This article was downloaded by: [JAMES COOK UNIVERSITY]
On: 17 March 2015, At: 09:31
Publisher: Taylor & Francis
Informa Ltd Registered in England and Wales Registered Number:
1072954 Registered office: Mortimer House, 37-41 Mortimer Street,
London W1T 3JH, UK

Transactions of the Botanical Society of Edinburgh

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/tped18>

The Multinucleated Condition of the Vegetable Cell, with some special Researches relating to Cell Morphology

Allan E. Grant

Published online: 01 Dec 2010.

To cite this article: Allan E. Grant (1886) The Multinucleated Condition of the Vegetable Cell, with some special Researches relating to Cell Morphology , Transactions of the Botanical Society of Edinburgh, 16:1-4, 38-52, DOI: [10.1080/03746608609468224](https://doi.org/10.1080/03746608609468224)

To link to this article: <http://dx.doi.org/10.1080/03746608609468224>

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever

or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at <http://www.tandfonline.com/page/terms-and-conditions>

PLATE IV.

- Fig. 13. Fruit of *Bornia radiata*, Brongn. (*Pothocites calamitoides*, Kdst.), showing a perfect spike composed of eight segments attached to a calamitic stem. Leaves are given off from the nodal regions of both stem and fruit, some of which show the dichotomous nature of the foliage. From the Calceiferous Sandstone series, Glencartholm, Eskdale.
- Fig. 14. *Bornia radiata*, Brongn. Enlarged sketch of the impression of the basal portion of the fruit of the specimen from Raeburn's Pit, West Calder, showing transverse bars and node on stem.
- Fig. 15. Lowest node of the stem of the Eskdale specimen, showing scars from which leaves have fallen. (Enlarged.)
- Fig. 16. Two unopened sporangia, from an upper segment of the spike of the same specimen. (Enlarged.)
- Fig. 17. One of the open (stellate) sporangia, from the lowest segment of the same example. (Enlarged.)
- Fig. 18. *Sphenophyllum tenerrimum* (Ett. MS.), Stur. From the Calceiferous Sandstone series, Raw Camps, East Calder.

Figs. 6-11, 14 and 18, are from specimens in the collection of the Geological Survey of Scotland, Edinburgh.

The Multinucleated Condition of the Vegetable Cell, with some special Researches relating to Cell Morphology.
By ALLAN E. GRANT. (Plates V. and VI.)

(Read 14th June 1883.)

[This is one of two competing Essays, to which half of the Society's Students' Prize of £10 was adjudicated.]

PART I.—*Previous Researches.*

Professor Schmitz* of Bonn showed that in the cells of *Siphonocladaceæ* (a family instituted by himself) there is often a great number of nuclei embedded in the layer of chlorophyll, and regularly distributed through it at intervals. Thus, in the genus *Valonia* of this family, there may be several hundred nuclei in each of the larger cells. Division of these takes place, as in Infusoria, &c. The special nucleus gradually assumes an ellipsoidal shape, the proto-

* *SB. Niederrhein, Ges. Natur.-u. Heilk.*, Bonn, May 5, 1879.

plasm or nucleoplasm becoming at the same time less dense in the middle, and denser at each end, forming the daughter nuclei. Gradually the protoplasm is drawn to each end, until only a thin connecting thread is left, which is finally ruptured.

At a certain period the protoplasm collects round the numerous nuclei, and finally separates into distinct bodies, thus giving rise to zoospores. The nucleus remains during the swarming of the zoospores, and again divides in the same manner in the *unicellular organisms*.

More recently, Professor Schmitz* has demonstrated the presence of numerous nuclei in the cells of *Saprolegnia* and allied forms, as also in *Peronospora*, *Mucor*, &c., which are embedded in the parietal layer of protoplasm.

In some of the larger species of *Conferva* there are two nuclei in each cell, which multiplied by bipartition before the division of the cell, which thus contains four nuclei for the time being. In the *Myxomycetes* he found the nuclei to be present in great numbers in the plasmodia.

As had previously been observed by De Bary, the asci of the *Ascosporeæ* contain eight nuclei, resulting from division of the parent nucleus. In various other plants of low organisation Schmitz has shown the multinucleated condition to be constant.

