×.

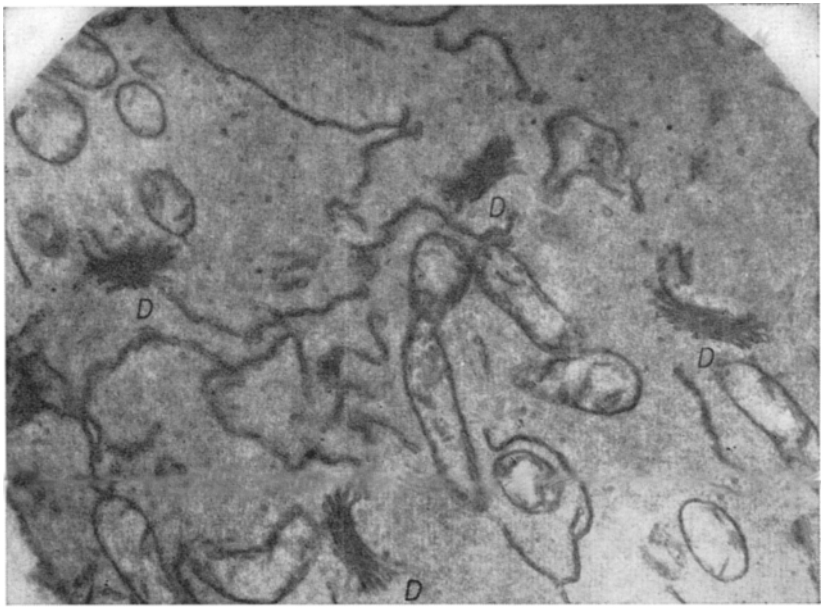

Fig. 11. The same. Disperse distribution of dictyosomes. Magnification 19 000×.

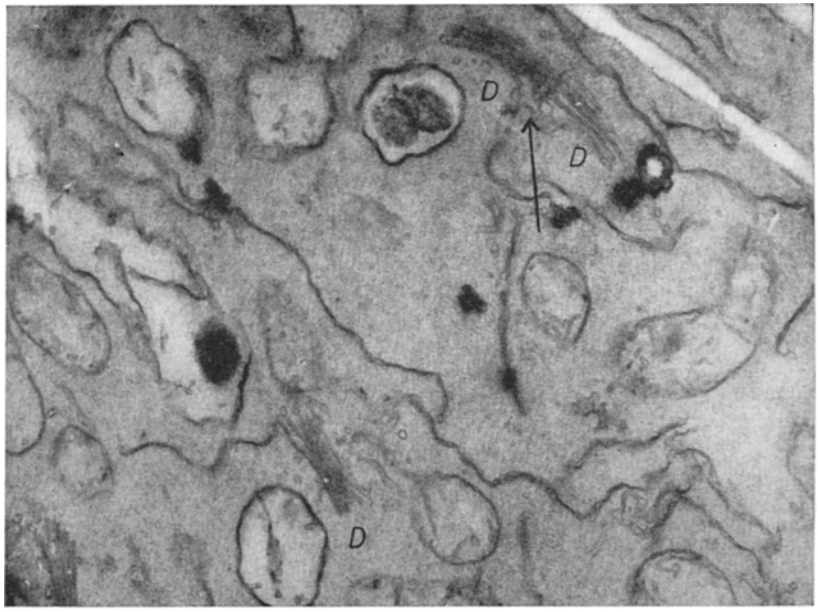

Fig. 12. The same. Dictyosomes in the position indicating division (arrow). Magnification 29 000×.

