Seek out the nests of these ants within a quarter of a mile (that would be enough), light a good fire over them in winter, when the inhabitants are at home, and after that there would be no difficulty in gradually covering the ground with plantations. The dried stems of the ubiquitous thistle, cow-dung, corn-cobs, or "paja" grass, would burn out these pests.

ARTHUR NICOLS

Cross-Breeding Potatoes

IN the interesting account of the latest successful attempt at raising hybrid potatoes by crossing with different species instead of, as heretofore, by varieties, it is taken for granted the new production will be disease-resisting. Until, however, time has tested the powers of the plant after cultivation, stimulated with all the appliances the potato-growers have at their command, it is rather premature to trust to this. Forty years ago I saw potatoes growing from seed imported direct from South America, and after three years' cultivation they all went with disease in the year 1848. The species I could not tell. The same varieties which go off with disease in this country are never affected in Tasmania, Australia, or New Zealand. At present the newer sorts in cultivation grow so sound and healthy that champions of fine quality over all the east of Scotland are now offering wholesale at three pounds for one halfpenny, and cannot find buyers. The results of the experiments in crossing referred to, while most interesting, will only prove beneficial if a disease-resisting plant is produced having all the table qualities of the old Regent, as well as its great reproductive power, which, with its ability to resist disease, it has now lost.

JAMES MELVIN

43, Drumsheugh Gardens, Edinburgh, January 19

PROTOPLASM[1]

THE fact of a direct continuity between the protoplasmic contents of adjacent cells is an important factor in plant histology. The history of this subject is briefly as follows:—

The individuality of the plant-cells, defended by Schleiden,[2] was first criticised by Hofmeister,[3] and more positively and later by Sachs.[4] For Sachs and also for Strasburger[5] the plant is only one cohering protoplasmic entity. Nägeli[6] has also in a recent work supposed that the protoplasm of each cell is in direct communication with that of the others, by means of delicate protoplasmic filaments.

So far the theoretical side of the question. The first *direct* observation was made in the year 1854 by Theodor Hartig, and not by Sachs as Walter Gardiner[8] states. We find in Hartig's paper the following description of the continuity of sieve-tubes, "Behandelt man in Wasser macerirte Siebröhren mit Schwefelsäure, so erfolgt häufig eine völlige oder theilweise Trennung der beiden Endflächen, in welchem Falle genau zwischen den correspondirenden Ptychodearmen sich Fäden *ausziehen*, die durch Tod dieselbe Färbung und Structur zeigen wie die Ptychodearme selbst. Fig. 18 stellt einen solchen Fall dar."

After Hartig's discovery, confirmed later by Hanstein and Sachs: Mohl, Nägeli, De Bary, Dippel, Wilhelm, Tauczewski, Russow, &c., examined the sieve-tubes and their plasmic connection. For a long time the connection of the sieve-tubes remained the only known fact, until Bornet[1] and E. Perceval Wright[2] in 1878, J. G. Agardh[3] in 1879, and Schmitz[4] in 1883 (the connective filaments were seen), and further, in 1884, Th. Hick[5] and Kolderup-Rosenvinge[6] published some accounts of the communication between adjacent cells in the Florideæ. It seemed to me very probable that in the Cyanophyceæ also communications between the adjacent filament-cells would be found. At least the drawings that Wille[7] gives put one in mind of similar phenomena.

After J. G. Agardh,[8] Tangl,[9] in 1880, succeeded in proving the direct communication in phanerogamous plants between the endosperm cells. In the various papers of Russow,[10] Gardiner,[11] and Hillhouse,[12] these communications are stated in many cases to occur in the bast-parenchyma, the phloem-ray cells of numerous plants, in various pulvini, in the cells of the leaf of Dionæa, in the cells of the stamens of Berberis, in a great number of endosperm cells, and in various cortical tissues.

