REMARKABLE SPIRAL ARRANGEMENT OF FIBRILS

IN THE CELL WALLS OF « NERINE FOTHERGILLI »

BY HARRY D. TIEMANN, M. E., M. F.

RESUMEN

Notable disposición espiralada de fibrillas en las paredes celulares de « Nerine fothergilli ». — El autor describe una disposición digna de ser observada, de las fibrillas de *Nerine fothergilli*, estableciendo que el material sugiere la posibilidad de que las fibrillas aisladas de él, tengan estructura similar a las de las paredes celulares celulósicas. Hace el estudio microscópico, tomando medidas y microfotografías e indica las técnicas seguidas para obtenerlas.

Spirally formed tracheids and vessels are of wellknown occurrence in the primary xylem of all vascular tissues of plants and in the secondary tissue of many. It is seldom, however, that they are so striking in formation as to be noticeable except under carefully prepared microscopic sections. The material here described, however, exhibits such unusual and remarkable effects as to deserve special notice. Moreover it suggests the possibility that the fibrils isolated here are similar in structure to those in the cell walls of cellulosic materials (**4**, **9**).

It was accidentally discovered while picking some leaves from a South African lily of the Amaryllis family *(Nerine fothergilli)* that the lower portions of the leaves, (close to the bulbs from which they originate), and especially the outer layers of the bulbs themselves, when broken and pulled apart longitudinally yielded quantities of fine spiderweb-like strands uniting the two parts, which seemed to stretch out like filaments of a viscous fluid. They are exceedingly fine, like the finest spider webs, and they stretch for distances of several millimeters. A microscopical examination revealed these filaments to consist of solid strands in structure like that of helical springs, which stretched out as they were pulled lengthwise. Apparently the filaments are composed of cellulose like the spiral thickenings of the walls commonly observed in tracheids or vessels in protoxylem tissue but of an extraordinary nature. They can be distinctly seen with a 16 mm objective.

My object in presenting these photomicrographs is mainly to bring this discovery to the attention of plant anatomists with the hope that it will be followed up by the further study of more carefully prepared material, and to contribute something to the knowledge of the nature of the structure of the cell wall.

The photographs give a fair idea of their appearance. Plate I shows a portion of one leaf pulled apart perhaps about 1 mm. The parenchyma cells are broken abruptly across, but the spring-like tracheids have all unwound without rupture. The spiral arrangement is visible although not nearly as clear as can be seen by direct observation under the microscope. Plate II shows another break, evidently where the two pieces after separation have been shoved partly together again, so that the strands have become buckled. Plate III is a higher magnification, $\times$ 174,8, and shows that the filaments are made up of numerous still finer threads. It also shows their origin in the vessels or tracheids of the leaf. The spiral filaments evidently consist of flat bands or ribbonds made up of many still finer fibrils arranged in parallel. Plate IV shows several filaments pulled out to an extreme length, one of which has broken and shows the spiral shape strikingly.

It has been recognized by botanists that spirally-lined tracheids occur in conjunction with elongating tissue. Strasburger states, « *Only annular or spiral vessels (tracheids and tracheie) can undergo extension or stretching. On this account they are the only kinds present in growing parts of plants* ». And Haberlandt says « *The first formed vessels which are differentiated while the young* *organ is still growing in length are always annular or spiral because it is only these two types of thickening that admit in any considerable degree of a subsequent longitudinal extension of the thickened walls ».*

The fibrils of which the spiral ribands are composed are clearly visible in a number of places in figure 3. They appear as numerous fine threads arranged in parallel separated by ligther colored lines.

It should be noted here that these microscopically visible fibrils are not to be confused with the submicroscopic « rodlets » of Frey-Wyssling (1) which he proposed in 1935 at the International Botanical Congress in Amsterdam (2). His rodlets, composed of crystallites of cellulose chain molecules, were found to be approximately 60 Å in diameter, whereas the fibrils here described measure 10,000 to 15,000 Å in diameter. The visible fibrils are therefore composed of very many of the crystalline rodlets. The cellulose chain molecules (3, 7) themselves, of which the rodlets (or the micelles or crystallites) are composed, are still smaller. They are arranged in a periodic crystal lattice spacing, as shown by X-ray diffraction spectra (5), of $8{,}35 \times 7{,}9$ Å transversely and 10,3 longitudinally (10).

