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Morphology and Function of the Golgi Apparatus

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Abstract. The polymorphism of the dictyosomes in the root meristeme of *Fagopyrum* is connected with their various functions in secretory processes and cell differentiation. The dictyosomes containing vesicular dilatations of the cisternae, which in this object occur more frequently than in others, probably participate in a similar way as the Golgi apparatus of the animal cell in the formation of lysozomes, in the formation of elements belonging to the group of dense bodies analogical lysozomes. These bodies are present in large numbers in the cytoplasm of cells, containing dictyosomes with vesicular dilatations. The other forms of the dictyosomes reveal indications of their participation in the production of the carbohydrate material of the cell walls, like most dictyosomes of other plant objects. However, no fusion of the Golgi vesicles with the plasmalemma was observed. According to their morphological appearance the typical forms of dictyosomes were classified on the basis of their relationship to secretory processes. Simultaneously the morphology and function of the Golgi apparatus was compared in the animal and plant cell. Several morphological varieties of the dictyosomes of plant cells, observed after the action of pathogenic factors and the effect of the fixation procedures, were also noticed in small quantities in the cells of the investigated objects.

Already in classical cytology the Golgi apparatus in the cells was considered a structure, employed in the formation of various secretes and products, depending on the specialization of the cell in the organism (lit. see Hirsch 1939). The opinion ". . . A great deal of work strongly suggests that the Golgi apparatus neither synthetises secretory substances nor is transformed directly into them; but that it acts as condensation membrane 'for the concentration' into droplets or granules, of products eleborated elsewhere and diffused into cytoplasm" (Kirkmann and Severinghaus 1938) is very close to the present statement on the function of the Golgi apparatus in the cell, even on the basis of electron microscopic observations.

In this paper will be paid to the structural changes of the Golgi apparatus related to the secretory processes in the plant cell. Simultaneously they will be compared with the Golgi apparatus in the animal cell.

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Material and Methods

The object is the root meristeme of *Fagopyrum* L. The roots were fixed with 2% $KMnO_4$ and embedded in araldite according to the procedure reported in HRŠEL (1965a, b).

Morphology of the Golgi Apparatus

a) Golgi apparatus in the animal cell

The Golgi apparatus in the animal cell contains flat sacks limited by the membrane, so-called cisternae, (the term cisterna was first used for some structures of the endoplasmic reticulum, see PALADE 1956). The cisternae of the Golgi apparatus are edged by vesicular dilatations. The cisternae lie close to each other so that the whole formation looks like a bundle in cross-section. Two main forms of the Golgi apparatus have been described in animal objects: 1) The anastomosing form, containing bundles of cisternae connected by anastomoses and branches, which form reticular structures in the cell; 2) The dictyosomes, composed of a bundle of short bundles of cisternae without anastomoses. The changes of the morphology of the Golgi apparatus are caused by the functional orientation of the Golgi apparatus, by differences in the ultrastructural composition of the cells of different tissues and by pathological effects. The cells of glands and neurons often contain the anastomosing form, the sex cells and unicellular organisms mostly contain dictyosomes (see HRŠEL 1965b). Pathological changes of the Golgi apparatus of the hypertrophic type have been described in tumor cells of the hypophyse and prostata (ref. OBERLING 1959).

b) Golgi apparatus in the plant cell

In plant cells the Golgi apparatus has only the form of the dictyosomes (see HRŠEL 1965b). The dictyosomes of the plant cell change also through the effect of their function, the function of the cell in the organism and pathological effects.

Of the organic changes of the dictyosomes the hypertrophic and stretched form from older cells near the periphery of the root cap of *Zea mays* have been described (WHALEY, KEPHART and MOLLENHAUER 1959; MOLLENHAUER, WHALEY and LEECH 1961). Vesicularly segmented cisternae of dictyosomes have been observed in the root cells of *Zea mays* (WHALEY, MOLLENHAUER and KEPHART 1959 and others). This formation originated in this case from the edge position of the dictyosome at the cutting of the object. In the cells of the root meristeme of *Fagopyrum* the following forms of dictyosomes were found in the area below the apical point: dictyosomes with straight oriented cisternae, separating from edges the vesicular elements which are of larger size than the diameter of the cisternae (Fig. 3). In most of the investigated cells the dictyosomes contain cisternae with the vesicular dilatation in centre (Fig. 4). In small quantity curved dictyosomes have also been found (Fig. 5) or have a circular appearance (Fig. 6).

In the cells of the root cap other forms of dictyosomes are present besides those described above: A straight form with separating small vesicles whose size is completely or almost equal to the diameter of the cisternae (Fig. 7). In another case all the cisternae contained in the bundle representing the

dictyosome, segment chain-like and spontaneously disintegrate to single small vesicles (Fig. 8). This form probably does not represent a dictyosome cut on the edge. In another case cisternae segmented vesicularly were observed placed only in the cisternae on the edge of the dictyosomes (Fig. 9). It is difficult to determine in this case whether a dictyosome is concerned fixed atypically by the cut or vesiculation of the dictyosomes. In other cells the cisternae of the dictyosomes are edged by comparatively large hypotrophic vesicles. In these dictyosomes the individual cisternae are often released and found distributed in the ground plasma (Fig. 10). The above mentioned varieties of the dictyosomes apparently reflect different functions and differentiation of the cells from different anatomic areas of the object (see below).

