VII. *On the Growth of the Flower-stalk of the Hyacinth.* *By* Alfred W. Bennett, *M.A., B.Sc., F.L.S., Lecturer on Botany at St. Thomas's Hospital.*

Read March 16th, 1876.

In a paper which I had the honour of reading before the Society at its meeting on November 4th, 1875, I gave some details in respect of the remarkably rapid growth of the flower-stalk of the female flower of *Vallisneria spiralis*. The general results arrived at were that the greatest "Energy of Growth" was displayed by the apical portion of the peduncle or that immediately beneath the flower-bud, the energy apparently decreasing regularly towards the base of the flower-stalk. As this appeared to be opposed to the law stated by Sachs and others to govern the rate of growth of the different successive internodes of an aerial stem, I was anxious to ascertain how far it was in accord with the relative rapidity of growth of different portions of a single elongated aerial internode. For this purpose I have taken the earliest opportunity during the present spring of measuring the growth of the common peduncle of the inflorescence of the Hyacinth, with the following results in two specimens, one grown in a hyacinth-glass, the other in soil in a pot.

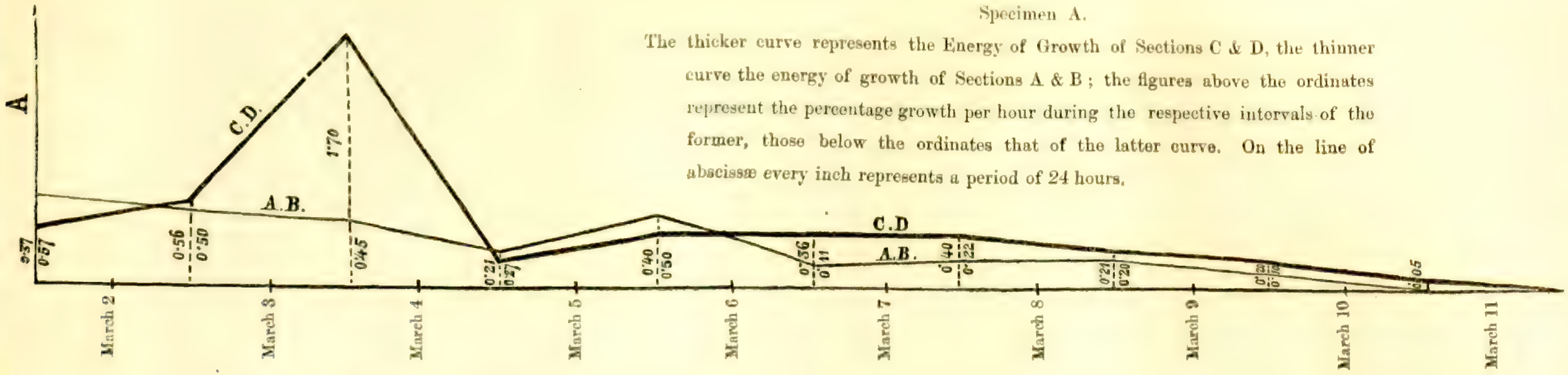
Specimen A, *grown in a hyacinth-glass.*

This was first measured at noon on Feb. 23rd, when the peduncle, with a total length of 1·25 in., was divided into two equal portions of 0·625 in. At 10 A.M. on the 26th, when it had increased to 1·55 in., each of the two sections was again divided, the length of the four portions, proceeding from above downwards, being 0·35, 0·4, 0·4, and 0·4 in. Measurements were made twice and sometimes three times a day; and it was soon evident that the energy of growth of these different portions was very unequal. By 10 P.M. on Feb. 29th each of the three uppermost portions was still only 0·5 in. long, whilst the lowest had increased to 1·0 in. From this time the increased rapidity of growth of the lowest portion was still more marked. By 10 P.M. on March 5th the lengths were respectively 0·9, 0·9, 0·85, and 2·35 in., and at 10 P.M. on March 11th, when the growth had finally ceased, the measurements were 1·15, 1·0, 1·0, and 3·45 in., making a total of 6·6 in. The following is a complete table of the measurements:—

