Surface structure of starch granules*

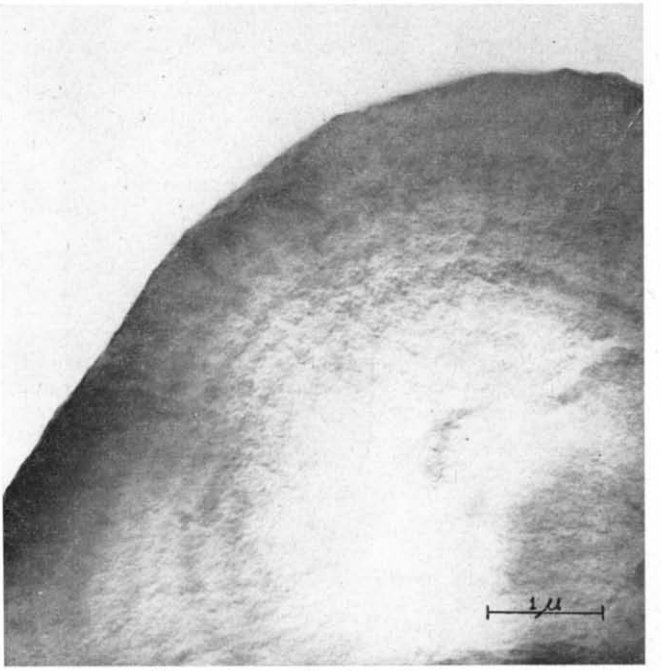

Fig. 1. A corn starch section 15,500 ×.

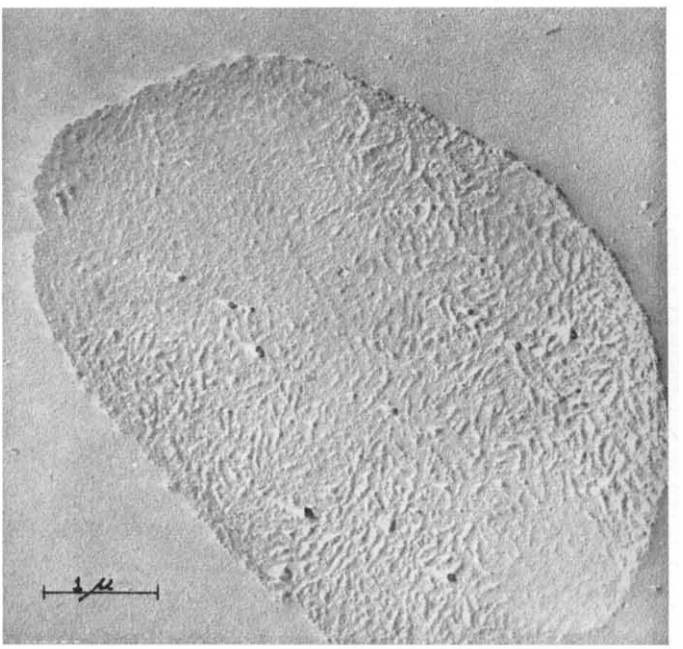

Fig. 2. A collodion replica of corn starch 15,500 ×.

The surface structure of starch granules is of industrial and biological importance. Surface structure influences sorptive power of granules and probably influences chemical reactivity of granules by affecting the rate of chemical penetration. Very likely the surface structure influences to some degree the rate at which granules are enzymically digested.

While starch granules have been examined extensively with light microscopes, their fine structure as revealed by the electron microscope has been little examined. The principal reason that starch granules have not been examined at high magnification is that they are too thick to be observed directly in the electron beam without undergoing extensive damage; although some electron micrographs of whole granules have been published[1].

Evidence now obtained by several methods suggests that the surfaces of native starch granules are remarkably smooth. Numerous observations of ultra-thin sections have shown a rather uniformly smooth outline without evidence of extensive wrinkles, crevices or pits. This has been true especially of corn, oat and wheat starches (seed starches) which have been the primary subjects of examinations. Sections were made with a wedge-modified Spencer Model 820 rotary microtome using glass knives mounted in a rocking knife-holder adapted for this microtome from the design of DEMPSEY AND LANSING[2]. Usually granules were embedded for sectioning in a mixture of 20% methyl methacrylate in *n*-butyl methacrylate either directly or by vacuum embedding, or by passing through a water-alcohol-methacrylate sequence. After sectioning, the specimen on its supporting grid

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was extracted by submerging in toluene for 10 minutes to remove embedding material. An example of a smoothly rounded edge in corn starch is shown in Fig. 1.

