This is the same value as we find for the pressure exercised on a solid, unmoving wall.

In order to calculate the number of collisions we have here neglected the extension of the molecule and the mutual attraction of the molecules. Therefore it is apparent that we cannot have obtained anything else but a first approximation.

Botanics. — "*Die Stelär-Theorie*". Dissertation of Mr. J. C. SCHOUTE. (Communication of Prof. J. W. MOLL).

According to the idea of VAN TIEGHEM, given about the tissues of root and stem of the vascular plants, they must be divided into three groups or systems of tissues, namely, epidermis, cortex and central-cylinder. It is such a natural thing to call the epidermis a separate tissue that already a long time before VAN TIEGHEM, it was acknowledged and is at present generally accepted.

It is a different thing about the theory that the central part of stem and root is taken up by a cylinder of tissue, the central-cylinder (or "stele"), which may consist of elements differing greatly, but which must nevertheless be regarded as a connected whole, forming a certain contrast with respect to the cortex. This consideration which can be called the "Stelar-theory" is accepted by some, rejected by others. It is of the greatest importance for instruction and for the construction of descriptions of the inner structure, and it has undoubtedly for both these reasons such a great practical weight, that for this reason only it deserves our attention in a high degree. The scientific foundations for this theory are not in such a good condition and assuredly its non-acceptance is owing to this. Of course the important question is, whether this distinction between cortex and central-cylinder has made its appearance already at an early period in the phylogeny of plants. With the present state of our knowledge this can perhaps not be proved with certainty; but to be able to answer this question in the affirmative two conditions must be put: 1st. the central-cylinder must be indicated if not in all, still in the greater part of stems and roots, 2nd. it must appear already at an early period in the development of these organs.

As for the root these conditions are amply satisfied, which gives great support to the theory of VAN TIEGHEM. But this is not the case to such an extent for the stem, partly perhaps in connection with the complications formed already at an early period by the develop-

ment of the leaves, partly in connection with the splitting up of the central-cylinder in these organs of many plants. Concerning the latter point VAN TIEGHEM himself and of late a number of American and English investigators: GWYNNE-VAUGHAN, JEFFREY, BOODLE, FAULL, WORSDELL, BRETLAND FARMER & HILL, Miss FARD, TANSLEY & LULHAM, BREBNER have shed much light. In all those cases in which stems show a number of loose strings, regarded by some as parts of a central-cylinder (schizostely), by others as vascular bundles, a single central-cylinder, the monostelic structure, is rule in the youngest internodes of the plant, in hypo- and epicotyl and in the internodes following immediately.

But in most cases there is no question about schizostely and so according to VAN TIEGHEM we must expect monostely. However it is a fact, that whilst in every root the most superficial microscopic investigation easily proves the existence of a central-cylinder, this is not at all the case for many stems. The inner layer of the cortex (endodermis), it is true, is often developed as a bundle-sheath indicating as that of the root does, the boundary of the central-cylinder, or also it contains starch-grains, so that a distinct starch-sheath is formed; but in a great many other cases, also in an investigation made for that purpose, as was done by H. FISCHER, it has not been possible to point out a well defined central-cylinder. FISCHER found in 100 investigated plants only in 32 cases a distinct endodermis.

It has now been shown by Mr. SCHOUTE that this objection to the Stelar-theory does not exist in reality. He collected out of the literature on this subject numbers of cases, in which a distinct endodermis had been observed in some shape or other. He himself studied a great number of stems of different plants and then it was evident how necessary it is to examine these organs in different and especially in young stages of their development, a thing FISCHER had not done. The result of this method of working was, that of about 400 dicotyledonous plants only in 7 no distinct endodermis was come across and among these 7 there were yet 4 which even showed a sharp boundary of the central-cylinder. Also the greater part of the Monocotyledonous plants possess an endodermis. It is not to be found in Gymnosperms but yet here as is the case in most of the above-mentioned exceptions, a distinct boundary between cortex and central-cylinder is often to be seen. So this result is very favourable for the Stelar-theory and is a contribution to its scientific confirmation.

But in yet another manner has Mr. SCHOUTE endeavoured to test the Stelar-theory, a test, which it is true has led to a negative result, but which enables us to draw weighty conclusions with regard to

the value of the well known Theory of the histogens of HANSTEIN.

In working out his theory VAN TIEGHEM purposely avoided as much as possible to make use of the history of development, and as has been proved justly. Yet it was quite natural to think that there was a connection between the structure of the full-grown stem and root and that of the same organs at a very early period of development, in embryo or growing point. For HANSTEIN had established a doctrine about the structure of the meristems, very much like VAN TIEGHEM's theory and had gained a number of adherents. He thought, especially on account of the arrangement of the otherwise equivalent cells, to be able to distinguish three tissues in those meristems, called dermatogen, periblem and plerome. The last was a column of cells in the middle part of the stem and root. Of course it was quite natural to think of an identity of dermatogen and epidermis, periblem and cortex, plerome and central-cylinder, in such a manner that the latter had developed out of the former. If it were possible to point out such a correspondence, this would be for the Stelar-theory as well as for the Theory of the histogens of great importance, though not of equal importance for both. If the central-cylinder is already found in the meristem as an independent whole, this points to the fact, that the differentiation of this tissue is old and then the Stelar-theory has gained another support. But as I said above, it is fully established in another way and can very well do without this support.