G. Berthold† has confirmed the observations of Schmitz regarding the plurality of nuclei in the cells of several *Siphonææ*. In *Codium* he was able to follow the division of the nucleus. After assuming a fusiform shape, it became constricted in the middle, and then swollen out at the ends. Finally, the two daughter nuclei were formed, the threads which joined them being ruptured. In *Deibesia* there were a large number of nuclei in the young sporangia, united by a network of threads. These were gradually replaced by a number of larger nuclei, each of which formed into a zoospore.

Again, M. Maupas‡ notices the occurrence of several nuclei in the animal cell in the cases of *Euchelys gigas*,

* *SB. Niederrhein. Ges. Natur-u. Heilk.*, Bonn, August 4, 1879.

† *MT. Zool. Stat. Neapel.*, ii. (1880), pp. 72-78.

‡ *Comptes Rendus*, lxxxix. (1879), p. 250.

Opalnia, *Actinosphaerium*, the Foraminifera, &c., and records observations on a fungus (*Empusa muscarina*), and several Algæ (three *Cladophora* and one *Vaucheria*).

He mentions that what have usually been considered vacuoles in *Empusa*, are in reality nuclei. A great number of nuclei were also observed to be present in a fresh-water Rhizopod. He finds it difficult to accept Ed. Van Beneden's theory of "fragmentation," since he has seen all the complicated changes usually taking place in the nucleus during "indirect" division.

M. Treub* has lately contributed a most important series of observations on the occurrence of more than one nucleus in the vegetative cells of phanerogams. He has discovered that the multinucleate condition is constant in the vegetative cells of certain plants belonging to the *Asclepiadaceæ*, *Apocynaceæ*, *Euphorbiaceæ*, and *Urticaceæ*. This condition was well seen in the bast fibres of *Humulus Lupulus*, *Urtica dioica*, and *Vinca minor*, and in the laticiferous cells, proved to be simple and branched single cells by De Bary of *Ochrosia coccinea*, *Vinca minor*, *Cyrtosiphonia spectabilis*, *Plumieria alba*, *Hoya*, *Gomphocarpus angustifolius*, *Stapelia ciliata*, and *Melica dioica*.

Ed. van Beneden maintains that in cells with more than one nucleus, fragmentation is the only method of multiplication of the nuclei. Treub, however, asserts that he has traced in the bast fibres of *Humulus Lupulus*, *Vinca minor*, and *Urtica dioica*, and in the laticiferous cells of *Vinca minor*, and *Urtica dioica*, the division of the nuclei by the ordinary method, with formation of nuclear plate, &c. He says that the nuclei in one cell generally divide simultaneously, but that he has seen thirty divide in turn in one cell. Strasburger observed that the process of free cell formation occurs in the same manner, but we have in addition the aggregation of the protoplasm round the nuclei, new cells being thus formed. Free-cell formation from one point of view may be looked upon as a state of transition between the multinucleated condition and ordinary cell division. Finally, these discoveries tend to exalt the position of the nucleus, and lower that of the protoplasm.

* *Comptes Rendus*, lxxxix. (1879), p. 494.

Hegelmaier* has discovered a plurality of nuclei in the cells of the suspensor of plants belonging to the tribe *Vicieæ* of *Leguminosæ*. Among the species he examined, were *Pisum sativum*, *Lens esculenta*, *Vicia Sepium*, and *V. pisiformis*. The two apical cells of the suspensor have numerous nuclei—it may be twenty or even thirty, usually about twelve—embedded in the parietal layer of protoplasm. In the two basal cells the number is still larger, and seems to depend on the size of the cell. The nuclei in the basal cells begin first to divide, and when these have reached a certain number, at least sixteen, those in the upper cells begin to divide. There is never the least trace of a septum between the nuclei in the lower cells, and the formation of a septum between those in the upper cells is extremely rare.

M. Guignard † also describes a plurality of nuclei in the suspensor of plants belonging to the tribe *Vicieæ* of *Leguminosæ*, e.g., in *Orobis angustifolius*, *O. aureus*, *O. niger*, and *O. rosensete*, and *Lathyrus heterophyllus*. The disposition of the nuclei is regular as a rule, but is not always so. They are situated in the layer of parietal protoplasm. They are commonly spherical, but are frequently ovoid, and are easily distinguished from the nuclei of the embryo sac. He is unable to assign a cause for this plurality of nuclei. It is not exclusively the size of the cells, as in some *Orchideæ* we find cells as large with only one nucleus. It is, he thinks, probably connected with some physiological function.