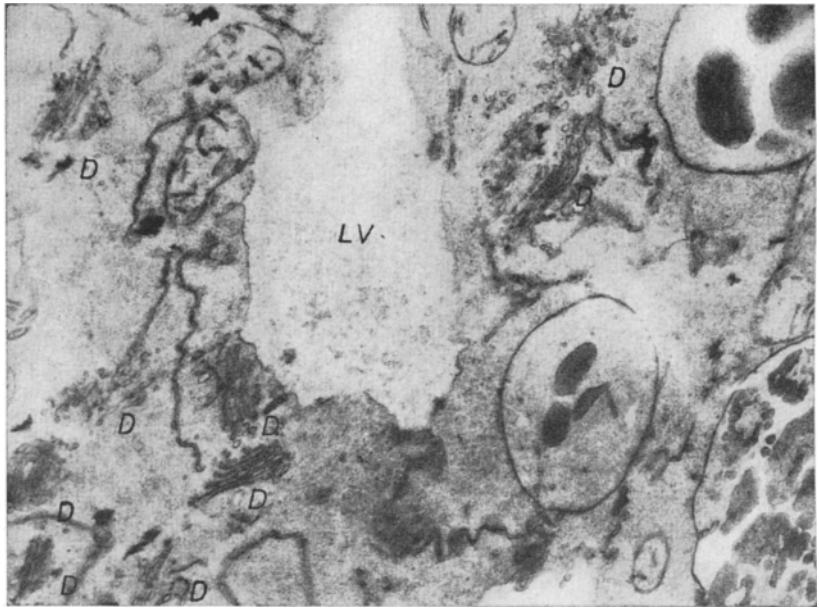

Fig. 13. The same. Grouping of dictyosomes in the so-called Golgi zone in close vicinity to the dense vacuole. D = dictyosomes; LV = light vacuole. Magnification 15 000×.

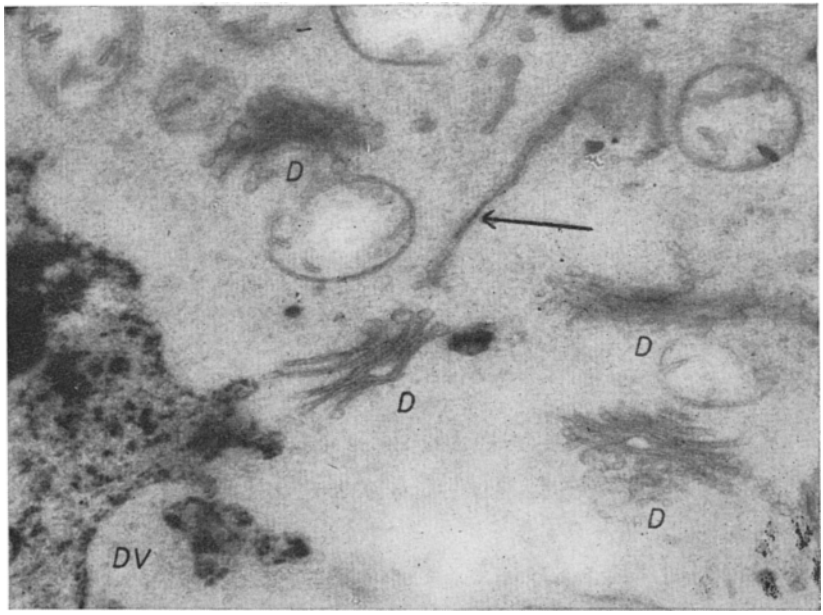

Fig. 14. The same. Dense vacuole, containing a light matrix with small dark inclusions in close vicinity to the Golgi zone. The arrow indicates the endoplasmic reticulum directed towards the dense vacuole. D = dictyosomes; DV = dense vacuoles. Magnification 26 000×.

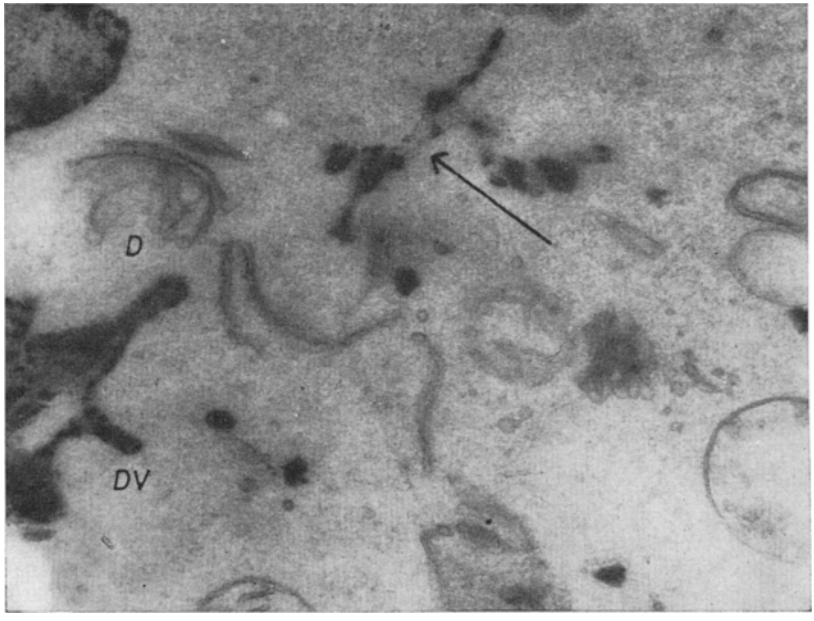

Fig. 15. The same. Beginning of deposition of dense matter in the endoplasmic reticulum. D = dictyosome; DV = dense vacuole. Magnification 23 000×.