In the case of plant cells changes of the form of the dictyosome, connected with pathological cases and artefacts, have also been described. The release of cisternae from the bundle in the dictyosomes was observed after treatment of seedlings of *Sinapsis alba* with streptomycin (ROSSNER 1960). The curved forms of dictyosomes with objects fixed by OsO_4 were found in the meristeme of *Allium cepa* roots after X-irradiation (WRISCHER 1960). Destruction changes arise with the root meristeme of *Avena sativa* after irradiation with γ-rays (GÜNTHER 1962). Dictyosomes edged by osmiophilic instead of clear vesicles were described in small leaves of *Cucumis sativa* infected with Cucumber virus 4 (HRŠEL 1962). Dictyosomes, separating small vesicles, were observed in the cells of the root apex of Zea mays, neighbouring with the area of excision (MOLLENHAUER, WHALEY and LEECH 1960). The curved form of the dictyosomes observed after fixation with $KMnO_4$ is considered an artefact caused by $KMnO_4$ (WRISCHER 1961). However, similar curved forms of dictyosomes were also found in *Micrasterias rotata* after fixation with OsO_4 (DRAWERT and MIX 1961). Dictyosomes with swollen cisternae were found with *Allium cepa* epidermis cells (DRAWERT and MIX 1963). Dictyosomes with hypertrophic cisternae, accumulated in the vicinity of the vacuoles, were observed in the root meristeme cells of *Triticum vulgare* after vital staining with neutral red (KONČALOVÁ-MAGEROVÁ 1964). Some of the mentioned forms of dictyosomes, observed as pathological cases according to the above mentioned references, occurred in small quantities in the cells of the root tips of *Fagopyrum* germinated under normal conditions. Although the origin of some of the changed forms from pathogenic effects cannot be excluded, the changes observed after this interference have to be evaluated very carefully.

Function of the Golgi Apparatus

a) Golgi apparatus in the animal cell

In electron microscopy the Golgi apparatus is mostly assigned a role in secretory processes. One of the first works on the Golgi apparatus dealing with exocrine cells of mouse pancreas assumed that some of its components are transformed into secretory products (SJÖSTRAND and HANSON 1954). Formation of zymogenic granules has also been observed in guinea pig pancreas cells in the area containing the Golgi apparatus (Golgi zone) (PALADE 1955). The opinion has also been expressed that one of the functions of the Golgi apparatus is the removal of water from the secretory products (DALTON and FELIX 1956). Secretion of material, forming the acrosome in spermatocytes by the Golgi

apparatus has been reported on cats and *Helix pomatia* L. (BURGOS and FAWCETT 1955); GRASSÉ, CARASSO and FAVARD 1956). In the acidophilic cells of rat hypophysis and in the pancreas cells of mice formation of secretory granules in the Golgi apparatus has been described (FARQUHAR and WELLINGS 1957). In the cells of the salivary glands of *Myzus persicae* the functional rhythm of the formation and degradation of the structures of the Golgi apparatus was followed during the secretory process (WOHLFARTH-BOTTERMANN 1959). The role of the Golgi apparatus in the formation of the melanine granules in human malignous melanome (WELLINGS and SIEGEL 1959), in the secretion of milk by rats and mice (BERGMANN and KNOOP 1959; WELLINGS and DEOME 1961), in the formation of glycogen in chicken embryo liver (KARRER and COX 1960), in the formation of mucous secretes in the Brunner glands of cats (MOX 1960), in the formation of collagen in the chondryocytes of rabbit ears (SHELDON and KIMBALL 1962) etc. was investigated.

The production of secretory products by the Golgi apparatus is based on the separation of vesicular elements containing a prosecrete or a secrete from the edges of the cisternae. The content of the vesicles can be of two types. In the first case the vesicles contain a secretory material, stained darkly with osmium or having the typical appearance of the complete secrete already before separation of the vesicle from the cisterne of the Golgi apparatus (KARRER and COX 1960; WELLINGS and DEOME 1961; SHELDON and KIMBALL 1962). In the second case the vesicular elements contain a light presubstance before separation from the cisternae, which only after separation of the vesicle from the cisternae becomes osmiophilic (WELLINGS and SIEGEL, 1959) or keeps further its original light appearance. In the latter case it is difficult to determine whether the free vesicular element actually had separated from the Golgi apparatus.

Electron microscopical analysis of the secretory mechanism of the animal cell has been summarized by KUROSUMI (1961).

Besides the relationship of the Golgi apparatus to secretory processes condensation of absorbed fat was observed in the area of the Golgi apparatus during the digestive processes in mice and rats (WEISS 1955; PALAY and KARLIN 1959).

A relationship of the dictyosomes to the centrosphere and the centriol was observed with human plasmoblasts (POLICARD, BESSIS, BRETON and THIERY 1958).

Participation of the Golgi apparatus in the formation of virus particles of the Bittner milk factor is assumed in cells of milk gland carcinoma of mice (OBERLING 1959).

Based on the electron microscopical localization of phosphatases the formation of the so-called lysozomes was observed, containing the acid phosphatase, from the separated vesicles from the periphery of the cisternae of the Golgi apparatus. Cisternae give the reaction for nucleoside-diphosphatase (ESSNER and NOVIKOFF 1962, NOVIKOFF, ESSNER, GOLDFISCHER and HEUS 1962). In studies of the epidermis cells of mouse embrya during differentiation the assumption was expressed that the Golgi apparatus apparently also plays a role in osmoregulatory processes (MENEFEE 1957).