Johow ‡ describes a plurality of nuclei in the cells of the vegetative system of some *Monocotyledons*, giving details of the occurrence of the phenomena in the case of *Tradescantia*, *Allium Cepa*, and *Orchis maculata*. The original nucleus of the cell becomes constricted, and then divides into two or more pieces, without any visible change of structure. This takes place in cells of considerable age, but in which the protoplasm is still in circulation, and contains chlorophyll and starch. He prefers to name this phenomenon "direct division," in preference to the term "fragmentation" applied to it by Ed. van Beneden.

* *Bot. Ztg.*, xxxviii. (1880), p. 513.

† *Bull. Soc. Bot. France*, xxvii. (1880), pp. 191-193.

‡ *Bot. Ztg.*, xxxviii. (1880), p. 826, Bonn, 1880.

Strasburger* has confirmed the observations of Hegelmaier and Johow in all important points. In the vegetative cells of Dicotyledons fragmentation does not appear to be so common as in those of Monocotyledons. He has seen it occurring, however, in very old cells of the pith of *Tropæolum majus* and in species of *Nicotiana* shortly before disintegration of the nucleus. According to Strasburger, the two phenomena of division and fragmentation of the nucleus are not identical. Division of the nucleus takes place in cells with vital activity, and under the influence of the surrounding protoplasm; fragmentation, on the contrary, is a process belonging to the nucleus only, which does not begin until the influence upon it of the surrounding protoplasm has ceased. The cell may remain for a long time in the multinucleated condition, but in many cases it rapidly leads to disorganisation of the nucleus.

M. Prillieux† describes the multiplication of the nuclei in the cells of the root of a plant grown in soil the temperature of which generally exceeded by about 10° that of the surrounding atmosphere. There were from two to four nuclei in each cell, and they were either isolated or united into a mass, and pressed against one another. They frequently varied in form and size. They multiplied by fragmentation, and often contained a number of nucleoli of various forms and sizes. The hypertrophied nuclei are vesicular, and the protoplasmic mass dense and finely granular, save in the centre, where it is more liquid. The nucleoli are found in the parietal layer. When the nucleus divides there is first formed in its interior a plasmatic portion, then the two halves swell and become isolated by prolongation of the dividing fissure. In some cases the two nuclei remain adpressed.

PART II.—*Special Researches.*

The following examination was by longitudinal sections of the stem or sometimes of the petiole, eosin (a solution in spirit) being the staining fluid commonly used.

* *Bot. Ztg.*, xxxviii. (1880), pp. 845-854 (pl. xii. figs. 1-22).

† *Comptes Rendus*, xcii. (1881), pp. 147-9.

The following plants were examined :—*Polygonum Sieboldii*, *Acanthus mollis*, *Podophyllum peltatum*, *Eschscholtzia californica*, *Impatiens Noli-me-tangere*, *Dictamnus fraxinella*—all Dicotyledons; *Lilium pyrenaicum*, *Polygonatum multiflorum*—both Monocotyledons.

Particular attention was given to *Polygonum Sieboldii* and *Acanthus mollis*.

Polygonum Sieboldii (Plate V. figs. 1-4).

This is a quick-growing herbaceous plant, flowering in the summer time. Its stem is hollow except at the nodes, and has a jointed appearance, the nodes and inter-nodes being distinctly marked. A transverse section of the stem shows it to be something like the burr (*Arctium Lappa*) in structure. Longitudinal sections were cut both radially and tangentially. The latter yielded the best results in this case. Different specimens showed that both the bast cells and the wood cells may be multinucleated, as well as the parenchymatous ground tissue. This condition is best seen, however, in the wood cells and ground tissue, especially in that part of the latter forming the medullary rays. In one specimen almost every cell has several nuclei. In the cells of the wood the nuclei, as a rule, were pointed either at one end or at both, and had frequently a fusiform or falciform appearance. Often they were of great length, and "drawn out," as it were, to extreme tenuity. Sometimes they were roundish or altogether irregular in shape (Plate V. fig. 4). Where there were only two or three in the cell they might be close together, or even adpressed, but frequently they were scattered about in an irregular manner. Some of the fibres were almost filled with nuclei. The nuclear membrane, giving rise to a double contour, was usually more or less distinct. The nucleoplasm was dense and finely granular. The nucleoli were usually placed towards the middle of the nuclei, and varied in number, there being, as a rule, one, two, or three present. Every nucleus contained at least one nucleolus. The endonucleolus could almost always be distinctly made out, and I believe was always present, though, on account of its small size, it might easily be obscured.