Finally, Terletzki[13] gave a brief account of the plasmic communication of the parenchyma-cells in the stem of some ferns. I have published also myself[14] a brief account of this interesting object, and described briefly the observations made during the summer of the past year. After Terletzki's paper I was induced to publish my observations, with the full details.[15] The physiological significance of the communication was, in the first instance, not understood; it was believed to be chiefly for the conduction of stimulus in the sensitive organs. But, after numerous observations, there was little doubt that the occurrence of communications between neighbouring protoplasts is not the exclusive privilege of the sensitive organs, and I further claimed the universality of the communication (at least in tissues) in my first paper.[16] This universal occurrence is since confirmed by recent researches.

I have in my second paper[17] given the results of my investigations made on various vegetative tissues. It is superfluous to say anything of the importance of the methods employed in such investigations. For fixing

[1] "On the Continuity of Protoplasm, and on the Protoplasm of the Intercellular Spaces and the 'Middle Lamellary' Protoplasm, with special reference to the Loranthaceæ and Coniferæ," by Dr Jules Schaarschmidt, *privat-docent* of Cryptogamic Botany and the Anatomy of Plants, Assistant at the Botanic Institute and Gardens, Royal Hungarian University at Kolosvár. Contributed by the author.

[2] Schleiden, "Grundzüge der wissenschaftlichen Botanik," i. anfl., 1842-43.

[3] Hofmeister, "Die Lehre von der Pflanzenzelle," Leipzig, 1867.

[4] Sachs, "Vorlesungen über Pflanzenphysiologie," p. 102, Leipzig, 1882.

[5] Strasburger, "Ueber der Bau und das Wachsthum der Zellhäute," p. 246, Jena, 1882.

[6] Nägeli, "Mechanisch-physiologische Theorie der Abstammungslehre," p. 41, München und Leipzig, 1884.

[7] Hartig, "Ueber die Querscheidewände zwischen den einzelnen Gliedern der Siebröhren in *Cucurbita pepo*," *Botanische Zeitung*, xii. col. 43, 1854.

[8] W. Gardiner, "On the Continuity of the Protoplasm through the Walls of Vegetable Cells." Sachs, *Arbeiten des bot. Instituts in Würzburg*, iii. i p. 52, 1884. [9] Hartig, *l.c.*, col. 43.

[1] Bornet. *Vide* Thuret et Bornet, "Études phycologiques," Paris, 1878.

[2] Wright, "The Formation of the so-called Siphons, and the Development of the Tetraspores in Polysiphonia," *Quart. Journ. Mic. Science*, July 1878; *Transactions* of the Royal Irish Academy, xxvii. 1879.

[3] Agardh, "Florideernes Morphologi," *Stockholm Vet. Akad. Handl.*, xv. p. 140, 1879.

[4] Schmitz, "Untersuchungen über die Befruchtung der Florideen," *Sitz. Ber. d. Rgl. Akad. d. Wissensch.*, p. 219, Berlin, 1883.

[5] Hick, "On Protoplasmic Continuity in the Florideæ," *Journal of Botany*, xxii. p. 33, 1884.

[6] Kolderup-Rosenvinge, "Bidrag-til Polysiphonia's Morfologi," *Saertryk af Botanisk Tidsskrift*, xiv. p. 9, 1884, f. 10-14, 26-28, 72, 75.

[7] Wille, "Ueber die Zellkerne und die Poren der Wände bei den Phycochromaceen," *Ber. d. Deutschen Botan. Gesellsch*, i. vi. p. 245, 1883, and *Bidrag-til Sydamerikas Algflora*, i.-iii., *Bihang till k. Svenska Vet. Akad. Handlingar*, viii. No. 18, p. 6, 1884. [8] Agardh, *l.c.*

[9] Tangl, "Ueber offene Communication zwischen den Zellen des Endosperms einiger Samen," *Pringsheim Jahrb. f. wissenschaftl. Botanik*, xii. ii. p. 170, 1880.

[10] Russow, "Ueber Tüpfelbildung und Inhalt der Bastparenchym und Baststrahlenzellen der Dikotylen und Gymnospermen," *Sitz. Ber. Dorpater Naturforschergesellsch.*, p. 350, 1882.