According to observations in the animal cell the Golgi apparatus is considered a structure which controls permeation of substances through the cell

by concentrating or transforming the substances leaving or entering the cytoplasm. The Golgi apparatus appears ideally adjusted for performing circulatory, secretory and osmoregulatory functions. This role is of primary importance for the cellular functions and is in agreement with the universality of this structure (OBERLING 1959). According to other opinions the Golgi apparatus has greater importance than the function in the formation of secretes. It is also assumed to be the morphogenetic centre of the cell, the "store of membranes" (WOHLFARTH-BOTTERMANN 1963).

b) Golgi apparatus in plant cells

There are two ultrastructural manifestations of the secretion by the Golgi apparatus in plant cells similar to those in the animal cells.

It has been observed in the first case that the substance is stained by osmium or permanganate already directly in the vesicular edges of the cisternae of the dictyosome so that separation of vesicles containing the secretory substance from the dictyosomes can be observed (Fig. 1). The dictyosomes showing the mentioned type of secretory activity were found in the secretion of mucous products in the cells of the carnivorous plant *Drosophyllum luisitanicum* (SCHNEPF 1960), which contain a polysaccharide composed of galactose, arabinose, xylose, rhamnose and glucuronic acid, but no protein SCHNEPF, 1963a). The effect of various factors (temperature, time of the experiments and water deficit) on the ultrastructural manifestations of the secretion by the dictyosomes was also investigated (SCHNEPF 1961). In the cells of the calyptra of *Zea mays* (MOLLENHAUER, WHALEY and LEECH 1961), *Micrasterias rotata* (DRAWERT and MIX 1962b), the root hairs of *Zea mays* (SIEVERS 1963) and in the root meristeme of *Triticum vulgare* (BUVAT 1963) separation of vesicles, containing a dark material from the dictyosomes and their fusion with the plasmalemma was also observed. In the root meristeme of *Zea mays* separation of vesicles was observed which contain a stainable substance from the dictyosomes after fixation with OsO_4 at a simultaneous reproduction of new cisternae (MOLLENHAUER and WHALEY 1963).

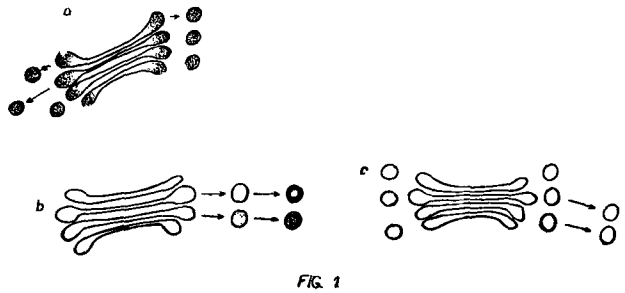

FIG. 1

Fig. 1. Diagram of steps of the secretion processes by dictyosomes in plant cells
a-b Forms secreting dense vesicles, c form separating clear vesicles.

Participation of the vesicles, separated from the dictyosomes, in the formation of cell walls was proved also by another method, i.e. by their accumulation and the presence of separated vesicles in the area of the formation of a cell plate wall (phragmoplast) in mitosis in the root meristeme of *Zea mays* (LEECH, MOLLENHAUER and WHALEY 1963; WHALEY and MOLLENHAUER 1963)

and in the root apex of *Phalaris canariensis* (FREY-WYSSLING, LOPÉZ-SÁEZ and MÜHLETHALER 1964).

Secretion of mucoid substances by the Golgi apparatus has been observed in the cells of the brown algae *Laminaria hyperborea* (SCHNEPF 1963b).

In the area of the dictyosomes in the apex and young leaves of *Triticum vulgare* localization of acid phosphatase (POUX 1963) was observed like in animal cells (see ESSNER and NOVIKOFF 1962). The lead precipitate appears to be localized in the vesicles of the dictyosomes in some cases.

In the second case the dictyosomes produce vesicles with a light substance (Fig. 1b, c), which after separation of the vesicle either becomes dark or remains light. Here belong besides other things the dictyosomes in the root meristeme of *Fagopyrum* which were investigated in the area below the apical point as well as in the area of the calyptra.

The dictyosomes below the apical point have the vesicular edging of cisternae, having though a larger diameter than those (Fig. 3, 4). Dictyosomes occur frequently which have a vesicular dilatation in the centre of the cisternae (Fig. 4). This phenomenon can be explained by the accumulation of the secreted substance in the centre of the cisterne and by its movement towards the edge. Dictyosomes of this type are often grouped into the Golgi zones containing a vesicle in the space between the individual dictyosomes as well as short cisternae of uncertain origin (Fig. 11).

In the neighbourhood of the Golgi zones dense lobulated or stellate elements occur frequently in large numbers which are similar to those presently considered as spherosomes (DRAWERT and MIX 1962a) or as transient forms between the spherosomes and the fat bodies (FREY-WYSSLING, GRIESHAUER and MÜHLETHALER 1963). In contrast to these they have smaller dimensions (Fig. 3, 4, 5, 6, 10 and 11). They are in close contact with the vesicles and the short cisternae themselves (Fig. 10) or are placed in the spaces between the dictyosomes in the Golgi zones (Fig. 11 and 15). Their assumed origin from the vesicular elements, separating from the dictyosomes, cannot be proved directly because of the light content of the separating vesicles. Their formation by this way appears indicated on the following grounds: they are present in large numbers in the proximal distance of the dictyosomes grouped in the Golgi zones (Fig. 11). Their dimensions are similar to those of the vesicles separated from the dictyosomes. Accumulation of the elements occurs mostly with the dictyosomes having vesicular dilatations in the centre of the cisternae. In cells containing a large amount of dense elements, most of the dictyosomes with vesicular dilatations are placed in the centre of the cisternae. Since similar dictyosomes appear only occassionally in other objects and since dense elements of this type are isolated in this case (see WHALEY, KEPHART and MOLLENHAUER 1959), it can be assumed that they are produced by these dictyosomes.

