- Fig. 60. Junction of three long cells of *Chylocladia articulata*. The protoplasm has collected at the top of one of them. $\times 600$.
61. *Halurus equisetifolius*. Meeting-point of two young cells. A dense layer of protoplasm lines the intercellular wall at each side. $\times 140$.
62. Two axial cells of *Ceramium rubrum*. The protoplasm runs in the form of a hollow tube from stopper to stopper. $\times 140$.

STUDIES IN VEGETABLE BIOLOGY.—II. On Rosanoff's Crystals in the Endosperm-Cells of *Manihot Glaziovii*, Müll. Arg.
By SPENCER LE M. MOORE, F.L.S.

[Read 2nd April, 1885.]

THE existence of crystals fixed to the wall of their containing-cell and themselves enclosed in an investment of cellulose appears to have been first noticed by Schacht*, who described in some detail the large single crystals found in the leaves of *Citrus vulgaris*. A few years afterwards Rosanoff† wrote his well-known memoir on the Crystal-masses in the pith of *Kerria japonica* and *Ricinus communis*, and in the petiole of several Aroideæ and the floral organs of *Encephalartos* and *Nelumbium*; he showed that the crystals are either directly fixed to the wall of the cell and surrounded by a cellulose investment, or, still retaining the investment, are pedicellate upon the wall. Similar crystals were found by De La Rue‡ in the leaves of *Hoya carnosa*. Pfitzer§, working over Schacht's ground, very elaborately monographed the crystals of *Citrus* which he found not in the leaves alone, but in their stalks and in the stem: he further proved that they are not, as Schacht had supposed, of sulphate, but of oxalate of lime; and he made a careful microchemical investigation of the supporting pedicels. He also discovered that at an early stage the crystal can be seen lying freely in its cell surrounded by a nimbus of protoplasm. Besides this, Pfitzer showed that the crystals met with in the cortical parenchyma of *Salix aurita*, *Populus italica*, and other trees are secured to their cell-wall by thick deposits of cellulose. Poulsen|| subsequently wrote a paper on the pedicellate sphere-crystals surrounded by cellulose of Rose-berries;

* Abhand. Senck. Gesell. z. Frankfurt, i.

† Bot. Zeit. 1865 and 1867

‡ Bot. Zeit. 1869.

§ 'Flora,' 1872. A short account of the crystals is given by De Bary in his 'Vergleichende Anatomie' (p. 147).

|| Vidensk. Medd. Naturhist. For. Kiöbenhavn, 1874.

and again* on the single similarly surrounded crystals, which he was the first to observe in the fundamental tissue, bast-parenchyma, petioles, &c., of various Phaseoleæ. It is scarcely necessary to say that crystals merely attached to the cell-wall are not included in the category of Rosanoff's crystals, the essential feature of which consists in the relation between them and a support of cellulose developed from the cell's wall.

It will be observed that up to the present time organs in the full tide of vegetation have been the home of these crystals; the announcement of their discovery in a resting tissue has now to be made. On freeing sections of the endosperm of *Manihot Glaziovii*, Müll. Arg., of their oil with ether or alcohol, and washing away, as far as is possible, the closely packed aleurone-grains, the walls of the cells are seen to be everywhere studded with single, twin, and sphere-crystals of small size. Fig. 1

Fig. 1.

General view of oil- and aleurone-freed endosperm tissue of *Manihot Glaziovii*.
× 450.

gives a general view of the tissue under a moderate power. The chief forms assumed by the crystals are as follow:—

(1) Clinorhombic crystals, sessile, or shortly pedicellate upon wall (fig. 1); truncation is sometimes carried further than is here represented. The size varies considerably.

(2) Sphere-crystals fixed directly to the wall or on short pedicels, or occasionally supported on narrow bars running across the lumen of the cell. These spheres differ greatly in size; they

* 'Flora,' 1877.

are frequently placed at the meeting-angles of the cells. They may be composed of small pyramids with blunt apices, or of a greater or less number of flat plates, or of clinorhombic crystals, or of a medley of the above. The masses are sometimes greatly reduced, as is shown at fig. 2, which represents a sphere-mass made up of a clinorhombic crystal capped by two small pyramids.

Fig. 2.

Fig. 3.

Fig. 2. Small sphere-crystal, composed of a clinorhombic crystal.

Fig. 3. Cellulose skeleton investing a five-sided prism. From a preparation treated with hydrochloric acid. $\times 600$.

(3) Five- (occasionally six-) sided short prisms with plane faces. These are best studied in sections treated with hydrochloric acid, which dissolves out the crystal, leaving a delicate skeleton of cellulose (fig. 3). It often happens that the angles of these crystals are not well developed.

(4) Twin crystals are of frequent occurrence (fig. 1), and occasionally mulberry-masses (the crystals composing which are exceedingly small) are to be found.

These crystals are in various ways surrounded and attached to the wall by cellulose. Examples of this attachment are drawn

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 4. A single cell, showing a shortly pedicellate sphere-crystal, the cellulose bands in association with it stretching some way across the lumen of the cell. $\times 600$.

Fig. 5. A clinorhombic crystal in a well-developed investment of cellulose $\times 600$. And two pyramids, $\times 600$.

Figs. 6, 7, and 8. Cellulose investment of crystals dissolved in hydrochloric acid. $\times 600$.

in figs. 4 and 5 and 6-8; the last three after dissolution of the crystals in hydrochloric acid. Fig. 6 represents the investment of a large sphere-mass at the junction of four cells; the support is thicker in fig. 7; in fig. 8 it is exceedingly delicate.

The crystals are composed of oxalate of lime; they are also doubly refractive. The investing support, if it swells up at all in chloriodide of zinc, does not do so to any appreciable extent: from a mixture of aniline rose and violet, it selects the former, showing that it has somewhat of the character of collenchyma.

Similar crystals are found in the tissues of the embryo; but whether they occur in the adult tissue, I cannot say. Mr. Scott, in his memoir on the latex canals of this species*, speaks of clinorhombic and sphere-crystals, but is silent as to their attachment to the wall and investment with cellulose.

My best thanks are due for aid in prosecuting the above researches to the Kew authorities, especially Mr. John R. Jackson, Curator of the Museums, who has been good enough to supply me with seeds; to the Royal Microscopical Society, whose Assistant Secretary, Mr. West, has been very helpful; to Mr. E. M. Holmes, for kindly assisting in the determination of species and communicating specimens of Florideæ; lastly, to Messrs. Fletcher and Davies, of the Mineralogical Department, British Museum, for obligingly looking at my preparations of the endosperm of *Manihot Glaziovii*.

On Vernation and the Methods of Development of Foliage, as protective against Radiation. By the Rev. GEORGE HENSLOW, M.A., F.L.S., F.G.S.

[Read 4th June, 1885.]

IN his work on 'The Movements of Plants,' Mr. Darwin says:—"The fact that the leaves of many plants place themselves at night in widely different positions from what they hold during the day, but with the one point in common, that their upper surfaces avoid facing the zenith, often with the additional fact that they come into close contact with opposite leaves or leaflets, clearly indicates, as it seems to us, that the object gained is the protection of the upper surfaces from being chilled at night by radiation."†

* Quart. Journ. Micros. Sc. 1884.

† P. 284.