[11] Gardiner, "On Open Communication between the cells in the pulvinus of *Mimosa pudica*," *Quart. Journ. Microsc. Sci.*, New Ser., xxii. p. 365, 1882.

"Some Recent Researches on the Continuity of the Protoplasm through the Walls of Vegetable Cells," *Ibid.*, xxiii. p. 301, 1883.

"On the Continuity of Protoplasm through the Walls of Vegetable Cells," *Proceed. Roy. Soc.*, p. 163, 1883.

"On the Continuity of the Protoplasm through the Walls of Vegetable Cells." Sachs, *Arbeiten d. Bot. Instit. Würzburg*, iii. i. p. 52, 1884.

[12] Hillhouse, "Einige Beobachtungen über den intercellularen Zusammenhang von Protoplasma," *Botanisches Centralblatt*, xiv. p. 86, 1883.

[13] Terletzki, "Ueber den Zusammenhang des Protoplasmas benachbarter Zellen und über das Vorkommen von Protoplasma in Zwischenzellräumen," *Ber. Deutsch. Botan. Gesellsch.*, ii. iv. p. 169, 1884.

[14] Schaarschmidt, "A protoplastok összeköttetésenek sa sejtközi plasma előfordulásának nehány esetéről," *Magyar Növénytani Lapok*, viii. No. 84, p. 17, February 1884; see Referate in the *Botanisches Centralblatt*, xviii., No. 18, 1884.

[15] Schaarschmidt, "A protoplastok összeköttetéséről és a sejtközi plasmáról különös tekintettel a Loranthaceákra és Coniferákra," *Ibid.*, No. 87, p. 65, July.

[16] Schaarschmidt, *Botanisches Centralblatt*, xviii. No. 18, 1884.

[17] Schaarschmidt, *Magyar Növénytani Lapok*, viii. p. 77, July 1884.

the freshly-collected materials I used alcohol, osmic or picric acid; all the observations described below were made upon fresh material, treated, after fixing for a few minutes, with strong or dilute sulphuric acid, so as to swell the cell-walls.[1] The fresh material was first cut in alcohol (or osmic or picric acid); the sections were then for a short time placed in a drop of sulphuric acid, and washed rapidly in a watch-glass with distilled water. After washings in several watch-glasses, the sections may be stained. For staining I first used the saffranine, and later solely the eosine (from Dr. Th. Schuchardt, Görlitz, Silesia). The eosine has a great and admirably defined selective staining power. It is a very excellent negative reagent for the cell-wall, and when employed with some precautions colours only or almost only the protoplasm. It is however requisite that a dilute solution of the dye should be made (1 part of eosine to 50–60 parts of water), and that the stained sections should be washed carefully (for ten to fifteen minutes) in water.

That the phenomena detailed below are not artificially produced by reagents is proved in certain instances. The presence of the connecting protoplasmic filaments in the *intact* (not swollen) *normal cell-wall or pit-closing membrane* was witnessed in the medullary cells of the mistletoe, the sections of which were merely mounted in water and stained with eosine.

I now proceed to give an account of the results I obtained with the various tissues in which the continuity of protoplasm was shown to exist.

Epidermis. Glaucium Fischeri gave the first results. In the leaf-epidermis the connecting processes of the protoplasms, many in number (one for each pit), are well defined; the same is the case in that of Viscum and Loranthus, but in the latter plants the fine connecting-threads were also visible. From the protoplasms of the epidermis-cells radiate numerous processes towards the pits, and in any two neighbouring cells the processes from the one protoplast are exactly opposite those proceeding from the other. *All the epidermis-cells*, as in *Ficus elastica*, are in direct communication with one another and with the "guard-cells" of the stomata. The same is also the case *in epidermis composed of several layers*. The connection is very difficult to make out, though visible after a moderate swelling in the *collenchymatic-hypoderm* (Rhus, Cotinus, *Cucurbita pepo*, Solanum, Liriodendron, &c.).