Another manifestation of the secretory activity of the dictyosomes of *Fagopyrum* is their accumulation in the vicinity of the cell plate which is the ground of formation on the new cell walls during mitosis (Fig. 12 and 13). The vesicular elements in the vicinity of the cell plate have the same appearance and size as the vesicles, separating from the dictyosomes (Fig. 13), which is in agreement with the observations of other authors mentioned previously.

In the cells of the calyptra two forms of dictyosomes were found besides

those described below the apical point. One of these produces the vesicles which in contrast to the preceding form are in a size equal to the diameter of the cisternae of the dictyosome (microvesicle) (Fig. 7). In some cases the dictyosome spontaneously break down into microvesicles (Fig. 8).

The second form of the dictyosomes is similar to that described as hypertrophic in the calyptra of the *Zea mays* root (MOLLENHAUER, WHALEY and LEECH 1961) (Fig. 10). Its cisternae are edged by large vesicles (Fig. 9 and 10). In contrast to the dictyosomes of *Zea mays* the vesicular edges of the cisternae as well as the vesicles themselves are light. The single cisternae released from the bundles of the dictyosomes are deposited freely in the ground plasma (Fig. 10). Fusion of the vesicles with the plasmalemma, observed with *Zea mays* (MOLLENHAUER, WHALEY and LEECH 1961; SIEVERS 1963) and with *Avena sativa* (GÜNTHER 1962), was not seen.

The cisternae of the electron microscopical Golgi apparatus contain larger or smaller vesicle dilatations on the periphery and within the membrane bundle. These dilatations were called "Golgi vacuoles" and described in animal and plant objects (DALTON and FELIX 1956; SITTE 1958 etc.). These elements are now described as Golgi vesicles. However, the true vacuolar system of plant cells appears to be independent of the membranes of the Golgi apparatus in most objects investigated (BUVAT 1958, DRAWERT and MIX 1961—62, etc.).

In spontaneous hypertrophy of the Golgi cisternae in the periphery cap cells of corn, swollen Golgi cisternae were described which can be mistaken for the true vacuoles (WHALEY, KEPHART and MOLLENHAUER 1959). However, they differ from these by different grouping and prolonged $KMnO_4$ fixation also causes different staining of the content of the dictyosome vesicles as compared to the content of the true vacuoles. Other authors are of the opinion that the dictyosomes have nothing in common with the true vacuoles which are stained with neutral red and they assume that the term "Golgi vacuoles" should not be used for vesicles and vesicular dilatations, since this designation could lead to their confusion with other vacuolar elements in the plant cell (DRAWERT and MIX 1961—62). In contrast to these observations a close connection was noticed between the Golgi membranes and the young vacuoles in the apical point of barley. Vacuoles can be formed by dilatation of the intra-membrane space of the cisterna on the periphery of the dictyosome (MARINOS 1963).

In the root meristeme of *Fagopyrum* no direct relationship of the vacuoles to the Golgi apparatus was observed, although the dictyosomes sometimes lay close to the dense and light vacuoles (Fig. 14), and to the vesicles within the cisternae of the dictyosomes attain only exceptionally considerable dimensions (Fig. 15).

The relationship of the Golgi apparatus to the true vacuoles is apparently in conformity with the functional characteristics of the membrane structures in various objects.

A close spatial arrangement of the chloroplasts and dictyosomes has been observed in *Micrasterias rotata* (DRAWERT and MIX 1961—62). This arrangement, according to the authors, can be connected with the similar function of the dictyosomes and chloroplasts in the production of carbohydrates. The carbohydrate metabolism of the chloroplasts and of the Golgi apparatus was

discussed in older work of studies of the Golgi apparatus in the germ cells of *Polytrichum*. Although the opinion on the identity of the Golgi apparatus with the chloroplasts (WEIER 1932) cannot be accepted, the electron microscopical observations of the membrane systems of the chloroplasts and the Golgi apparatus show a certain similarity in the arrangement of the flat membrane types, especially when the chloroplast grana of higher plants and of the membrane of the Golgi apparatus are compared. No relationship between plastids and dictyosomes was observed in the root meristeme of *Fagopyrum*.

Discussion

On the basis of the morphological varieties observed in *Fagopyrum* and other objects the dictyosomes can be classified as follows: 1) Secreting dictyosomes. 2) Forms changed in the differentiation processes.