Surface replicas of granules were made by both the wet and the dry methods. In the wet method the usual agar-collodion procedure was used. Granules were atomized onto a partially cooled and hardened 2% agar gel. After the granules had partially submerged in the gel a 1.5% collodion solution was drained across the gel and the film thus formed floated off with water. Specimens on grids were chromium shadowed at an 18° angle. In the dry procedure granules were atomized on acetone moistened collodion covering a glass slide. Granules were then removed from the hardened film by digestion with saliva for 24 h at 40° C followed by a 1% malt diastase solution for 24 h. On washing and drying the collodion was shadowed lightly with chromium and coated with a 100 A layer of silicon dioxide (du Pont Ludox)[3]. After placing on a grid the collodion was removed by dioxane in a KELLENBERGER extractor[4].

Figs. 2 and 3 show replicas of corn starch granules made by the two procedures. Similar surfaces are shown by commercial corn starch, native granules teased from the flowery endosperm of corn grain and by corn starch defatted with 80% methanol. The surface of an oat granule is shown in Fig. 4.

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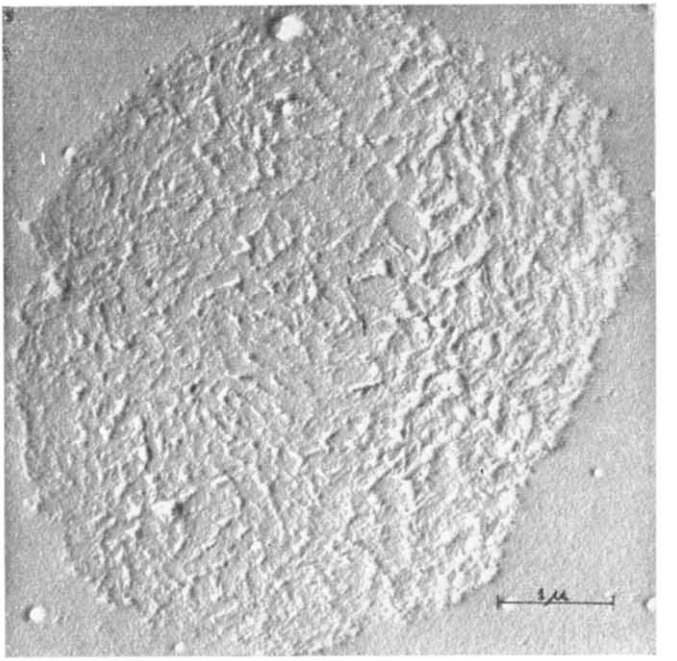

Fig. 3. A silica replica of corn starch 15,500 ×.

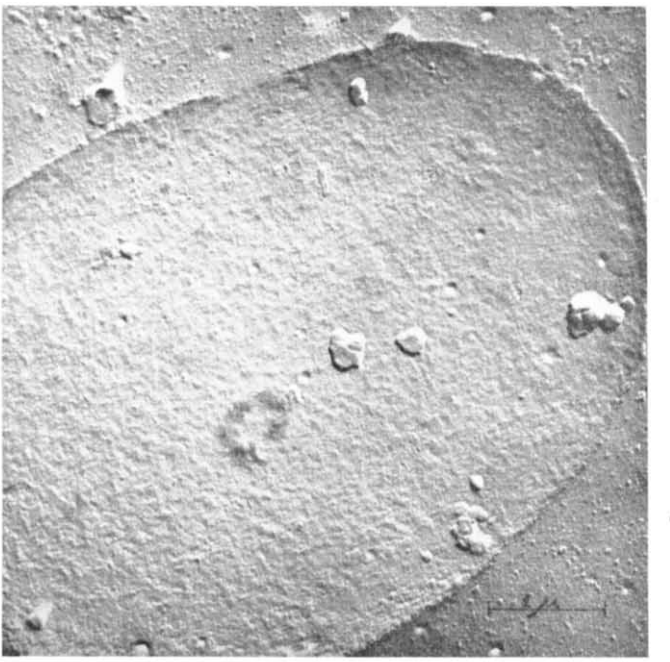

Fig. 4. A collodion replica of oat starch 15,500 ×.