The *bark-parenchyma* is one of the most favourable objects for investigation, and even when the cell-wall has been very conspicuously swollen or dissolved, the connection is unaltered (Loranthus, Viscum, *Abies alba, Picea excelsa, Gingko biloba*, &c.). When no *hypoderm* exists, the protoplasts of the epidermic-cells should be directly connected with those of the bark-cells. Such is the case in Viscum and Loranthus. The epidermal cell-walls of these plants may have undergone considerable swelling, and so the connective processes become very extended, but the fine connective threads are still conserved. In the *leaf-parenchyma* (Viscum, Loranthus) the connection is very distinct also in the cotyledons of *Phaseolus multiflorus*. It is very difficult to prove the communication in leaves where the parenchyma has been doubly differentiated, viz. into chlorenchyma and into pneumo-enchyma. The *medullary-parenchyma* of Loranthus or Viscum furnish excellent objects for such investigations; the fine bent threads (five to eight in number) can be very *distinctly examined* after a feeble swelling of the cell-wall. In the Coniferæ I find only the connective processes distinct (Gingko, &c.). In the Loranthaceæ the communication is to be directly seen between the *medullary-ray-cells* and *xylem-cells*, between the *phloem-ray-cells* and *bast-parenchyma*; finally between the *medullary-ray-cells* and the *sclerenchyma-cells* [these last are found in the neighbourhood of the xylem (primary) vessels in Viscum.]

The *bast-fibres* of Viscum, Loranthus, are in direct communication with one another, and in Viscum the fibres of the inner-phloem also communicate with the medullary-cells. The communication between *cambium, young bast-fibres*, and *bast-parenchyma*, in the Coniferæ can be demonstrated only with high powers. The communication and connection of the *soft-bast* protoplasts is eminently remarkable. These protoplasts remain in connection even after total dissolution of their cell-walls (Cucurbita, Coniferæ, Loranthaceæ, &c.). I investigated also the sieve-tubes, and have found that these in their entire length are connected with *neighbouring sieve-tubes*, or *bast-parenchyma-cells*, or *collateral cells* (*Nebenzellen*) (Viscum, Loranthus, *Ficus elastica*, &c.). The connective threads are often strongly developed in Cucurbita. They assume the figure of a compressed sphere.

Xylem.—I may remark that the details of the xylem communications are very difficult to observe. In general I have studied the communication of the xylem elements best in the Loranthaceæ, and especially in Viscum. The xylem of the mistletoe is composed of libriform cells, compensating cells (*Ersatzzellen*), and vessels. The cell-walls of the libriform cells are very much thickened, and bear pits only on the middle part of the cell. These cells are variously curved and bent, and offer favourable conditions for investigation—but then the communication of the *libriform cells with one another, libriform cells + compensating cells*, and of the latter together can be easily seen. In the Coniferæ the communication of the xylem elements is only clear in the younger states. In the *young tracheides* the distinct threads could be very clearly seen. In the *older tracheides* merely a striation (caused by the threads) could be detected through the pit-closing membrane). As regards the occurrence of a direct continuity, the *xylem vessels* gave generally a negative result. Although in many instances the occurrence of protoplasm in the great xylem vessels could be demonstrated, still direct communications seemed to me to be extremely rare. I could find this direct connection in one instance in Loranthus. The great (but only the pitted) vessels were here connected with the adjacent cells.

Finally, the protoplasts of the secretory cells are also in direct communication with the neighbouring protoplasts, such as in the resin-cannel cells. The cells of the resin-cannels are, in the Coniferæ, directly connected with the adjacent leaf- or bark-parenchyma, or phyllogen-cells. In the bark of Gingko I was also able to confirm the communication of the crystal-bearing cells (crystal-glands) with the bark-parenchyma cells. I have no doubt that the same structure would be equally well demonstrated in the various secretive cells and vessels. In all the observed cases the communication of adjacent protoplasts is effected by delicate wavy protoplasmic threads. The connective thread either in a roundabout way traverses the sieve-pore pit-closing membrane, or directly traverses the cell-wall when the membrane is unpitted or the pits feebly developed. From a physiological point of view the pits form one of the most important arrangements.