In the cells of the parenchyma, including the medul-

lary rays, there was very frequently more than one nucleus. The nuclei were usually circular, or approximately so. It is interesting to note the usual difference in shape between the nuclei generally of the fibres and of the parenchyma or soft bast. The idea suggests itself that the shape and length of the cell, and therefore the difference on the protoplasmic stream, may be the cause of it. The nuclei in the parenchymatous cells are not so numerous as those in the fibres, which may possibly be due to the difference in the size of the cells, as suggested by Hegelmaier, but I do not think this likely. The nuclear membrane is well seen in these nuclei; each nucleus has a nucleolus, and the endo-nucleolus can generally be made out.

In this plant I have been enabled to trace the formation of the multinucleate condition distinctly, and have found it in all cases to be due to "direct division."

The first step is undoubtedly division of the endo-nucleolus, but only in one case (Pl. V. fig. 1a) did I see this, though I do not doubt that it could be more carefully made out if carefully looked for. In the case referred to, the endo-nucleolus had become swollen out at each end and constricted in the middle, giving it a dumb-bell-shaped appearance.

The next step, namely, division of the nucleolus, was observed in another cell of the same specimen. It had become dumb-bell-shaped like the endo-nucleolus, and each daughter nucleolus contained an endo-nucleolus (Pl. V. fig. 1b). In another cell the third stage was noted. The nucleus had become deeply constricted, and on each side of the constriction was a nucleolus with its contained endo-nucleolus (Pl. V. fig. 1c).

I have seen the nucleus constricted in all sorts of ways. Sometimes the constriction begins at one side and gradually extends to the other side, until the nucleus is divided. This would appear to be the commonest method. At other times the constriction begins at both sides, and the two constrictions meet at length. The figures belonging to Strasburger's paper in the *Botanische Zeitung*, before referred to, very closely correspond to what I have observed in this and other plants. Some of them I have copied (Pl. V. fig. 5).

Acanthus mollis (Plate V. figs. 6 and 7).

In this plant the multinucleated condition is well seen in the ground tissue. More remarkable, however, than the occurrence of more than one nucleus in some of the cells, is the fact that most of the nuclei contain several nucleoli, and these in turn may contain several endonucleoli. The nuclear membrane was most distinct, and in one specimen the nucleolar membrane could be plainly seen.

The nuclei sometimes exhibited an indistinct, irregular outline, and had the appearance of being about to disintegrate. The tissues examined were those of the petiole, and the plant was past maturity.

As in *Polygonum Sieboldii*, the nucleoplasm was dense and finely granular; but the most noticeable fact in connection with this subject was, that there was sometimes a hyaline layer of protoplasm in the nucleus, in which was placed the nucleolus. This, I fancy, seemed to occur oftenest in large, well-nourished looking nuclei (Pl. V. fig. 7a). In such a case as this one cannot fail to see that the nucleolus is a most distinct body, and does not at all resemble a "thickening of the intranuclear network," or the "result of a shrivelling up and intimate fusion of a part of the network." It is worthy of notice that in the cells of this plant, or indeed other plants, where the nucleus contains several nucleoli, there is usually one nucleolus larger than the rest, and which contains several endonucleoli instead of one (Pl. V. fig. 7d).

Various stages of direct division have been observed in this plant. One case (Pl. V. fig. 6) was especially interesting, and served to illustrate the fact that the nucleolus always takes precedence of the nucleus in division. The nucleus had become constricted at one side; the nucleolus, however, was also constricted, and bent down over the nuclear constriction, so that it must have been divided before division of the nucleus could take place.

Eschscholtzia californica (Plate V. fig. 8).

In longitudinal sections of the stem of this plant the multinucleated condition was chiefly found in the ground

tissue. It was of fairly common occurrence. The nuclei were often very large, and contained a good many nucleoli. The nucleoli were also large, and in one the nucleus was the largest I ever saw. The limiting membrane could be most distinctly seen (Pl. V. fig. 8). There were frequently several endo-nucleoli in each nucleolus; usually there were two.