The HANSTEIN-theory of the histogens is a different case. Every one who studies the literature impartially, will have to own that this doctrine rests on a very weak foundation, perhaps not with respect to the dermatogen, but very certainly as far as the plerome is concerned. It is true, there are some roots and a very few stems in whose thin tops the cells are arranged in a remarkably regular order, so that a central-cylinder can be distinguished as plerome. But in many roots and in nearly all stems there is no question about tracing such an arrangement up to the growing-point. It is really to be wondered at that this HANSTEIN-theory in its generality has found so many genuine adherents; this is certainly partly owing to the conviction, expressed by many and silently shared by others, that plerome and central-cylinder are one and the same.

Yet this had never been accurately examined till it was undertaken by Mr. SCHOUTE. But it is clear, that a positive result would be of the greatest importance for this theory. For there is no sense in accepting histogens without full-grown tissues corresponding to them. Moreover might be expected of a positive result the possibility of finding an undoubted plerome when following the boundary of

the central-cylinder upwards, also in those cases in which up till now, the efforts had not been successful, perhaps on account of the great number of cells.

The investigation of Mr. SCHOUTE was an accurate comparative study of connected series of cross and lengthwise sections. It would lead me too far if I were to speak of this more in particulars. But in general the investigation was conducted in such a way that an attempt was made to pursue in the direction of the growing point the boundary between the series of cells which could be distinguished as endodermis and central-cylinder in the older parts. The results were in short as follows.

Of the root of *Hyacinthus orientalis* and *Linum usitatissimum* the series of cells of the endodermis and the outer layer of the central-cylinder (pericycle) were successfully and uninterruptedly pursued up to the growing-point. In these cases a cylinder of tissue could be distinguished in the top, which could quite naturally be compared to the plerome of HANSTEIN and which corresponded exactly to the later central-cylinder. Also in *Helianthus annuus* in the main the same was found, though the plerome did not appear here as a complex of cells closed at the top. In the stem of *Hippurus vulgaris*, one of the few stems in which different investigators have distinguished a plerome, this was not only successfully found back, but also the series of cells of endodermis and pericycle could be pursued uninterruptedly to the growing-point. However the cells of the plerome proved to form not only the central-cylinder but also the endodermis and two layers of cells of the cortex, so that the required correspondence did not exist here. In the stem of *Elodea canadensis* an uncertain result was obtained, as here a starch-sheath and a bundle-sheath were found, and it was not possible to make out which of the two must be regarded as endodermis. But in the root of *Ficaria ranunculoides* and in the stalks of *Aesculus Hippocastanum*, *Lysimachia Ephemerum*, *Evonymus europaeus* and *Ajuga reptans* an important negative result was obtained. Here it was perfectly evident that the series of cells of endodermis and pericycle cannot be pursued up to the top, but that they very soon stop short and are replaced by shorter series of cells not exactly in their prolongation and which in their turn soon undergo the same fate. In other words in all these cases the expectation was not only disappointed that in this way in difficult cases a plerome was to be found, but it was also irrefutably established that it does not exist here.

After the above-mentioned explanations it need not be demonstrated that these results as a whole must be regarded as fatal to the Theory

of the histogens. That in some selected roots there is some correspondence, makes no difference. That in slender tops built up out of relatively few, lengthwise series of cells a regular arrangement of cells may appear as was described above, is the most natural thing in the world. To give a particular explanation of this is unnecessary, and in no case are these single indications sufficient to establish solely on them a theory of histogens as that of HANSTEIN. And yet this would have to be done if one wished to adhere to this theory, for all other facts plead strongly against it. *Hippuris*, almost the only plant showing a plerome in the stem, has a structure altogether opposed to the theory. And the irregularly built tops form without doubt the overpowering majority.

It seems to me that by the investigation of Mr. SCHOUTE the Histogen theory of HANSTEIN is proved to be erroneous. A conclusion of somewhat general importance can still be deduced from these investigations. Many botanists think that to the celldivision in meristems a certain phylogenetic importance must be given, somewhat comparable to that of the germinal layers in zoology. But here is forgotten that in zoology in the history of development folds and again folds are spoken of, to a certain extent also histological differentiation is mentioned, but little or nothing of directions of cell-division or of arrangements of otherwise entirely equivalent cells. If the zoologist attains at beautiful results by the study of the history of development, it in nowise ensues from this that the study of the arrangement of cells in meristems will be able to furnish these. Rather will the botanist have to expect such explanations from the study of the development of outer forms, and of inner differentiations as a result of differences in the nature of cells. Experience has taught us that this expectation has a right to exist. But the Histogen-theory has certainly contributed to nourish the above mentioned wrong opinion. Now that this has been proved to be incorrect we may expect that the historic and phylogenetic importance which has often been ascribed to the divisions and arrangements of nondifferentiated and perfectly equivalent meristemcells will be reduced to its right and very slight proportion.

Groningen, Jan. 29, 1903.