Although the Golgi-apparatus is one of the most described cell components, little is known about its function. For the enormous number of papers relating to the subject I may refer to the reviews of Hirsch (1939) and Hibbard (1945).

The exocrine pancreas cell is a very suitable material for the study of this problem. Three arguments may be put forward for this statement. In the first place with the usual techniques it is easy to make visible the Golgi-apparatus in this cell. Secondly, the pancreas cell forms microscopically visible products during its functional activity, the pro-enzyme granules. Thirdly, there is an undeniable topographical relationship between the Golgi-apparatus and these pro-enzyme granules. The last-mentioned fact points to the possibility that the apparatus is cooperating in the process of formation of the granules in the pancreas cell.

It is important to know as much as possible of the structure of the apparatus in order to learn more about its function. Precise descriptions have been given by many authors (Morelle 1925, 1927, Nassonov 1924, and others), but doubt has arisen with respect to some points concerning the structure of the apparatus in the pancreas cell of the white mouse on account of the conflicting results of Ries (1935), Hirsch (1939, 1940) and Järvi (1940). Especially the discussion between Hirsch (1940) and Järvi (1940) on the subject will be reviewed below. For the moment is suffices to remember the fact that each of the three last-mentioned authors used the impregnation technique with osmic acid according to Kopsch (as modified by Kolatchev) to study the same organ of the same animal. Hirsch (1940) and Järvi (1940) even partly used the same sections. Nevertheless, their interpretations of the Golgi-images obtained in this way differ greatly.

Therefore, the first aim of this paper has been to re-investigate the structure of the Golgi-apparatus of the pancreas cell of the white mouse after osmic impregnation, in order to find out whether technical failures can have caused contradictory statements, as mentioned above. After that, I have tried to give a true description of this structure and of its functional changes as it shows itself in fixed material after osmic impregnation.
Technical aspects of the problem.

Among the impregnation techniques for the Golgi-apparatus KOPSCHE'S method (as modified by KOLATCHEV) is the most adequate to apply to pancreas material, as it is the most selective one: Champy-fixation during 24 hours and OsO₄-impregnation during 3—8 days in a 1 % solution at 35° C. The effects of this treatment on tissues have been fully discussed by HIRSCH (1939). Therefore, it will suffice to make some remarks concerning especially important points.

It is a well-known fact that even after KOPSCHE'S technique and its modifications besides the Golgi-apparatus several other cell substances can be blackened. It is often a matter of some difficulty to decide which of these substances do belong to the Golgi-apparatus and which do not. RIES (1935) observed in the pancreas cell the structures called „lipochondria” by him, to be blackened after impregnation with osmic acid and reckoned them among the Golgi-structures, but JÄRVI (1940) proved them to be pigment granules which can be found in adult animals only. Hence, this paper has been based on material of juvenile white mouses as well as of adult ones and it was found again that “lipochondria” do not occur in the pancreas cell of juvenile animals.

After Champy-fixation, the outer parts of the piece have been badly fixed. This is caused, probably, by the different rate of penetration of the components of the fixing mixture. Moreover, these outer parts appear to be surfeited with osmium even after a moderate impregnation with osmic acid (MORELLE 1925). In sections, one can always distinguish several zones showing different degrees of impregnation and fixation. JÄRVI (1940) already presumed that RIES (1935) did not sufficiently take into account this phenomenon and, therefore, came to the false conclusion that the Golgi-apparatus of the pancreas cell periodically disappears. But even when one recognizes this danger it is difficult to decide which degree of impregnation should be preferred in order to study the structure of the apparatus. According to JÄRVI (1940) the finest threads, connecting the Golgi-elements with each other, are not visible after light impregnation, but this author admits that a stronger impregnation may mask the finest details in thicker Golgi-threads. The same difficulties are important for a decision as to the most adequate thickness of the sections.

In this paper special attention has been paid to lightly impregnated and very thin sections (1—3 μ). Contrary to the most recent authors who studied the pancreas (RIES, HIRSCH, JÄRVI) I have counterstained these impregnated sections with ALTMANN'S acid-fuchsin. The counterstaining technique yields several profits, whereas is causes no damage at all to the Golgi-apparatus. Badly-fixed cells can easily be recognized, the protoplasm being overcharged with acid-fuchsin. In wellfixed cells the protoplasm appears to form a lightly-coloured background to red mitochondria, yellow-red pro-enzyme granules, black Golgi-structures and white vacuoles.
Results

The figures 1—9 on page 356 show a number of sections of exocrine pancreas cells in different stages of their activity, which can be found in the pancreas of every normal white mouse having permanently access to food. The sequence of these figures reproduces the well-known production cycle of the pancreas cell.