Dictaüs fraxinella (Plate VI. fig. 1).

In this plant the multinucleated condition was several times observed in the cells of the parenchyma (Pl. VI. fig. 1). More noticeable than this, however, was the number of nucleoli contained in each nucleus. The number varied from about one to ten.

Podophyllum peltatum (Plate VI. fig. 3)

A plurality of nuclei was observed in most of the cells, both of the ground tissue and of the bundles. In the figure (Plate VI. fig. 3) the cells are from the parenchyma, but the cells of the bundles show the phenomenon fully better. I have drawn a nucleus divided by direct division from one of the cells of a bundle (Pl. VI. fig. 3). Nearly all the nuclei in this plant contained more than one nucleolus.

Impatiens Noli-me-tangere (Plate VI. fig. 2).

A multiplicity of nuclei in the cells of this plant was not very common, but it was observed in some of the cells of the parenchyma (Pl. VI. fig. 2). A good many of the cells in the centre of the stem of this plant contained no nuclei, which would seem, therefore, to have disintegrated, although the plants taken were young. The nuclei, when present, contained several nucleoli as a rule, and the endo-nucleoli were distinct and large.

Lilium pyrenaicum (Plate VI. figs. 4 and 5).

In this monocotyledon many of the cells contained more than one nucleus. The limiting membrane of the nucleus was beautifully seen in many cases. Most of the nuclei were multinucleated. The nucleoli were large (Pl. VI. fig.

5). Direct division was several times seen (Pl. VI. figs 4, 5).

Polygonatum multiflorum (Plate VI. fig. 6).

Many of the cells here contained several nuclei, both in the bundles and ground tissue. The nuclei were very evident, and there were generally several in each nucleus. One case of direct division of the nucleus I have figured (Pl. VI. fig. 6).

The Work of Others in the Field Described.

First, M. Treub asserts that he has traced all the phenomena usually occurring in indirect nuclear division in the cells of phanerogams. I have entirely failed to see these phenomena, though I have carefully sought for them. His opinion is that his researches have tended to lower the position of the protoplasm and exalt that of the nucleus. All recent researches seem to tend to the same point. Hegelmaier notices that division of the nucleus is always preceded by that of the nucleolus. Dr Macfarlane confirmed this; and I have invariably found this to be the case, and also believe with Dr Macfarlane that division of the endo-nucleolus is the first step towards division, whether direct or indirect. Johow finds that no visible change in the structure of the nucleus during direct division, thus differing from Treub and agreeing with myself. He also mentions that the condition of more than one nucleus in the cell occurs in cells of considerable age, but in which the protoplasm is still in circulation. This also I find to be the case. M. Prillieux found that the nuclei divided by ordinary direct division or fragmentation in the cells of the roots of the plants grown in heated soil. The hypertrophied nuclei were vesicular, and the protoplasm dense and finely granular, save in the centre where it was more liquid. This description of the nuclei applies generally to those in multinucleated cells, in so far as I observed them. Strasburger has also found direct division to be the manner of division of the nuclei in the vegetative cells of phanerogams. He says, however, that it is in cells in which the protoplasm has "lost its power upon the nucleus" that this phenomenon occurs, while in cells in which the protoplasm

is still "vitally active," *i.e.*, can cause the nucleus to divide, the process of indirect division can still go on, with formation of cell-plate. Now, as before stated, it would appear from recent observations, especially those of Dr Macfarlane, that it is in the nucleus and bodies contained where the process of division begins, in fact that the "generative" force proceeds from within outwards. The protoplasm therefore would not seem to exercise any power over the nucleus which causes it to divide, but rather the nucleus influences the general cell-protoplasm, causing deposition finally of the cell-plate. The expression, "influence of the protoplasm over the nucleus" should be confined to its office of nourishing the nucleus. Since then, in the cells in which the multinucleated condition was observed the protoplasm was still in circulation, the protoplasm may, in this modified sense, be said to have still retained its influence over the nucleus. It will be observed that none of the observers, whose results I have summarised and compared with my own, have advanced any reason for the occurrence of this condition. M. Guignard, indeed, states that it is not exclusively the size of the cell, but probably is concerned with some physiological condition. He does not, however, suggest what that condition is. Strasburger would seem to be of the idea that it is of pathological significance.

