

XVI.—*The Higher Bacteria (Sphærotilus).*

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PLATE XX.

THE botanist's definition of this organism is as follows :

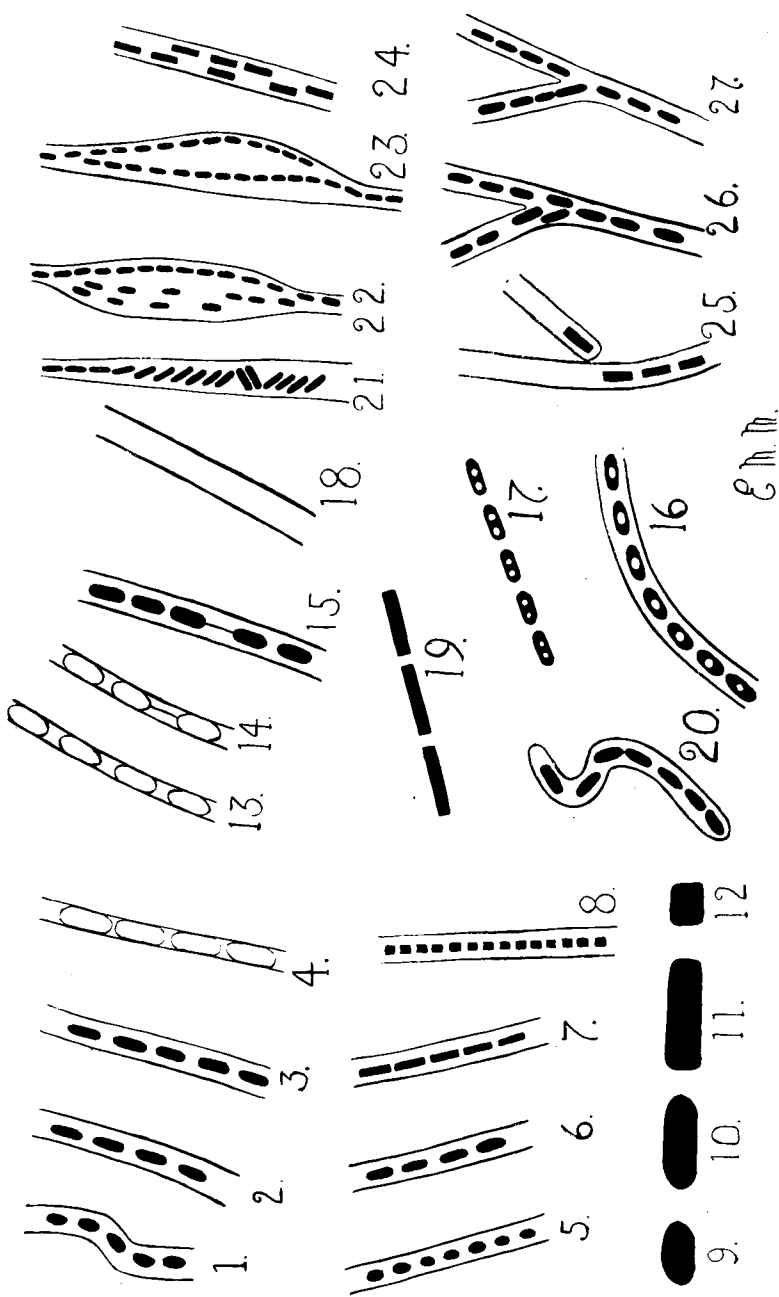
Sphærotilus natans vel *Cladothrix natans* belongs to the genus *Cladothrix* and the family Chlamydobacteriaceæ.

S. natans forms slimy masses in factory waters and streams, and in this species there are many parallel hyphæ, each surrounded by a gelatinous sheath.

From personal observation the opinion was formed that there are four different types of organism, which have been hitherto described under the designation of *S. natans*. This paper deals with the *Sphærotilus* group only, since the similar organisms of the *Cladothrix* class, notably *C. dichotoma*, are really members of the general class of iron bacteria, while *S. natans* is a polysaprobe associated with running water polluted by sewage: and while

EXPLANATION OF PLATE XX.

- Fig. 1.—*Sphærotilus natans*. "Microscopic Water Analysis," Mez. This is identical with the author's *Sphærotilus A*.
 „ 2.—Ditto. "The Examination of Waters for Water Supplies," Thresh. This differs from the *Sphærotilus natans* of Mez., and is identical with the author's *Sphærotilus B*.
 „ 3.—Ditto. "*Sphærotilus natans*," Wilson and Johnson. In the original plate the sheath is not shown, but has been added by the author. This is identical with *Sphærotilus B*.
 „ 4.—*Cladothrix dichotoma* Ellis. This is inserted for comparison from the most recent and complete work on this organism.
 „ 5.—*Sphærotilus A*.
 „ 6.—*Sphærotilus B*.
 „ 7.—*Sphærotilus C*.
 „ 8.—*Sphærotilus D*.
 „ 9.—Characteristic cell of *Sphærotilus A*.
 „ 10. „ „ *Sphærotilus B*.
 „ 11. „ „ *Sphærotilus C*.
 „ 12. „ „ *Sphærotilus D*.
 „ 13.—*Cladothrix dichotoma*. Observed by the author. Compare 4.
 „ 14.—Ditto. Cell in transverse fission. Ellis.
 „ 15.—*Sphærotilus B*. Cell in transverse fission. Compare 14.
 „ 16.—Cells of *Sphærotilus B*. Exhibiting unstained portions, possibly a form of endospore.
 „ 17.—Ditto. Discharged from sheath with two unstained globules in each cell.