	A	B	C	D	Total.	Increase.
Feb. 26th, 10 A.M.	·35	·4	·4	·4	1·55	
12 noon	·35	·4	·4	·45	1·6	·05
10 P.M.	·35	·4	·4	·5	1·65	·05
27th, 1 P.M.	·4	·4	·4	·55	1·75	·1
10 P.M.	·4	·4	·4	·55	1·75	·0
28th, 10 A.M.	·45	·4	·4	·65	1·9	·15
3 P.M.	·45	·4	·4	·7	1·95	·05

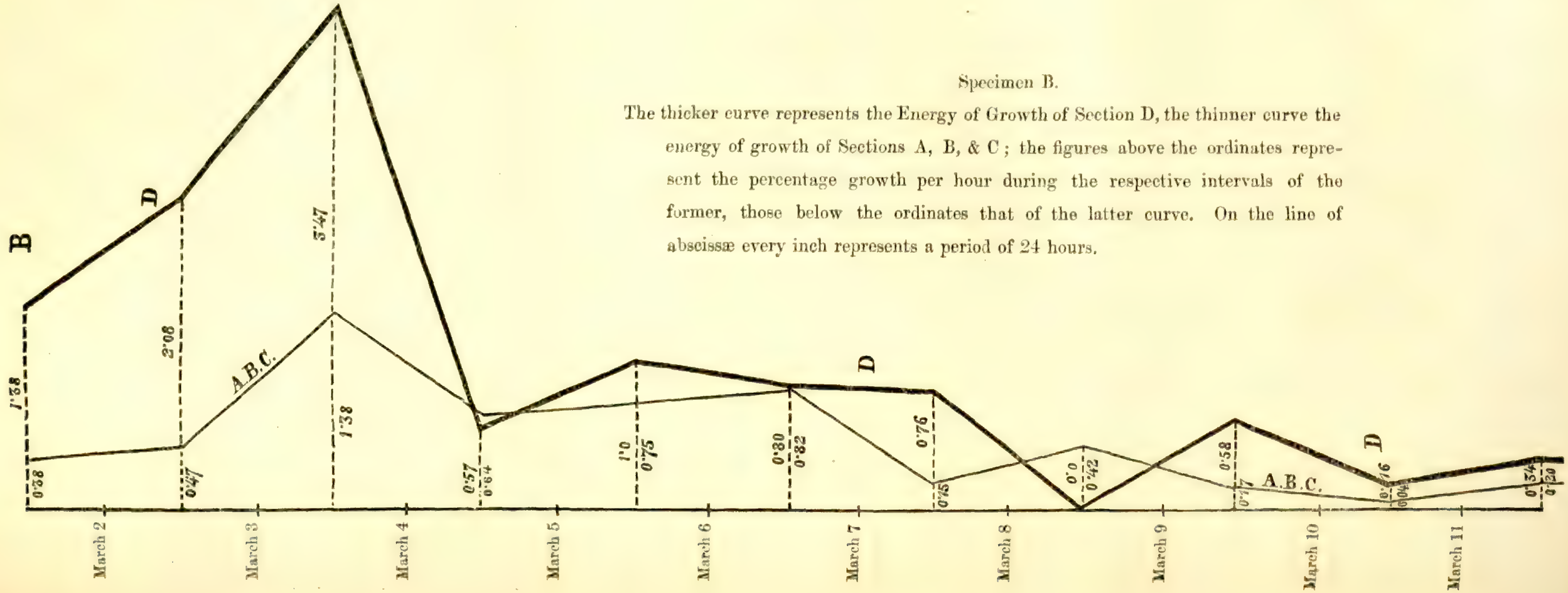
	A	B	C	D	Total.	Increase.
Feb. 28th, 10 P.M.	·45	·45	·4	·75	2·05	·1
29th, 10 A.M.	·5	·45	·45	·8	2·2	·15
3 P.M.	·5	·5	·45	·95	2·4	·2
10 P.M.	·5	·5	·5	1·0	2·5	·1
March 1st, 10 A.M.	·55	·55	·5	1·2	2·8	·3
10 P.M.	·6	·55	·5	1·25	2·9	·1
2nd, 10 A.M.	·65	·6	·55	1·3	3·1	·2
6 P.M.	·7	·65	·55	1·35	3·25	·15
3rd, 10 A.M.	·75	·65	·6	1·5	3·5	·25
3 P.M.	·75	·7	·6	1·7	3·75	·25
10 P.M.	·8	·7	·6	1·9	4·0	·25
4th, 10 A.M.	·8	·75	·75	2·2	4·5	·5
10 P.M.	·85	·8	·8	2·3	4·75	·25
5th, 10 A.M.	·85	·8	·8	2·3	4·75	·0
10 P.M.	·9	·9	·85	2·35	5·0	·25
6th, 10 A.M.	·95	·9	·9	2·5	5·25	·25
10 P.M.	1·0	·9	·9	2·7	5·5	·25
7th, 10 A.M.	1·0	·9	·9	2·75	5·55	·05
10 P.M.	1·0	·9	·95	2·9	5·75	·2
8th, 10 A.M.	1·05	·9	1·0	3·0	6·0	·25
10 P.M.	1·1	1·0	1·0	3·15	6·25	·25
9th, 10 A.M.	1·1	1·0	1·0	3·2	6·3	·05
11 P.M.	1·15	1·0	1·0	3·25	6·4	·1
10th, 10 A.M.	1·15	1·0	1·0	3·4	6·55	·15
10 P.M.	1·15	1·0	1·0	3·45	6·6	·05
11th, 10 A.M.	1·15	1·0	1·0	3·45	6·6	·0

