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Trypanosoma lewisi Kent (Protozoa: Mastigophora): Ultrastructure and Theory of Locomotion

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ABSTRACT

Trypanosoma lewisi Kent is a nonpathogenic hemoflagellate of rats (Rattus spp.). After briefly reviewing its ultrastructure, the writers postulate that inside the flagellum the change in shape of kinetosomal plate 1 may cause one of the central microtubules and the helical-like structure to contribute to flagellar movement. The energy to run this system may be transferred from the kinetoplast with its associated mitochondrion.

INTRODUCTION

Trypanosoma lewisi Kent is a nonpathogenic hemoflagellate of the black rat, Norway rat, and other Rattus spp. It is transmitted in nature by the rat flea, Nosopsyllus fasciatus (Bosc, 1801); Jordan, 1933.

The purpose of this study is to confirm the findings of a similar investigation by Anderson and Ellis (1965) and to contribute further to their postulation concerning the mechanism of flagellar movement.

MATERIALS AND METHODS

White rats (Rattus sp.) about 1-2 months old were injected intraperitoneally with Trypanosoma lewisi (Wotton and Becker, 1963).

The trypanosomes freed from contaminating host tissue cells were pelleted by the method of Linecio and Watkins (1963). The pellet of trypanosomes was fixed in 6.25% glutaraldehyde in 0.2 M cacodylate-buffer at pH 7.2-7.4 for 2 hr at 0-4°C. The pellet then was washed with the same buffer three times for 10-20 min each time. Before osmication, the pellet was teased apart to make 1-mm³ blocks. Osmication was carried out for 2 hr at 0°C in a 1% solution of veronal-buffered osmium tetroxide at pH 7.4 (Palade, 1952).

The blocks were dehydrated through a graded series of ethanol, treated in two changes of propylene oxide for 1 hr each, and embedded in Epon 812 (Pease, 1964). The blocks were sectioned with an LKB Ultratome at 600-800 Å. Sections were double stained in 2% aqueous uranyl acetate for 2 hr (Watson, 1958) and lead citrate for 10-20 min (Reynolds, 1963) before examination with a Siemens Elmiskop 1A.

RESULTS AND DISCUSSION

The cell membrane is typically trilaminar with longitudinal subpellicular microtubules running parallel beneath it (Figs. 1, 2). The cell membrane invaginates near the posterior end of the organism to form two flagellar pockets, and the area where the flagellar membrane and the cell membrane meet is the attachment zone (Figs. 1, 2). The attachment zone may have the same morphological characteristics as the desmosome in vertebrate epithelial cells (Anderson and Ellis, 1965).

The flagellum consists of nine peripheral and two central longitudinal microtubules, the typical 9 + 2 pattern (Fig. 2). One of the central microtubules, along with a helical-like structure, arises form kinetosomal plate 1 and traverses the length of the flagellum (Fig. 1); the other central microtubule originates at the disc-like kinetosomal plate 2, passes through kinetosomal plate 1, and parallels the other central microtubule (Fig. 1) as described by Anderson and Ellis (1965). The nine paired peripheral microtubules are embedded in the cytoplasm forming the primary kinetosome. Each of these nine peripheral microtubules consists of two subunits; subtubule A has an arm-like structure; subtubule B is without this structure but may contain a lateral arm which bisects subtubule B forming a doublet pattern (Fig. 2), thus confirming the original observations of Anderson and Ellis (1965).

According to Anderson and Ellis (1965), the proximal end of the primary kinetosome consists of nine peripheral triplet

Figure 1. Longitudinal section through posterior of organism. Cell membrane (Cm), central microtubules (Ct), endoplasmic reticulum (Er), flagellar membrane (Fm), flagellar pocket (Fp), Golgi complex (G), helical-like structure (Hs), primary kinetosome (K), secondary kinetosome (Kt), curved kinetosomal plate 1 (K1), kinetosomal plate 2 (K2), kinetoplast (Kp), mitochondrion (M), peripheral microtubules (Pt), ribosome (R), Subpellicular microtubules (Sm), triplet microtubule (T), and attachment zone (Z). 18,000x.
Figure 2. Oblique section through attachment zone (Z). Subtubule A (A) with arm-like structure, subtubule B (B), cell membrane (Cm), two central microtubules (Ct), lateral arms (La) in some peripheral microtubules (Pt), and subpellicular microtubules (Sm). 30,000x.

Figure 3. Cross section through kinetoplast showing tubular structure of electron dense band (B) and less dense matrix (Mt). The other cross section shows the nucleus (N) and the nucleolus (n). 30,000x.

Figure 4. Longitudinal section through posterior of organism. Kinetoplast (Kp) and its mitochondrial extension (M). 20,000x.

Figure 5. Longitudinal section through posterior of organism. Dense body (D) and possible dense cell product (d). 22,000x.

microtubules which surround a dense central core, whereas the distal end of the primary kinetosome consists of nine double peripheral microtubules surrounding a less dense central core. Portions of this ultrastructure are shown in Figure 1.

The region between the primary kinetosome and kinetosomal plate 2 is the secondary kinetosome (Fig. 1).
The nucleus, bounded by a typical double membrane and containing a prominent nucleolus, is near the middle of the organism (Fig. 3). The presence of two nuclei may be indicative of occasional binucleate forms, but probably indicates approaching binary fission.

These morphological investigations led to the postulation of the mechanism of flagellar movement. If the curved appearance of kinetosomal plate 1 is not the result of fixation and one of the central microtubules is attached to kinetosomal plate 1, the differences observed in the shape of kinetosomal plate 1 may be associated with flagellar movement. If the distal ends of the central microtubules are embedded in a firm matrix or attached to the flagellar membrane at the distal end of the flagellum, then the diaphragm-like kinetosomal plate 1 may change from the curved to the flattened position and vice versa, causing the flagellum to move. Anderson and Ellis (1965) suggested that the helical-like structure associated with the central microtubules may play a role in the movement of the flagellum. If the helical-like structure is attached to kinetosomal plate 1, then the change in shape of the plate may cause the helical-like structure to contribute to flagellar movement. The energy for changing the shape of kinetosomal plate 1 may be transferred from the kinetoplast with its associated mitochondrion. Judge and Anderson (1964) and Anderson and Ellis (1965) suggested that since there is no structural continuity between the kinetosome and kinetoplast, the energy-containing material used in flagellar movement may be a humoral substance which may be diffusible through the double membrane of the kinetoplast. Thus the mechanism of flagellar movement is still under discussion.

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LITERATURE CITED


