THE INTRACELLULAR FIBRE SYSTEMS OF PARAMECIUM

BY LEONARD G. WORLEY

Zoölogical Laboratories, Harvard University

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Within the present century, at least two sets of intracellular fibres, considered of significance in the coördination of the beat of the cilia of Paramecium, have been described. Rees (1922) has emphasized the importance in this respect of a group of fibres, each of which has its origin at a basal granule in the ectoplasm and then follows a course through the endoplasm toward the nuclear region where all of the fibres are said to converge and from what has frequently been called a "motorium." These fibres have been termed by some authors the "fibres of Rees" and they constitute, together with the motorium, the so-called "neuromotor apparatus" of Paramecium. This "neuromotor apparatus" has been demonstrated in sections of Paramecium stained with iron haematoxylen. Rees's figure of this system has been reproduced in several publications.

An ectoplasmic system of fibres has also been noted in fixed Paramecium material. Apparently Schuberg (1905) was the first to observe that the basal bodies of the cilia were directly connected by means of longitudinal ectoplasmic fibres. These fibrillae, which run the length of the cell, were disclosed in specimens killed with osmic acid and treated with dahlia, tannin and iron haematoxylen. This investigator pictures the basal corpuscles arranged in longitudinal rows and shows a fibre connecting all of the corpuscles of each row.

Silver impregnation methods have been employed recently by Klein (1928; 1929) and Gelei (1932) in revealing the structure of this same system of fibres. These authors have described the apparatus in considerably greater detail than was done by Schuberg and have called the rather complicated organization of fibres which they have demonstrated in a large number of ciliates, the "silver-line system." The longitudinal fibrillae have been referred to as the "direct connecting fibres" by Klein (1928), but according to this writer, there also exist "indirect connecting fibres" in the ectoplasm which connect transversely the longitudinal rows. The direct connecting fibres and the cross fibres divide the ectoplasm into small rectangular or hexagonal areas or "Feldchen" which over the greater portion of the surface of Paramecium are arranged somewhat like bricks in a wall. The paths of the longitudinal fibres are straight while the indirect connecting fibres must follow a crooked course around the "Feldchen." The cross fibres meet the primary connecting fibres in the intervening spaces between basal bodies. They are consequently in communication with the basal bodies only indirectly.
It is noteworthy that these fibre organizations, both the neuromotor mechanism of Rees and the silver-line system of Klein and of Gelei, have been disclosed only in fixed and stained or impregnated material. As far as I am aware, neither sets of fibres have ever been observed in living cells. For this reason and others, the existence of such an apparatus as Rees has described has been doubted by Alverdes (1923) and Jacobsen (1931) and its rôle as a neuromotor device has been questioned by Hofker (1928) and Parker (1929). The function of the “neuromotor apparatus,” if it exists at all, remains to be ascertained. The silver impregnation method employed by advocates of the silver-line system might be criticized because there is no positive assurance that the structures seen in such preparations are not, in part at least, of an artificial nature. The drying process used by Klein cannot help but result in some distortion of the material so treated. Klein (1929) has, however, ascribed a coördination and conductile function to this set of fibres. It occurs to me that it would be appropriate to possess unquestionable proof of the existence of such fibres before a function is attributed to them. With this consideration in mind, the following observations are presented.

It has been found possible by employing microdissection methods to remove the ektosarc from Paramecium individuals and to flatten it against
the cover glass within a moist chamber. Two microdissection needles, with their tips bent at right angles to the main shafts, are usually utilized in this process. These are inserted through the ectoplasm and into the endoplasm of an individual Paramecium specimen at as nearly as possible the same point. They are then moved apart slowly and a large rent out of which the endoplasm pours is consequently formed. The surface tension of the film of water on the cover slip aids in flattening out a large area of ectoplasm in a plane parallel with the glass. With the endoplasm thus disposed of, observations of the ectoplasmic structure not possible otherwise are facilitated.

In living, unstained ectoplasmic sheets secured in the manner just described, the longitudinal or direct connecting fibres of the silver-line system can be clearly seen extending antero-posteriorly, joining the basal bodies in the manner described by Schuberg and Klein. On the dorsal or aboral surface the basal corpuscles of two adjacent rows are usually alternate in position or nearly so (Fig. 1). Cilia, basal granules and longitudinal fibres are visible. The margin of such a sheet of ectoplasm frequently becomes "frayed out" and single isolated fibres bearing their basal bodies
are not uncommonly seen. Such isolated fibres resemble in their appearance strands of loosely strung beads.

The longitudinal fibres of the dorsal side appear not to be held together by any definite structures other than the undifferentiated ectoplasm and they break away from each other and float about in the fluid surrounding the preparation. The indirect connecting fibres or cross fibres are supposed to be of approximately the same diameter and structure as the longitudinal connecting fibres and they should be expected to be seen with almost equal clarity. They are, however, invisible in my preparations. Indirect connecting fibres have never been observed in living material in areas where basal corpuscles do not lie opposite each other on adjacent rows. In the vicinity of the cytostome (Fig. 2), however, basal granules are arranged in horizontal as well as longitudinal rows and in the intervening spaces between basal granules, cross fibres pass, radiating in several directions from the pharynx. These are fairly straight fibres and they appear to be continuous across the longitudinal rows. Brown (1930) faintly indicates perpendicular fibres of this kind around the cytopharynx in the figures accompanying his work. In figure 2, the proximal margin of the cytostome is visible at the lower edge of the photograph. The longitudinal or direct connecting fibres extend horizontally in the picture while the cross fibres run vertically, meeting the primary fibres perpendicularly or nearly so. Isolated fibres with their attached basal bodies appear in the upper right-hand corner of the figure.

No evidence for the existence of the fibres of Rees has ever been obtained in my studies, but I believe that it may be safely stated that the direct connecting fibres and the indirect connecting fibres in the vicinity of the cytostome in Paramecium are not artifacts.