The first two rows of cells (fig. 1—6) represent the process of formation of pro-enzyme granules. These cells are in the "restitution period" according to the nomenclature of Hirsch. At the end of this period, the cell reaches the accumulation stage (fig. 7); it contains a big mass of granules. The figures 8 and 9 show the extrusion of products, which is characterized by the occurrence of big vacuoles originating from the deliquescence of pro-enzyme granules.

Moreover, all these figures show the Golgi-apparatus, blackened with osmium. The figures suggest very strongly that the apparatus is changing gradually and in a definite way during the restitution period. Still, the data given in this paper do not prove this at all. In my opinion, a subjectively arranged series of different cells cannot be used in all cases, and particularly not in this case, to make a true reconstruction of a process that is going on in one cell. Therefore, only the following definite conclusions can be drawn from the observations made in this investigation.

The Golgi-apparatus of the exocrine pancreas cell has, as a whole, the structure of a continuous network in all stages of its activity. This may not be visible in very lightly impregnated sections, but it is obvious in stronger impregnated ones, even when the cells have reached the accumulation stage. This is in accordance with Järvi's view (1940)1—3. The assertion of Hirsch (1940) as to the occurrence of isolated Golgi-elements does not hold for the pancreas cell as far as Kolatchev's preparations can show.

In very thin and lightly impregnated parts of a section small vacuoles can be observed being always in connection with the Golgi-apparatus (fig. 2—9). It is a very difficult matter to decide whether these vacuoles are lying in the centre of the blackened Golgi-threads or are only attached to them very closely. In the sections they are never quite encircled by black substance, but the fact that parts of the black rings are missing may be caused by insufficient impregnation. These Golgi-vacuoles have, probably, been observed by Morelle (1927) but it is doubtful whether Järvi (1940)1 has seen them. Speaking about meshes in the Golgi-net and vacuoles this author says on page 25: "Es muss daher besonders betont werden, dass es meistens wegen der Kleinheit und Zartheit der Strukturen nicht gelingt, die Form dieser Maschen treffend, entweder als Vakuole oder als Schlinge, genau zu charakterisieren". Nevertheless Hirsch (1940) contends to have seen distinct Golgi-vacuoles in Järvi's preparations.

Hirsch (1940) asserts the shape and mass of the Golgi-net to change
in a specific way during the restitution period. Järvi (1940)\textsuperscript{1} denies that any changes of that kind worth mentioning occur. However, a mere look at the figures 1—9 of this paper convinces one of the fact that important changes in the shape of the apparatus may occur. In some cells (fig. 1) Golgi-vacuoles are lacking completely, in other ones they are abundant. It is more difficult to decide whether the mass of the blackened substance is changing or not. This mass seems to decrease as the restitution of pro-enzyme granules makes progress, but this may be a false impression caused by the Golgi-net being stretched out as the mass of granules increases.

All previous investigators of the pancreas agree that there can be a marked topographical relationship between the Golgi-apparatus and the pro-enzyme granules. In the accumulation stage (fig. 7) this may be a consequence of the circumstance that there is hardly any room left in the cell for the two to lie apart. But in other cases (for instance like that of fig. 4) little groups of granules are attached to the apparatus in such a manner that a functional relation is suggested rather strongly. However, as I pointed out on page 355, it is, in my opinion, not permitted to draw a conclusion from incidental indications like this. I shall revert to this point in the next paper of this series.

\textit{Summary.}

In thin (1—3 \(\mu\)) preparations of the pancreas of the white mouse, impregnated lightly according to Kopsch' technique as modified by Kolatchev, and counterstained with acid fuchsin (Altmann) the following observations can be made. The Golgi-apparatus of the exocrine pancreas cell has, as a whole, the structure of a continuous network in all stages of its activity. Small vacuoles can be observed in varying numbers, lying always in connection with the apparatus. They cannot be mistaken for the protoplasm-containing meshes of the network. Important changes in shape of the apparatus may occur during the period of restitution of pro-enzyme granules. There can be a marked topographical relation between Golgi-apparatus and pro-enzyme granules, suggesting a functional relationship between the two without giving definite proof of this.

\textbf{REFERENCES.}


Fig. 1—9. Sections of exocrine pancreas cells showing pro-enzyme granules, Golgi-apparatus with vacuoles and some of the mitochondria at different stages of the production cycle of the cell. CHAMPY-fixation, KOLATCHEV-impregnation, ALTMANN-staining. × 3000. Fig. 1—6: restitution period. Fig. 7: accumulation. Fig. 8—9: extrusion.
Die Beziehungen zwischen dem Vitamin C und der Golgi-Substanz im exokrinen Gewebe des Pankreas und in den Speicheldrüsen der Katze. Protoplasma 34, 362 (1940)


Les constituants du cytoplasme dans le pancréas et leur intervention dans le phénomène de sécrétion. Cellule 37, 75 (1927).