The protoplasts are also in direct connection with the intercellular protoplasm. The intercellular plasm which fills the intercellular spaces was first observed by J. G. Agardh[1] in the Florideæ, and by Russow[2] (1882) in various phanerogamous plants. I have (1883) also studied (first in the bark of *Liriodendron tulipifera*) its occurrence in many phanerogamous plants, and published my observations in 1884.[3] At this time also Berthold published a paper[4] in which he confirmed its occurrence

[1] See, for details of my method, *Zeitsschrift für wissensch. Mikroskopie*, &c., i. ii. p. 301, 1884.

[1] *L. c.*, p. 140 &c. [2] *L. c.*, p. 350 &c.

[3] In the *Magyar Növénytani Lapok*, viii. 1884, pp. 19, 74.

[4] Berthold, "Ueber das Vorkommen von Protoplasma in Intercellularräumen," *Berichte der deutschen botan. Gesellsch.*, ii. 1884, i. p. 20.

in many plants, and later Terletzki[1] gave some details. The observations of these authors established the occurrence of protoplasm between the parenchyma cells in a small number of plants, but as I have stated this is not a rare phenomenon, but one of general occurrence, and I have found that the intercellular spaces of the true prosenchymatic tissues may also contain protoplasm.

I have investigated the plasma of the intercellular spaces in various collenchymatic, parenchymatic, and prosenchymatic tissues. For the investigation it is very important to use the reagents (absolute alcohol, picric acid, or osmic acid) very shortly before cutting the sections. Between the larenchyma cells, in the intercellular spaces protoplasm will always be found (bark and medullary parenchyma of the Loranthaceæ, Gingko, &c.). In longitudinal sections made of thick (2½ cm.) branches of Viscum the connection between the medullary parenchyma cells and the protoplasm fillingt he intercellular spaces is also clearly to be seen. On the contrary, between the thin-walled cells which contain little protoplasm the intercellular plasm cannot, or in very rare instances, be detected (medulla of Phaseolus, Cucurbita, Sambucus, &c.). In the prosenchymatous tissues, *e.g.* in the bast-fibre of Viscum—after moderate swelling with sulphuric acid—the intercellular protoplasm, when stained with eosine, is clearly to be observed. The connection of this intercellular protoplasm with the protoplasts of the fibres is easily seen. We find intercellular protoplasm also in the xylem, *e.g.* in *Rhus cotinus*.

Most important is a fact which I have discovered in the course of my investigations, namely, the occurrence of inter-lamellar protoplasm. This was present very constantly in the leaves of mistletoe. The sections prepared with dilute sulphuric acid and stained, very exactly showed the fine plasmatic threads, corresponding in their disposition exactly to the middle lamella. This middle-lamellary "protoplasm" surrounded the protoplasts as a frame the picture, and ended in the protoplasm of the intercellular spaces. The threads are thicker at these points. The greatest precautions must be taken in the investigation of this middle-lamellary plasma: all very strong acids, &c., should be kept away from the prepared sections. When the cell-wall is very vigorously swelled the fine processes which bind the protoplasts together appear penetrating into the plasma-frame. This plasma-frame surrounds each cell, and in a section the framework of lamellæ occur in all planes and in all successive sections, and all the various constituent threads appear to intersect one another at all angles; it is consequently clear that the middle-lamellary plasm forms a *plasmatic mantle* round the protoplasts which is increased at each edge with the pillar-form (of three to four sides) intercellular plasm portions.