Measurement of the spacings of the parallel black lines seen in the ribands shows great uniformity, that is, the fibrils are all of approximately the same diameter and equally spaced. It is noticeable that wherever single fibrils are visible as separate from the ribands, they appear as two dark lines separated by a white line. It is probable that this appearance is due only to diffraction of light, as when viewing a fine cylindrical rod of glass. If the fibrils are thus cylindrical and transparent, the appearance of an individual under the microscope would be of this nature or else of a single black line between two white lines. As a matter of fact, in the dry condition they break up the light into prismatic colors showing parallel red and green lines. The photographs were made with a dark red color screen, the specimens being mounted in glycerine.

It is difficult, therefore, to get an accurate measurement of a single fibril, but where a number occur in parallel side by side in a riband, their spacing may be determined with a fair degree of accuracy.

From various measurements both of the photographs and directly under the microscope, the spacings were found to average about 2,00 microns (= 20,000 Å) fort the wet material. Dry material was somewhat less in size, indicating that these « unit fibrils » swell in water.

In order to determine if the fibrils shown in the photographs were composed of crystalline material, presumably cellulose, they were examined under polarized light. The fibrils are birefringent. They manifest color effects in polarized light because of interference in the vibration of the doubly-refringent light ray. For example, if examined between crosed Nicol prisms with a selenite plate inserted in the optical system, the fibrils appear blue in one maximum brightness position and yellow in the other. The retarded vibration is in the longitudinal direction of the fibrils the same as in wood fibers (**1**, **8**).

It is of interest to compare the dimensions of these strands with those of wood fibers. Bailey and Brown (**6**) have made hundreds of measurements on strands obtained from disintegrated wood paper pulp and determined their diameters to be from 0,9 to 1,0 microm. From their observations they have proposed the idea that *all natural cellulose material is made up of strands or fibrils of this unit size*, namely about 1,0 micron (= 10,000 Å) in diameter. Our observations would seem to substantiate this proposition. Although our measurements on *Nerine* based on the width of a band of several fibrils gives the spacings as larger tan this, the actual diameters of the individual strands must be *lees* than 2,0 microns, and might easily be 1,0.

Nerine fothergilli is a bulbous plant of the Amaryllis family, a native of South Africa. It is interesting to observe that the leaves and stems of the monocotyledons in general grow in length by elongation from the *bottom* rather than apex, whereas the dicotyledons increase in length by unfolding of a terminal bud. One would naturally expect, therefore, to find spirally thickened cells at the base of the leaves, according to the statements of Strasburger and of Haberlandt quoted above. To what extent this may occur in other members of this order of plants I am not aware, but I have never seen nor heard of anything remotely resembling the remarkable structure of this *Nerine.* However, it should be mentioned that the leaves of Red Osier Dogwood, *Cornus stolonifera,* a somewhat similar effect occurs, which may readily be observed by pulling a young leaf apart across the midrib.

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Forest Products Laboratory [1], Forest Service
U. S. Department of Agriculture.