The secreting dictyosomes can be approximately compared with three known types of cells, forming secretes, i.e. apocrinic merocrinic and holocrinic cells, shown in Fig. 2. The dictyosomes of the first type do not change during separation of the vesicles containing the secreted substance. They are found in the meristeme cells below the apical point and in the cells of the internal part of the calyptra of the root meristeme of *Fagopyrum* (Fig. 2, pict. 1a, b, c). The dictyosomes of the second type secrete a large quantity of a substance at simultaneous disintegration or vesiculation of the peripheral cisternae. These dictyosomes can reduplicate new cisternae (see MOLLENHAUER and WHALEY 1963) (Fig. 2, pict. 2a, b). The dictyosomes of the third type desintegrate completely when the substance is secreted. In these dictyosomes hypertrophy of vesicular edges of the cisternae is observed and the cisternae are released from the bundle (see SCHNEPF 1960, Fig. 17; MOLLENHAUER, WHALEY and LEECH 1961) (Fig. 3a). In other objects the cisternae is divided into two vesicles, containing the excreted substance or the whole cisterne is enlarged

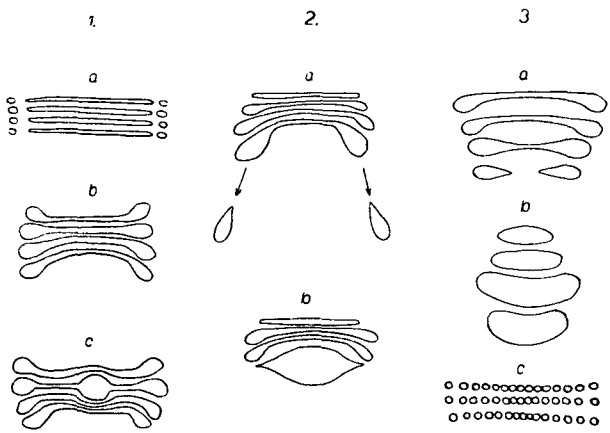

FIG 2.

Fig. 2. Forms of secreting dictyosomes
1 "Apocrinic", 2 "merocrinic", 3 "holocrinic".

(Fig. 2, pict. 3a) and gives rise to vesicular formations (see WHALEY, KEPHART and MOLLENHAUER 1959; MOLLENHAUER, WHALEY and LEECH 1961; GÜNTHER 1962) (Fig. 2, pict. 3b). It is also possible that total disintegration takes place and whole cisternae segment into microvesicles or vesicles (Fig. 2, pict. 3c). Total disintegration of cisternae of dictyosomes, as well as its segmentation to microvesicles was observed in the cells of the calyptra of *Fagopyrum*.

The forms of the dictyosomes changed during differentiation were found in the internal part of the root meristeme below the apical point. In cells differentiating to phloem and xylem elements, disintegration of the bundle of cisternae was observed at simultaneous vesiculation in a similar way as in the cells of the external part of the calyptra (see HRŠEL, MOHELSKÁ and WOLFOVÁ 1964).

The present view on the Golgi apparatus of the plant cell follows from the following information:

Based on cytochemical studies of the polysaccharides of the Golgi apparatus by the HIO_4-Schiff reaction in the light microscope the opinion has been expressed previously that this structure is connected with carbohydrate metabolism and its function in the formation of cell walls in plant cells (GERSH 1949). Based on electron microscopical observations the Golgi apparatus in the plant cell like in the animal cell is considered primarily as a structure connected with secretion. In plants it secretes substances containing carbohydrates compounds necessary for the formation of cell walls (see DRAWERT and MIX 1961—62). In other cases it produces polysaccharides of mucoid character which are secreted by the cell (SCHNEPF 1963, 1963a, b). In special cases the Golgi apparatus can also participate in the formation of true vacuoles by dilatations of the cisternae (MARINOS 1963). The comparatively large polymorphism of the dictyosomes in the root meristeme cells of *Fagopyrum* as compared to other objects can be explained by their participation in the secretion of carbohydrates as well as in the production of dense bodies. The dictyosomes with vesicular dilatations of the cisternae have a similar function as the Golgi apparatus of the animal cell which in the described cases participates in the formation of lysozomes belonging to similar elements (lit. see NOVIKOFF, ESSNER, GOLDFISCHER and HEUS 1962). This opinion is supported by the observation of acid phosphatase localization in the vesicles connected and unconnected with the dictyosome in the plant object *Triticum vulgare* (POUX 1963).

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Ivan Hršel, Ústav experimentální botaniky, Československá akademie věd, Praha: **Morfologie a funkce Golgiho aparátu.** — Biol. Plant. **7** : 437—448, 1965.

Polymorfismus dictyosomů v kořínkovém meristému *Fagopyrum* souvisí s jejich různou funkcí při sekrečních pochodech a diferenciací buněk. Dictyosomy obsahující vesikulární dilatace cisteren, které se vyskytují u tohoto objektu častěji než u jiných, se pravděpodobně účastní analogickým způsobem jako Golgiho aparát živočišné buňky vzniku lysozomů při tvorbě útvarů, náležících podobně jako lysozomy, do skupiny hustých tělísek. Tato tělíska jsou v cytoplasmě u buněk, které obsahují dictyosomy s vesikulárními dilatacemi, ve velkém množství. U ostatních forem dictyosomů byly nalezeny známky, které svědčí, že spolupůsobí při produkci polysacharidového materiálu buněčných stěn podobně jako většina dictyosomů jiných rostlinných objektů. Nebylo však pozorováno splývání Golgiho vesikulů s plasmalemmou. Podle morfologického vzhledu bylo provedeno utřídění typických forem dictyosomů na základě jejich vztahu k sekrečním pochodům. Zároveň byla srovnávána morfologie a funkce Golgiho aparátu v buňce živočišné a rostlinné. Řada morfologických úchylek dictyosomů rostlinných buněk, které byly nalezeny po účinku patogenních faktorů a vlivu fixačních postupů, byla v malém množství pozorována také v buňkách studovaného objektu.