THE HIGHER BACTERIA (SPHAEROTILUS).

exhibiting false dichotomy it does not require an iron content in the stream it inhabits.

The author is of the opinion that the group *Sphaerotilus* comprises a number of species of higher bacteria. The type-organism is characterized as a sheathed string of bacterial cells. There are two sub-groups—(1) coloured and (2) uncoloured. Group 1 includes *S. roseus*, with which the author does not deal. In Group 2 the sub-groups are classified by the shape of the vegetative cell.

- A. Sheaths containing ovoid cells.
- B. Elongated cells with rounded ends.
- C. Oblong cells with square end.
- D. Short square cells.

Sphaerotilus is associated with sewage pollution, but does not usually occur in raw sewage. The degree of pollution may be roughly estimated by the presence or absence of diatoms. It is a strict aerobe. Morphologically it is identical with *C. dichotoma*. The filaments, often anchored at one end to some stationary object, consist of cells within a sheath. The sheath is a thick soft tube in its early stage, later becoming harder.

While the organism is growing vigorously the sheath may expand from the pressure of the rapid numerical increase of vegetative cells.

Transverse septa from the sheath separate the cells during the earlier stages of growth.

Three or four cells without a visible sheath have been observed

EXPLANATION OF PLATE XX.—continued.

- Fig. 18.—Empty sheath. Showing hard, tube-like form of old sheath.
- „ 19.—Cells of *Sphaerotilus C*. Either projected en bloc from sheath, or nucleus of a string which has not yet developed a visible sheath.
- „ 20.—Spiral-shaped fragment of *Sphaerotilus B*. This fragment is not ciliated and is not motile. It is probably a short thread distorted and broken adrift by adverse influences. It has the soft sheath of a young string and the ends are closed.
- „ 21.—*Sphaerotilus B*. The effect of pressure in a partly hardened sheath. The cells are turned on their axis, but cannot escape through the cell-wall.
- „ 22.) Ditto. Partial multiplication of thread. Due to pressure of growth in
- „ 23.) a fairly soft sheath.
- „ 24.—*Sphaerotilus C*. Duplication of threads inside the sheath, due to growing pressure. This sketch suggests the possibility of multiplication by longitudinal fission under certain circumstances. Compare 22 and 23, which might also be explained by this means.
- „ 25.—Ditto. Pressure has occurred when the sheath was very soft, and caused false dichotomy; the sheaths have since hardened and partly emptied.
- „ 26.—*Sphaerotilus B*. False dichotomy, due to pressure. The pressure is continuing, and the sheath is not yet very hard; a second cell is slipping into the branch string formed by the first.
- „ 27.—Ditto. False dichotomy; pressure relieved by branch formation; sheath still soft.

but it is not clear whether they have been expelled en bloc from a sheath or if they constitute a new organism which has not yet produced a visible sheath.

In size the cells are from $0.4-0.6\ \mu$ by $0.6-6.5\ \mu$, according to species. In some apparently old cells are unstained globules, possibly spores. Division is by transverse fission.

Multiplication is effected by growth from expelled vegetative cells, or from sporogenous cells.

Owing to constant growth and the hardening of the sheath, cells may be expelled at the free end. False dichotomy takes place only if the sheath be soft. Sometimes parallel rows of cells are found in parts. For good development *Sphaerotilus* requires oxygen and nitrogenous material found in sewage. Hence its presence is an indication of pollution by sewage, raw or partially treated.

The observations were carried out on specimens of natural growth, by means of an artificial stream-bed, polluted by raw diluted sewage. For this purpose a porcelain drain-trough about one metre long and 15 cm. wide, of right angle V section was used. The trough is tilted $1-30^\circ$ and a layer of marble chips spread along the bottom. A thin stream of water is allowed to trickle in at the top, while raw sewage drips in about 5 cm. farther down. This artificial stream is inoculated with the growth.

A single species may be obtained by plating on G.P.B., and then inoculated in the artificial stream: for this small wooden troughs are most suitable.

Satisfactory growth is obtained by sterilizing with ultra-violet light, sewage in Fernbach flasks in layers not more than 5 mm. deep. This last method gave the best results.

SUMMARY.

Occurrence.—The *Sphaerotilus* is found in streams polluted by raw or partially purified sewage. It may be floating down stream or anchored to twigs, etc., immersed in stream at level water. The growth is essentially aerobic.

Size.—A sheath bacterium, sheath $2.0-2.8\ \mu$ broad, cells $0.4-0.6\ \mu$ broad, and $0.6-6.5\ \mu$ long.

Characteristics.—False dichotomy and multiplication of threads in sheath due to growth pressure.

Optimum Temperature.— $20-25^\circ\text{C}$.

Culture Media.—Best results have been obtained on sewage sterilized by ultra-violet light.

Preparations.—Stains well with the usual dyes; gentian-violet is perhaps the best. Sheath stains lightly, cells dark.