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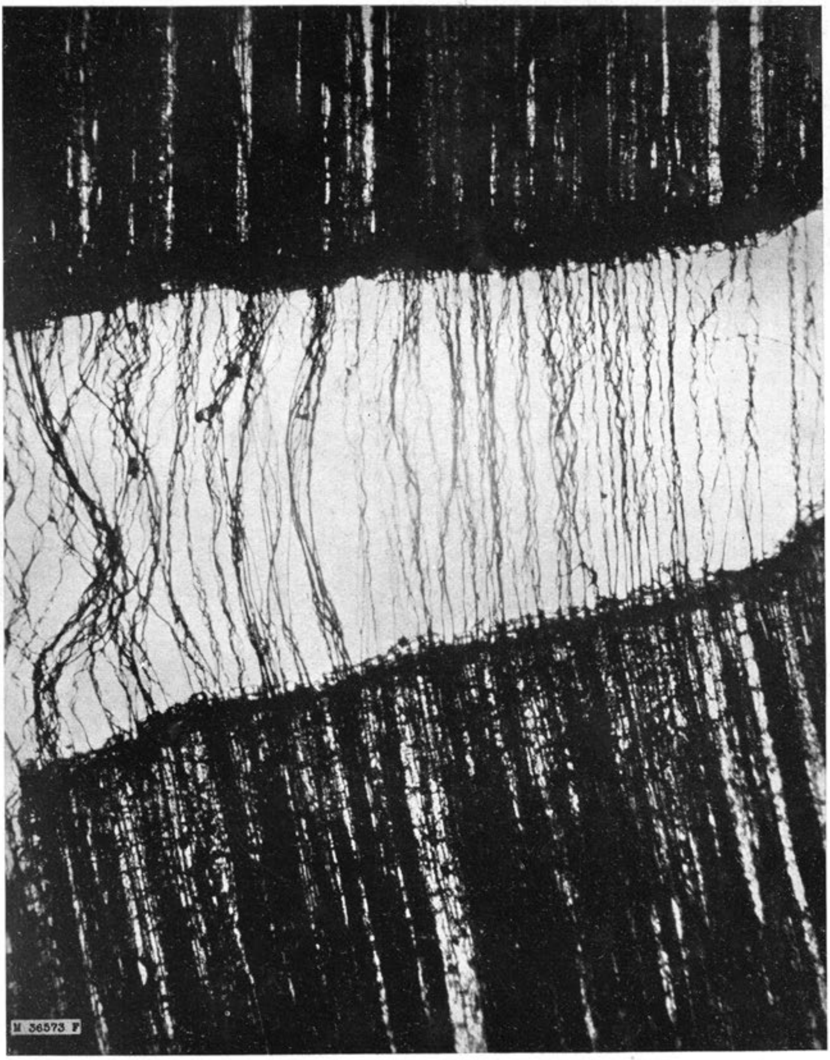
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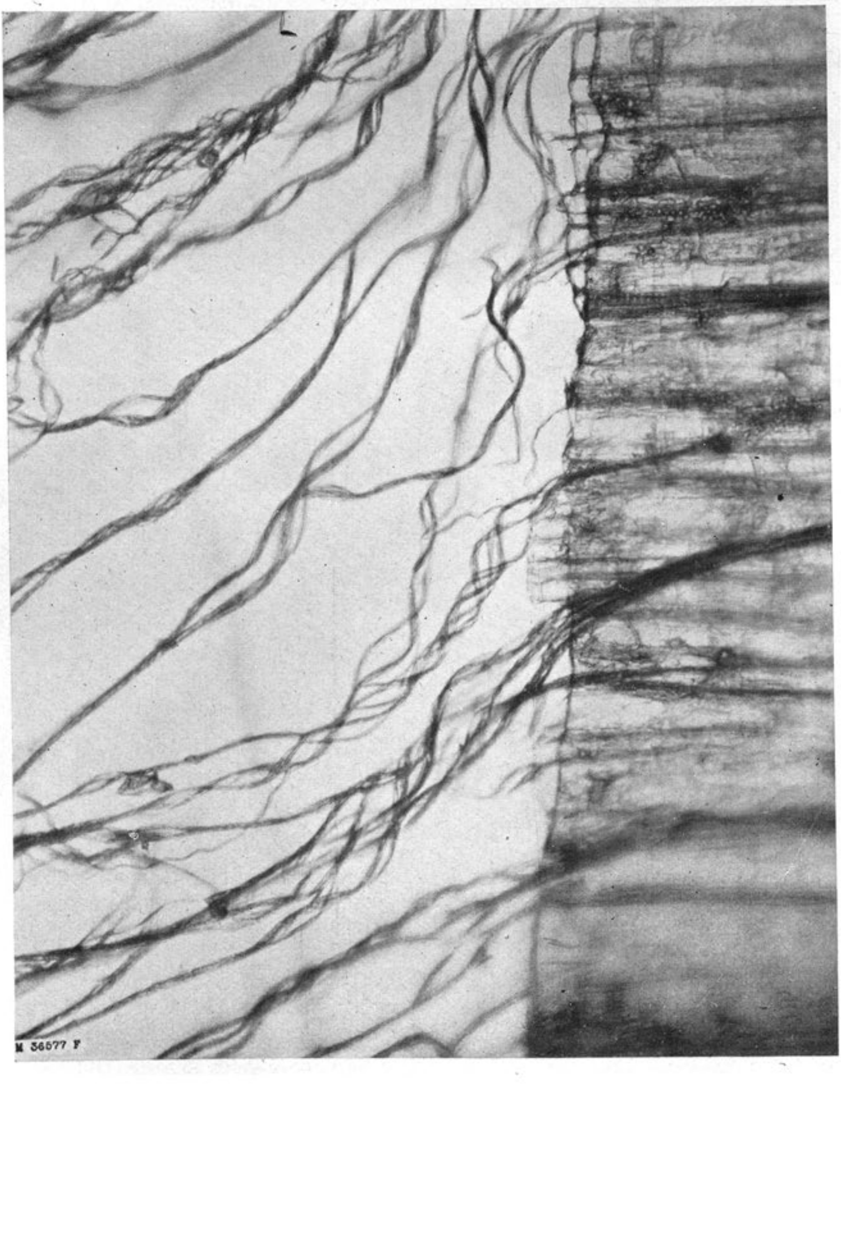
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