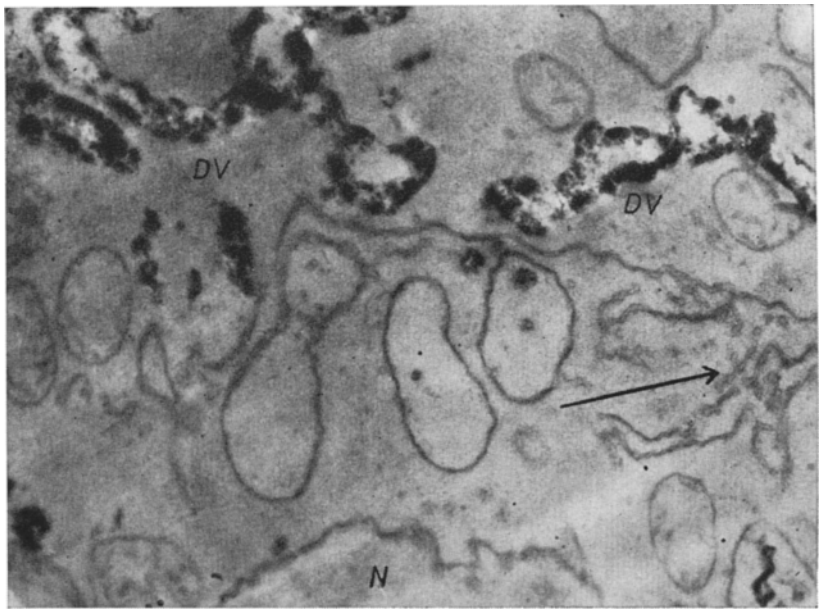

Fig. 16. Branched arrangement of the endoplasmic reticulum, which is probably the basis for the later canalicule-form of the dense vacuoles. DV = dense vacuoles; N = nucleus. Magnification 23 000×.

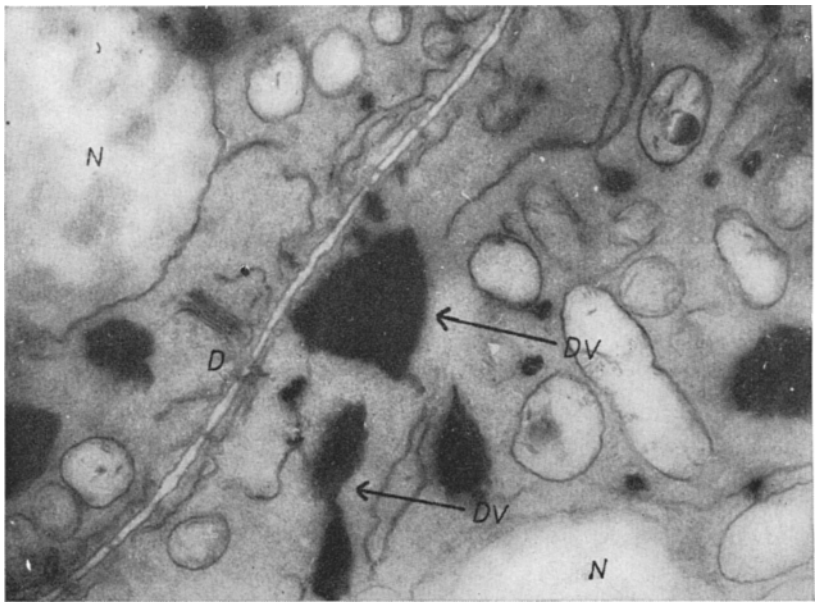

Fig. 17. Drop and spheroid form of dense vacuoles compared with the dictyosome. D = dictyosome; DV = dense vacuoles; R = nucleus. Magnification 19 000×.