The intercellular plasm preserves its vitality, and in some instances we observe that some changes take place in the intercellular spaces. The intercellular plasm may be observed to cover itself with a special cell-wall; this membrane is the product of the intercellular plasm. This protoplasm can transform itself into a true new cell. In many cases in various tissues we have found this new mode of cell-formation, thus in the collenchymatous tissues (hypoderm of Liriodendron, Ficus, Sambucus, Solanum, Cucurbita, &c.), or in the xylem (*Rhus cotinus*), in the common parenchymatous bark (Viscum, Loranthus, &c.), in the medulla, &c. These newly formed cells grow very fast, and are only in their form and appearance different from the older cells. This cell-formation is very rapid, and it appears at first sight that the number of the tissue elements is by these "intercellular cells" (*Interstitial-celler* of J. G. Agardh,[2] who has observed this metamorphosis in the Florideæ), or "between-cells" (*Közti-sejtek* in Hungarian), considerably increased. A consequence of this great and fast growth is the formation of new "secondary" or "tertiary" intercellular spaces round the newly formed or transformed cells.

[1] *L. c.*, p. 169. [2] *Botaniska Notiser*, 1884, p. 130.

General Results.—I will now briefly conclude with a statement of the general results of my investigations upon the communication of the protoplasts, and upon the intercellular and middle-lamellary plasm.

(1) The protoplasts of all the tissues in united cells are in direct connection by means of finely attenuated protoplasmic threads.

(2) The connective threads traverse the pit-closing membrane (which is of a sieve-plate structure), while in unpitted cells they traverse directly the cell-wall. By these threads is the communication between the connective processes which occupy the pit-cavity from both sides directly established.[1]

(3) The intercellular plasm occurs not only in the intercellular spaces of the parenchymatic tissues, but also in those of true parenchymatic tissues.

(4) This intercellular plasm contains, in many cases, chlorophyll-granules[2] (Viscum).

(5) The intercellular plasm is in direct connection with the adjacent protoplasts.

(6) Corresponding to the middle lamella around the cells, we find a plasmatic frame; the sides of this frame end in the "intercellular" plasma. This plasmatic frame forms a veritable mantle round the protoplasts, and is increased at each edge by an intercellular plasm portion, which latter has a pillar form.

(7) The connective threads of the protoplasts traverse this "middle-lamellary" plasma; both are also connected.

(8) The probable origin of the intercellular plasma is this. During the cell-division, when the division was almost ended, little cytoplasmic portions become included in the young cell-wall, and it is also very probable that the connective threads, in many instances, are the remainder of the "nuclear connective threads," and that the middle-lamellary protoplasm is the remainder of the "cell-plate." All these plasma portions are by the thickened cell-wall much compressed together, and therefore only visible or distinctly visible by the swelling of the cell-wall.

(9) The intercellular plasm can cover itself with a cell-membrane, and in this way we find at the place of the intercellular spaces veritable new cells. About these new cells appears later new secondary or tertiary intercellular spaces.

(10) The protoplasm of the crystal-bearing cells (crystal glands) and that of the resin-cannel cells is also in communication with the adjacent cells.

The protoplasts of the plants (composed from tissues) form a higher unity, one synplast.

COLLECTING DESMIDS

IN his recently published "Desmids of the United States" the Rev. T. Wolle gives the following directions for collecting Desmids:—

The outfit need not consist of more than a nest of four or five tin cans (tomato or fruit), one within the other, for convenience of carriage, ten or twelve wide-mouthed vials, and a small ring-net made of fine muslin at the end of a rod about four feet in length. After selecting what seems to be a good locality, drag the net a few feet among the grasses and mosses, allow the bulk of the water to drain through the muslin, and then empty the residue into one of the cans; repeat this process as often as may be desirable. Ten or fifteen minutes after the cans have been filled most of the surface-water may be poured off, and the remainder transferred to a glass vial, where the solid contents will gradually sink, and the superfluous water can be again poured off, and the vessel

[1] Gardiner has also observed this fact in the plants investigated by him: for this reason we give this in the first place.

[2] J. G. Agardh has also observed endochrome granules in the intercellular spaces of the Florideæ. See *Botaniska Notiser*, 1884, p. 103.