И. Гршел, Институт экспериментальной ботаники ЧСАН и Институт экспериментальной биологии и генетики ЧСАН, Прага: **Морфология и функция аппарата Гольджи.** — Biol. Plant. **7** : 437—448, 1965.

Полиморфизм диктиосом в корневой меристеме *Fagopyrum* связан с их разной функцией при процессах секреции и дифференцировки клеток. Диктиосомы, содержащие везикулярные дилатации цистерн, которые встречаются у этого объекта более часто по сравнению с другими, участвуют-повидимому-аналогичным образом как аппарат Гольджи животной клетки в возникновении лисозом при образовании структур, принадлежащих подобно лизосомам к группе густых телец. Эти тельца находятся в большом количестве в цитоплазме клеток, которые содержат диктиосомы с везикулярными дилатациями. У других форм диктиосом найдены признаки, свидетельствующие о том, что они содействуют при продукции полисахаридного материала клеточных стенок подобно большинству диктиосом других растительных объектов. Однако, не наблюдалось слияния везикулов Гольджи с плазмалеммой. Типичные формы диктиосом были классифицированы по морфологическим признакам на основании их отношения к процессам секреции. Сопоставлена также морфология и функция аппарата Гольджи в животной и растительной клетках. Ряд морфологических отклонений диктиосом растительных клеток, которые найдены после действия патогенных факторов и влияния процессов фиксации, наблюдался в малом количестве также в клетках изучаемого объекта.

Fig. 3. Dictyosomes from the area below the apical point
Dictyosome with normally developed cisternae. DB Dense body. Magnification 40 000×.

Fig. 4. Dictyosomes from the area below the apical point
Most frequent form of dictyosomes with vesicular dilatation (V) in the centre of the cisterna. DB Dense body in close vicinity of the cisternae of the dictyosome. Magnification 40 000×.

Fig. 5. Dictyosomes from the area below the apical point
Dictyosomes with curved cisternae. Magnification 25 000×.

Fig. 6. Dictyosomes from the area below the apical point
Dictyosome with concentrically shaped cisternae, V = vesicle, DB dense body in the immediate vicinity of the dictyosome. Magnification 40 000×.

Fig. 7. Dictyosome from the area of the calyptra
Dictyosomes (D) producing microvesicles. M Mitochondria, N nucleus. Magnification 20 000×.

Fig. 8. Dictyosome from the area of the calyptra
Disintegrating segmenting dictyosomes producing microvesicles. Magnification 20 000×.

Fig. 9. Dictyosome from the area of the calyptra
Dictyosomes, containing large numbers of vesicles on the peripheral cisternae, and vesiculated cisternae, apparently due to interception of the edges of the dictyosomes during cutting. D Dictyosome, DV dense vacuole, M mitochondria. Magnification 20 000×.

Fig. 10. Dictyosome from the area of the calyptra
Dictyosome with released cisternae. One isolated cisterna (C). DB Dense body in immediate vicinity of the cisterna. Magnification 45 000×.

Fig. 11. Cells below the apical point
Golgi zone, containing dictyosomes surrounded in the immediate vicinity by groups of dense bodies (DB). Magnification 25 000×.

Fig. 12. Cells below the apical point
Dictyosomes (D) in the immediate vicinity of the formation of the cell plate, N Nucleus. Magnification 16 000×.

Fig. 13. Cells below the apical point
Dictyosomes (D) in the vicinity of the formation of the cell plate, producing vesicular elements corresponding to the vesicles in the structure of the cell plate. Magnification 23 000×.

Fig. 14. Cells below the apical point
Two dictyosomes (D) closely adhering to the dense vacuole (DV). Magnification 20 000×.

Fig. 15. Cells below the apical point
Dictyosomes with enlarged vesicular dilatation (V). In the vicinity a group of dense bodies (DB) in connection with vesicles and cisternae of uncertain origin. Magnification 24 000×.