The hypothesis advanced by Dr Macfarlane, in his paper read before the Royal Society of Edinburgh,* seems to be without doubt the correct one, in at all events most cases, *viz.*, that the occurrence of a plurality of nuclei in cells past division is due to a *continued functional activity* of the nucleus, more or less perfect, engendered by an *excess of nutrition*, and by conditions generally favourable to growth. It receives special support from the experiments of M. Prillieux when he produced the condition artificially by superheating the soil in which certain plants were grown. The same cause, namely excess of nutrition, is, I believe, the reason of the multinucleated state of the cells for the absorption of bone, called osteoclasts, in the animal system, as also of those large cells in the spleen which apparently disintegrate and absorb the coloured corpuscles of the blood.

* *Trans. Roy. Soc. Edin.*, vol. xxx. p. 585.

The multinucleated condition would be thus produced then in cells in a manner somewhat after this fashion:—In cells that are young and dividing rapidly, the nucleus is then in possession of its full vitality, and can influence the surrounding protoplasm, causing, finally, the formation of a septum. A little later the nucleus has lost some of its vitality or “power of division,” and, as a result, is unable longer to influence the general cell-protoplasm. It is still able to divide itself, however, and passes through all the stages of indirect division except the formation of a cell-plate. Such a case would be that in the cells of the suspensor of some *Leguminosæ*. Still later, again, we may imagine the nucleus in a well-nourished plant retaining enough vitality to divide directly without going through the phenomena of indirect division. This is, as it were, the “last functional effort” put forth by the nucleus before retiring into a state of rest. Disintegration may, as noticed by Strasburger, occur immediately, or the cell may continue multinucleated for some time. The presence of several endo-nucleoli in each nucleus, or of several nucleoli in each nucleus, I look upon as simply a modification of the same condition. All these conditions may occur together in one cell, or any one or two may occur. The presence of several nucleoli in one nucleus seems to be the commonest condition.

In plants of low structure, such as *Derbesia*, the multinucleated condition of the cells is not analogous to that in the vegetative cells of phanerogams, as in such a plant the condition is quite normal, and merely occurs in the process of reproduction. In cells, however, such as those of *Chara*, which are past division, the hypothesis of extra nutrition applies, no doubt, equally.

According to Strasburger, fragmentation of the nucleus occurs as a final change before its disintegration in some very old cells of *Tropæolum* and *Nicotiana*. This must be looked on as a senile change, nay, almost a pathological condition. It may be caused by an irritant.

With regard to the comparative frequency of occurrence of this phenomenon among Dicotyledons and Monocotyledons, I believe Strasburger's idea that it is most frequent

among the latter to be correct. Six out of the eight plants examined by me were Dicotyledons.

PART III.—*Some Points in the general Morphology of the Cell.*

The older cells do not afford much evidence of the arrangement of the protoplasm in a definite intercellular network, such as is seen in the young actively growing cells. The nearest approach seen to it is the mooring of the nucleus to the cell-wall, sometimes much as in *Spirogyra*. Another point is the difference in shape of the nuclei in the various cells. To this I have alluded before, and stated that I believe it to be due to the difference in shape of the cells, and to the "dragging" of the protoplasm, in the course of its circulation, upon the nucleus. The nuclear membrane was often very distinct indeed, and, in fact, could almost always be made out. I also frequently saw that the nucleolus also was bounded by a distinct limiting membrane.

I have also alluded before to the existence of a curious hyaline circle of protoplasm in the body of the nucleus at times, this being particularly seen in large hypertrophied nuclei.* The independent and important characters of the nucleolus and endo-nucleolus seem now fully established, and there would seem to be no reasonable doubt that division of the endo-nucleolus institutes the act of division, whether direct (as I have observed) or indirect.

One remark as to the production of the multinucleated condition of the cell artificially. I believe that a series of more extensive experiments, conducted somewhat on the lines of M. Prillieux's, would conduce greatly to establishing the hypothesis advanced by Dr Macfarlane.

