

PERIODIC STRUCTURE IN THE FLAGELLA OF *BRUCELLA BRONCHISEPTICA*

by

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A previous electron microscopical investigation of the flagella of a bacterium isolated in this laboratory (American Type Culture Collection # 11,813) has shown these flagella to have the external contour of a double helix¹. In this communication it is shown that the flagella of other organisms may have different periodicities along their lengths.

Brucella bronchiseptica is another bacterium showing a periodicity along the length of the flagella but this periodicity is distinctly different from the one previously reported. Fig. 1 is a composite micrograph showing, on the left, a low magnification picture (13,500 ×) of a single bacterium with its associated flagella and, on the right, three sections of flagella at a higher magnification (77,000 ×). Another micrograph demonstrating the periodic structure in the flagella is shown in Fig. 2 (77,000 ×).

The external contour of these flagella appears to be helical in nature. The order or type of helix can be determined by measuring the periodicity, the angle of the striae, and the diameter of the flagella and substituting them in the usual equation for a helix. The average periodicity measured along a total of 17 microns of flagellar length was 190 angstroms; the average of about 300 determinations of the angle the periodic striae make with the perpendicular to the flagellar axis was 54.5 degrees; and the average diameter from about 200 flagella was 139 angstroms. This latter measurement was made on micrographs of shadowed specimen screens on which diluted purified flagellar suspensions had been dried. On such screens there are frequently seen groups of flagella lying directly adjacent to one another one layer thick on the substrate. The average diameter was determined by measuring across groups of from 7 to 40 of such flagella. It is difficult to measure accurately the diameter on a single flagellum because either the edge seems to merge into the substrate at a high enough magnification to make an accurate linear measurement or the edge is obscured by being in the shadow. Whether the external contour of these flagella is a single, double, triple, or quadruple helix can be determined by substituting, along with the diameter, one, two, three or four times the periodicity for the pitch in the equation

$$p = \pi d \tan v, \quad p = \text{pitch}, \quad d = \text{diameter}.$$

The four different values obtained for v , which is the angle the striae make with the normal to the axis of the helix, are 23.5, 41.0, 52.5, and 60.1 degrees, respectively.

Reference p. 324.

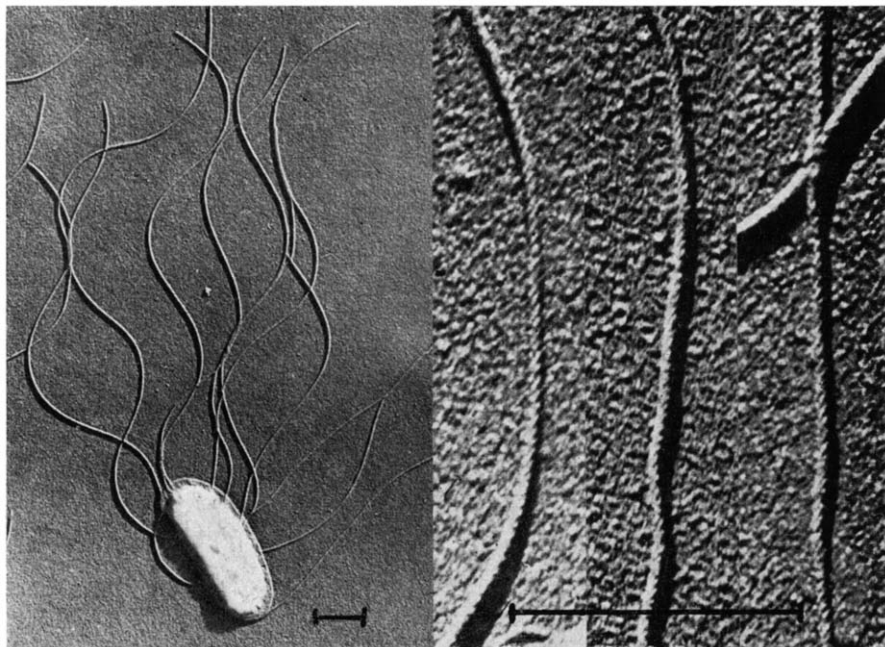


Fig. 1. A *Brucella bronchiseptica* bacterium at 13,000 \times on the left and three sections of flagella showing a periodic structure at the higher magnification of 77,000 \times on the right. Palladium shadowed. Reference line 0.5 microns.



Fig. 2. Another micrograph of *Brucella bronchiseptica* flagella showing the characteristic periodicity of a counter-clockwise triple helix. Magnification 77,000 \times . Palladium shadowed. Reference line 0.5 microns.

A comparison of these values with the measured average value of 54.5 degrees with an average deviation of ± 2.7 degrees shows the external contour to be that of a triple helix.

The flagella of *Brucella bronchiseptica* and the flagella previously described¹ differ in another morphologic feature. The triple helix associated with the former flagella is a counterclockwise or left-handed helix, whereas the double helix of the latter one was a clockwise or right-handed helix. The double helix was erroneously reported in the previous communication¹ as being counterclockwise as it indeed appeared from the micrograph which was printed to agree with the direction as originally photographed. However, the specimen screen is so placed in the microscope that the electrons penetrate the substrate before they penetrate the shadowing which contributes to the image formation. Thus, the image on the plate is of the side of the flagella away from the electron source. What appears to be the top surface of a clockwise helix in the micrographs of Figs. 1 and 2 is in reality the underside of a counterclockwise helix.

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SUMMARY

The flagella of the bacterium *Brucella bronchiseptica* have the external contour of a counterclockwise or left-handed triple helix. The average periodicity along the length of the flagella was measured as 190 angstroms with the average diameter of the flagella measuring 139 angstroms.

RÉSUMÉ

Les flagelles de la bactérie *Brucella bronchiseptica* ont un contour externe en hélice triple, tournant dans le sens contraire des aiguilles d'une montre ou vers la gauche. La périodicité moyenne le long de l'axe des flagelles est de 190 angstroms, le diamètre moyen des flagelles étant de 139 angstroms.

ZUSAMMENFASSUNG

Die Geisseln der Bakterien *Brucella bronchiseptica* weisen den äusseren Umriss einer dreifachen, dem Uhrzeiger entgegengesetzten oder linksgerichteten Schraube auf. Die Durchschnittsperiode den Geisseln entlang beträgt laut unseren Messungen 190 Å, mit einem durchschnittlichen Durchmesser der Geisseln von 139 Å.

REFERENCE

- ¹ L. W. LABAW AND V. M. MOSLEY, *Biochim. Biophys. Acta*, 15 (1954) 325.

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