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Shape of *Treponema pallidum*

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Treponema pallidum was found to be not helical, but a flat wave twisted into one to five different planes per cell.

The morphology of *Treponema pallidum* has been extensively reviewed (6). It is currently considered to be a thin, delicate, spiral organism with tapering ends (6), and the spirals have been described as being regular or irregular, appearing sometimes in dark fields as a series of bright dots or radiant beads (*Bergey's Manual*). Sequeira (4) in 1956 considered this organism and *Treponema pertenue* to exist as flat wave forms, not spirals, with the wave planes often changing up to 180 degrees over the length of the cells. Such changes in pitch of the wave plane produced zones of narrowing which appeared to pass to and fro along a nonmotile cell rocked by minor movements of the medium. Confirmation of Sequeira's seemingly important observation has not been noted. The purpose of this communication is to confirm and extend Sequeira's observations.

Virulent Nichols strain of *T. pallidum* and the Reiter and Kazan 8 treponemes were obtained from Paul Hardy, Johns Hopkins University. The former was maintained by intratesticular passage in rabbits as previously described (5). The Reiter and Kazan 8 treponemes were grown in spirolate broth (BBL) with 10% sterile rabbit serum. Fresh material from human syphilitic lesions was obtained through the courtesy of Dieter Groeschel, Springfield Hospital, Springfield, Mass. Actively growing cultures of *Spirochaeta* and *T. denticola* were obtained from E. Canale-Parola, and their conditions of growth have been previously described (1, 3). The culture of *Leptospira* was isolated and grown in this laboratory (2). Dark-field and phase-contrast observations were made on Leitz and Zeiss microscopes. Micrographs of dark-field observations were taken on Polaroid 46-L film with an Aristophot camera and printed on high-contrast paper. Photographs were made either of motile organisms whose motility was permitted to slow to the point that printable exposures could be made or of preparations with hydroxyethyl cellulose (Natrosol, Hercules Inc., Wilmington, Del.) incorporated in concentrations up to 1%. The latter lessened Brownian movement without altering the shape or eliminating cellular motility.

T. pallidum gave the appearance of being helical, especially at magnifications below 1,200× and when highly motile. However, close observations of slowly rotating cells above 1,200× showed the apparently coiled cells (Fig. 1) to be actually flat waves (Fig. 2, 4). It was not unusual to find cells with the waves "on end" (Fig. 2, 3, and 4). However, cells more often had the appearance of that in Fig. 5, changing to the shape in Fig. 6 as the cell slowly rotated. Three to five changes in the pitch of the flat wave plane per cell were common (Fig. 5, 6, and 7). Under low magnifications, this shape gives the impression of being helical during rapid rotation and gives the appearance of a series of bright dots moving back and forth along the cell during slow rotation. Cells were frequently seen undergoing division (Fig. 8); the waves of one cell lay in one plane, and the waves of the other cell in another plane. These observations were verified by phase-contrast microscopy. In no instance were slowly rotating cells observed which exhibited waves or helical shapes regardless of position, as in the case of regularly coiled *Leptospira* (Fig. 9). *T. pallidum* showed the same characteristics of shape in fresh extracts from testicular lesions, in testicular extracts which had been preserved in liquid nitrogen and thawed, and in fresh material from two human cases of syphilis. *T. denticola* had the same general shape as *T. pallidum*.

Cells of the Reiter treponeme were irregularly coiled, with alterations in the direction or pitch of the coils at intervals along the cell (Fig. 10). Cells of Kazan 8 treponeme were also helical when observed as they slowly rotated; they also exhibited changes in the pitch of the helix, especially at the ends of the cell (Fig. 11). Thus, the Reiter and Kazan 8 treponemes differed in shape from virulent Nichols strain

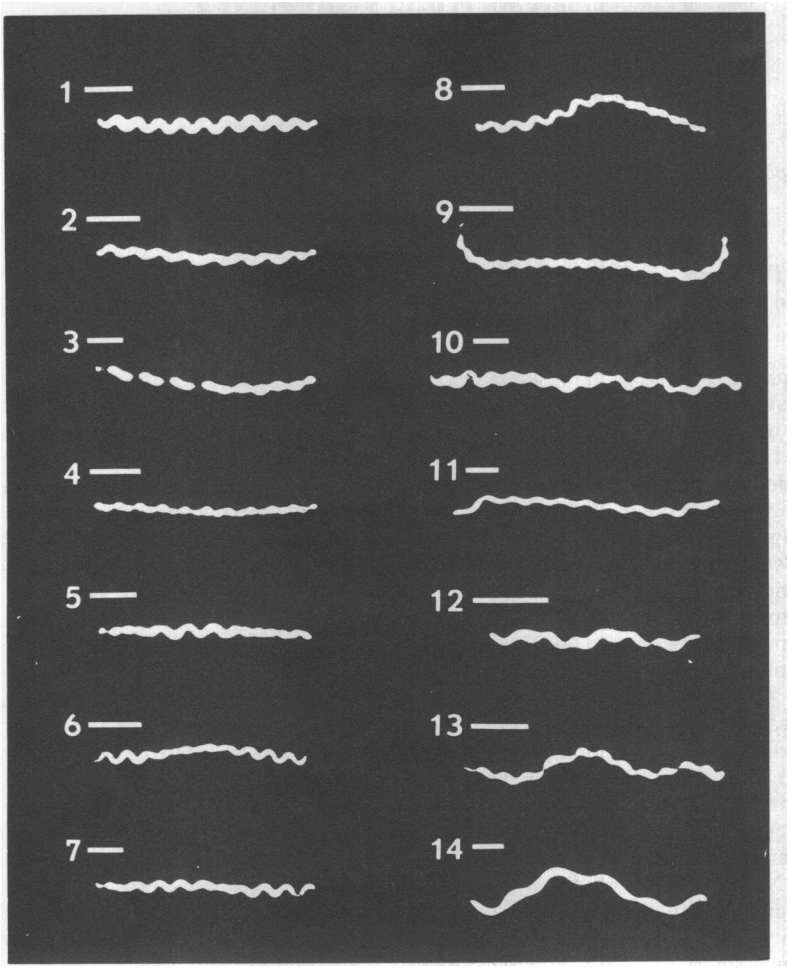

FIG. 1–14. *Dark-field micrographs of slowly rotating or stationary spirochaetes. Bar equals 2 μm. (1–8) Nichols virulent strain of Treponema pallidum. (9) Leptospira B-16 strain. (10) Reiter treponeme. (11) Kazan 8 treponeme. (12) Spirochaeta zuelzerae. (13) Spirochaeta stenostrepta. (14) Spirochaeta aurantia.*

T. pallidum.

Spirochaeta zuelzerae (Fig. 12), *S. stenostrepta* (Fig. 13), and *S. aurantia* (Fig. 14) all had helical shapes with relatively uneven coils often arranged in secondary waves.

The conclusion from these observations supports the view that *T. pallidum* is not helical but a flat wave form existing in one to five planes per cell. It is certainly possible that these or other strains or other types of preparations could yield cells with helical shapes and that *T. pallidum* may exist in helical and flat wave forms. However, in this study, all slowly rotating cells were observed under high magnification to have flat wave forms. Because *T. pallidum* is the type species and its shape is shared with *T. denticola* and *T. pertenue* (4), future revisions in the description of *Treponema* and *Spirochaetales* should reflect these observations.

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