Fig. 3

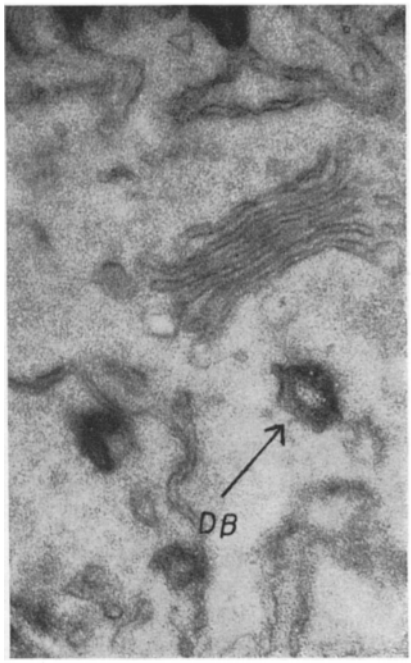

Fig. 4

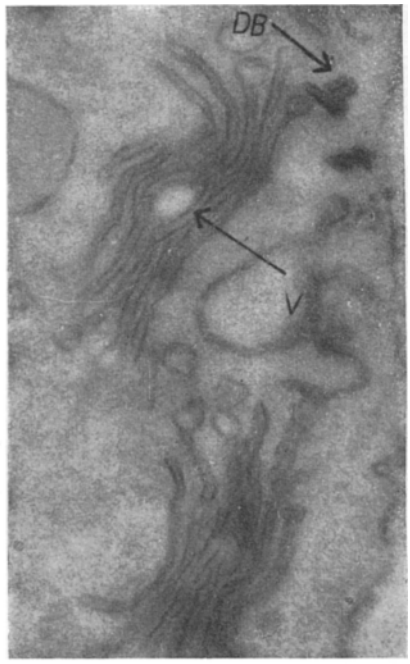

Fig.5

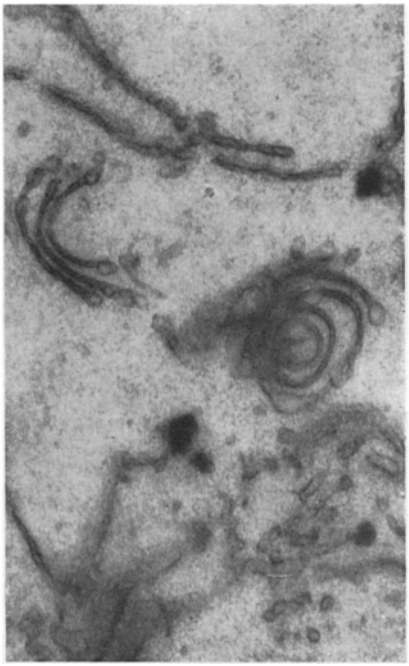

Fig. 6

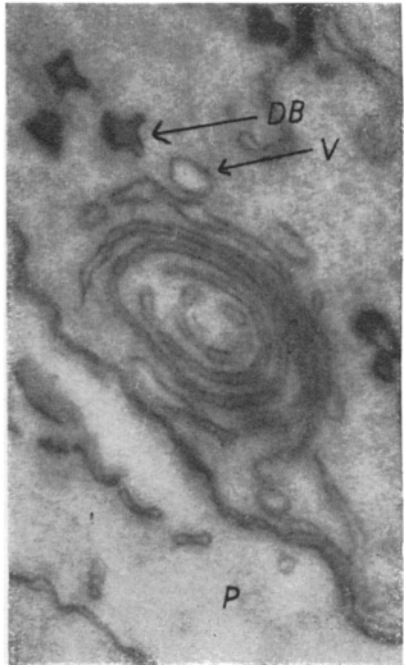

Fig. 7

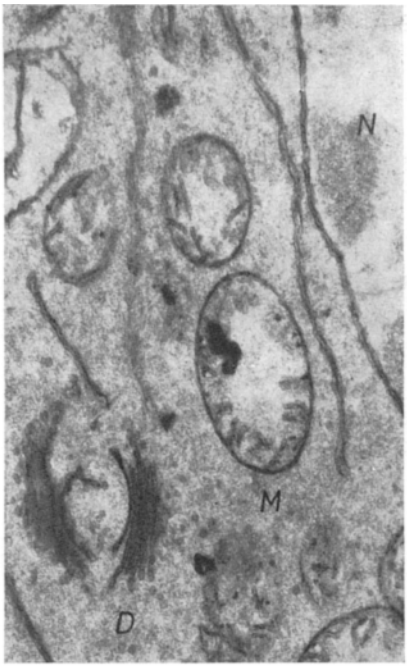

Fig. 8

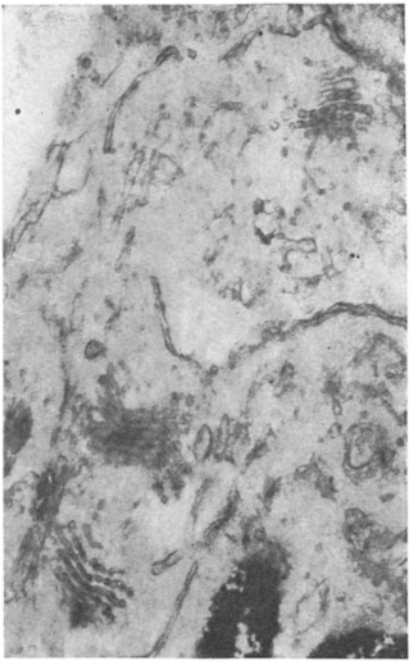

