# ON THE STRUCTURE OF PROTOZOAN FLAGELLA

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Among the flagellate micro-organisms (protozoa, algae, swarm spores of fungi, etc.) there exists a diverse assortment of flagellar types. One type of flagellum is somewhat feather-like. It has a shaft composed of a fibrillar core or axoneme enclosed by a sheath, and along one or both sides of the flagellum there extend many delicate filaments. A German worker (3), describing these filaments long ago, called them "Flimmer." Cox (2) and Brown (1) employ this widely-used term in preference to various others which have been introduced. Euglenoids generally possess a flagellum with a single row of flimmer along one side. The chrysomonads or yellow-brown algae commonly exhibit one short simple flagellum and a relatively long flimmer-flagellum with filaments on both sides. Cox (2) is the first to demonstrate the presence of flimmer upon cryptomonad flagella. They appear to be distributed along the flagellum somewhat as in *Euglena,* although they seem to be sturdier than those of the euglenoids.

There is no general agreement, as yet, concerning the nature and significance of flimmer. We do not know how they are formed or what functions they perform, if any. It is not even known with certainty whether they occur upon the flagella of normal living flagellates. What is proposed in this paper is one hypothesis concerning the possible nature of flimmer and their mode of formation. It is based upon electron micrographs of the flagella of various protozoa, but especially upon those of *Ochromonas variabilis* Meyer (Order Chrysomonadina) depicted by Brown (1) and Cox (2), upon suggestions by Owen (5) and Pitelka (6), and upon a vivid imagination. The hypothesis is as follows:

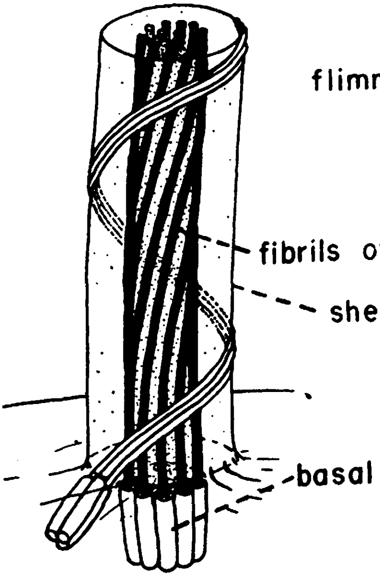


*FIGURE 1*

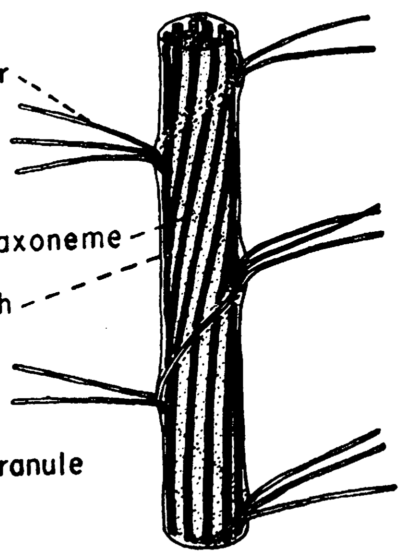


*FIGURE 2*

The basal granule, a deeply-staining body in the cytoplasm at the base of the flagellum, contains a cluster of about a dozen "fibril factories." (See Fig. 1.) Each of these "factories" consists of enzyme molecules which "manufacture" protein micelles or fibrils. As the fibrils are pushed out toward the cell surface and beyond, the cell membrane and a layer of cytoplasm are carried outward, forming the flagellar sheath. The bundle of fibrils forms the axoneme of the growing flagellum. A smaller group of "fibril factories"—let us say three—is extruding another bundle of fibrils at the same time. This second factory cluster is closer to the cell membrane, has greater access to oxygen diffusing inward, and thus, with a higher metabolic rate than the basal granule, extrudes its fibril bundle somewhat more rapidly than does the basal granule. This difference in growth rate results in a coiling of the superficial fibrils about the axoneme, and produces a fibrous helix in the sheath.

Under certain conditions (perhaps in the normal, active organism), the fibrils of the sheath fray into individual micelles which commonly remain attached only at one end (Fig. 2). These are the flimmer. One, two, or all three of the parallel micelles may fray out in any given region along the flagellum. If, during drying (as in the preparation of specimens for electron microscopy), the sheath membrane shrinks back toward the axoneme, bumps or ridges remain in the region of the helical fibrils, and the flimmer arise from these bumps, as seen in Miss Cox's micrographs (2).

As indicated before, the above account is purely hypothetical. However, a few points which fit into such an interpretation might be mentioned. The length and location of the flimmer, as seen in electron micrographs, are just right for such an interpretation. The diameter of the flimmer, which we estimate at about 0.02 or 0.03 micron, is within the range cited for axial (axoneme) fibrils of various protozoa by other investigators (e.g., 0.025 - 0.04 micron is cited as the diameter of axial fibrils of *Trichonympha* flagella by Schmitt, Hall, and Jakus, (8) ). Various proteins, including myosin, collagen, and fibrin, commonly form fibrils of these dimensions (4, 7).

If the unilateral flimmer of *Chilomonas* and the euglenoids originate in the manner here hypothesized, each micelle represents one entire helical turn around the flagellum, instead of a half-turn as diagrammed for *Ochromonas*. Also, the coils of the helix must be closer together than in*Ochromonas*. Perhaps the types of flagella which do not exhibit flimmer have a non-fibrous sheath.

## LITERATURE CITED


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