* With regard to this hyaline circle of protoplasm in the nucleus, the following occurs in the last edition of Quain's *Anatomy* (1882), vol. ii. p. 10:—"Eimer describes a more complicated arrangement as existing in many nuclei, in the form of a clear 'hyaloid' zone, encircling the nucleolus and bounded by a circlet of granules, which are united with the nucleolus by fine radial filaments. It is difficult to avoid thinking that the appearance described by Eimer must be mainly an optical effect produced by reflection of light from the sides of the nucleolus." Although I have not noticed the "fine radial filaments" spoken of, I have often seen the so-called "hyaloid zone," and can only conclude from the latter remark of the editor of Quain that he has never seen the appearance indicated.

EXPLANATION OF PLATES.

PLATE V.

- Fig. 1. Cells from *Polygonum Sieboldii*.
 a. Endo-nucleolus is dividing.
 b. Nucleolus is dividing.
 c. Nucleus is dividing.
- Fig. 2. Cells from *Polygonum Sieboldii*.
 a. Nucleolus containing two endo-nucleoli.
 b. Nucleus containing two nucleoli, a large and a small one, each with an endo-nucleolus.
 c. Nucleus "fragmenting" or "dividing directly."
- Fig. 3. Cell from *Polygonum Sieboldii*.
 Nucleus dividing directly.
- Fig. 4. Various-shaped nuclei from fibres of *Polygonum Sieboldii*.
- Fig. 5. Fragmentation of nuclei copied from Strasburger's paper in the *Botanische Zeitung*.
- Fig. 6. Cell from *Acanthus mollis*, from the petiole-nucleus and nucleolus dividing, the nucleolus being so placed as to be divided before the nucleus.
- Fig. 7. Nuclei from *Acanthus mollis*.
 a. shows the "hyaline" layer of protoplasm.
 b. shows three large nucleoli, with their limiting membrane.
 c. shows a nucleolus containing two endo-nucleoli.
 d. shows two nucleoli, one being larger than the other, and containing a distinct endo-nucleolus.
 e. shows a nucleus dividing.
 f. shows a nucleus, evidently newly formed, or else where nuclear membrane has been torn across.
- Fig. 8. Large nucleus from *Eschscholtzia californica*, containing two nucleoli, one very large, and showing limiting membrane very well.

PLATE VI.

- Fig. 1. Multinucleated cell from *Dictamnus Fraxinella*.
 Fig. 2. Do. do. from *Impatiens Noli-me-tangere*.
 Fig. 3. Cells from *Podophyllum peltatum*
 a. Multinucleated cell.
 b. Do. do.
 c. Do. do.
 d. Nucleus dividing.

Fig. 4. Cells from *Lilium pyrenaicum*.

a. Nucleus dividing, and containing several large nucleoli.

b. Multinucleated cell, the two nuclei each containing several nucleoli.

Fig. 5. Cell from *Lilium pyrenaicum*.

Nucleus dividing, and containing several nucleoli.

Fig. 6. Cell from *Polygonatum multiflorum*.

Nucleus very large, and beginning to divide.

NOTE.—It being of course often, indeed generally, almost impossible to find the same cell again, these figures were drawn on the spot, most of them with a camera lucida (Nachet's), kindly lent me by Professor Dickson.

On the Coal incrusting the large Pinaceous Fossil Stems in front of the Herbarium, Royal Botanic Garden, and its bearings on the question of the Formation of Coal.

By ANDREW TAYLOR.

(Read 8th March 1883.)

In view of the great interest taken by visitors to the Garden in these relics of a former vegetation, it may be worth while to recall Sir Robert Christison's elaborate researches into the fossilisation of these trunks, given at great length in the *Transactions of the Edinburgh Royal Society*,* as well as in our own, in which he showed that this coal did not represent the former bark of the trees now fossilised. An hypothesis of the formation of this coal on the trunk, as well as a thin seam found above the former site of the Redhall specimen, may be of far more importance in the light of subsequent investigations than the venerable author seemed disposed to assign it.

In all the trunks mineralogically examined, the encasing material was a bituminous splint coal of a conchoidal fracture, and burning with a dense white smoky flame. The density of this coal in the Redhall specimen is 1.284; giving a hard coke, and leaving 2.95 per cent. of a pale ochre ash, which shows traces of iron to the action of nitric acid. None of the coals from the various trunks examined showed the uniformly vegetable structure demanded by

* *Trans. E. R. S.*, vol. xxxii. p. 203; *Proc.*, vol. viii. p. 377.