Fig. 9

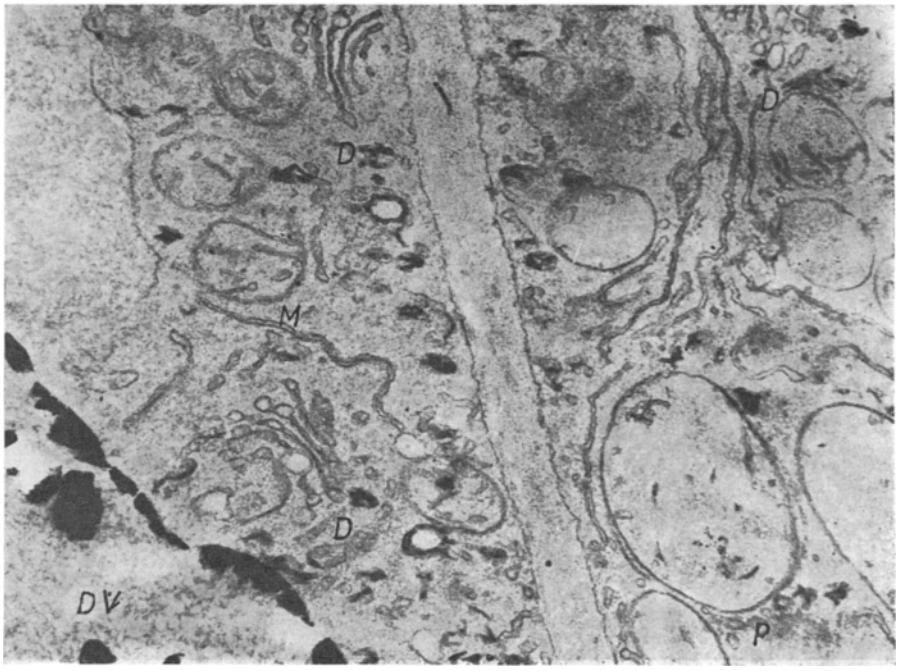

Fig. 10

Fig. 11

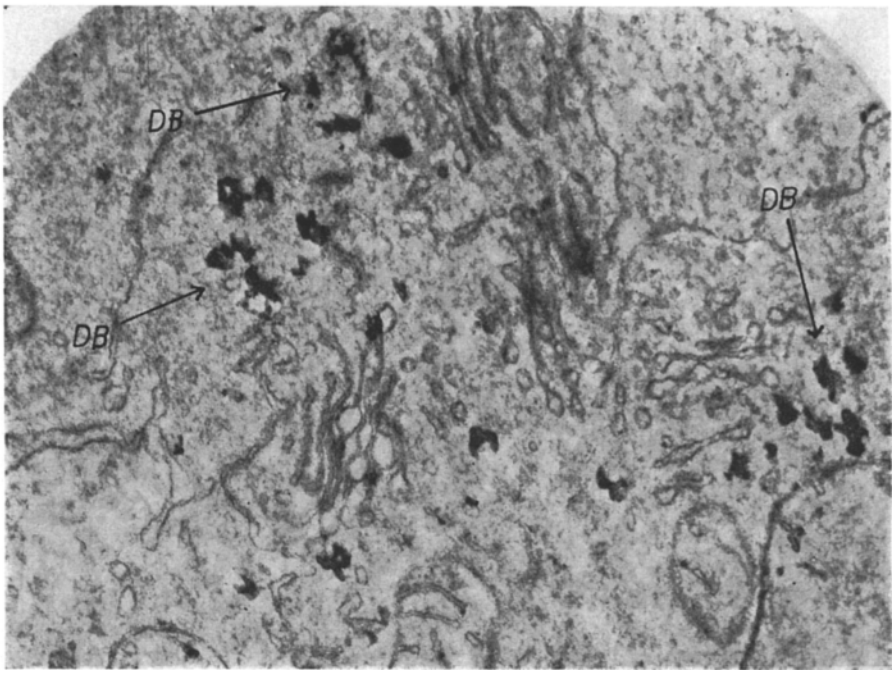

Fig. 12

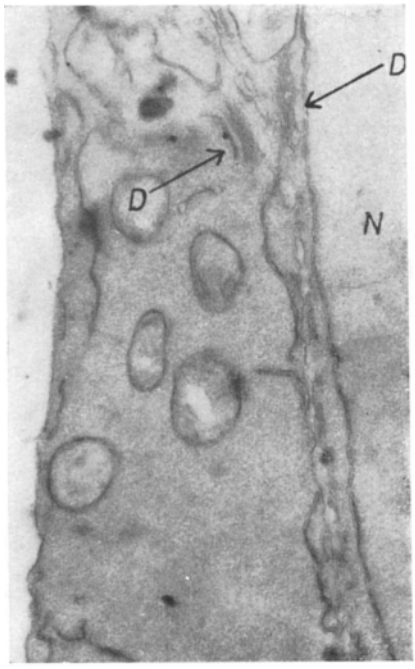

Fig. 13

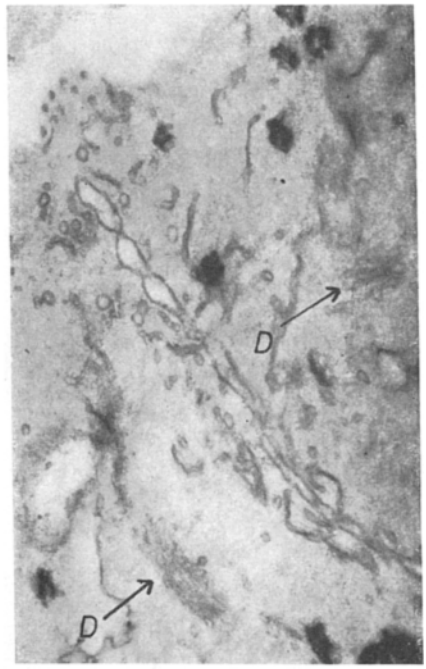

Fig. 14

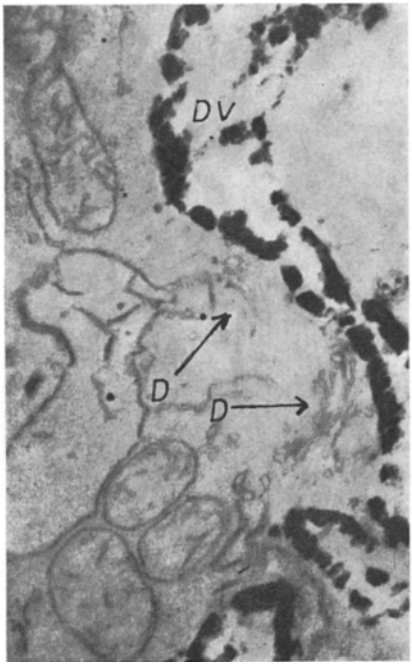

Fig. 15