It will be seen from the above table that by far the greatest total energy of growth was displayed by the lowest of the four segments, which increased during the twelve days between Feb. 26th and March 10th from 0·4 to 3·45 in., or 762·5 per cent. of its original length. The next greatest energy, but at a great interval, was exhibited by the apical section, which increased from 0·35 to 1·15, or 228 per cent., while the two central portions exhibited the least activity, increasing only from 0·4 to 1·0, or 150 per cent. of their original length. Dividing the peduncle into an upper and a lower half, and constructing the "Curve of Growth" in the same manner as those given for *Vallisneria* (p. 137), the accompanying diagram (Curve A) represents the results diagrammatically. On the ordinates, again, 1 in. represents a growth of 1 per cent. per hour on the length at the commencement of each interval; but each inch on the line of abscissæ represents a period, not of 12 but of 24 hours. In order, therefore, to compare the curve of growth of the Hyacinth with that of *Vallisneria*, the former ought to be flattened out so as to occupy twice the space. It will be seen that the rate of growth was subject to great variations on different days, dependent, no doubt, on the temperature and other causes. Making the division between day and night at 10 A.M. and 10 P.M., the growth was nearly equally divided between them, the 5 inches growth between Feb. 26th and March 10th being accounted for by about 2·65 in the daytime and 2·35 at night.



Specimen A.

The thicker curve represents the Energy of Growth of Sections C & D, the thinner curve the energy of growth of Sections A & B; the figures above the ordinates represent the percentage growth per hour during the respective intervals of the former, those below the ordinates that of the latter curve. On the line of abscissæ every inch represents a period of 24 hours.



Specimen B.

The thicker curve represents the Energy of Growth of Section D, the thinner curve the energy of growth of Sections A, B, & C; the figures above the ordinates represent the percentage growth per hour during the respective intervals of the former, those below the ordinates that of the latter curve. On the line of abscissæ every inch represents a period of 24 hours.

Specimen B, *grown in a pot.*

In the second example, the evidence was still more conclusive that the growth of the peduncle is mainly basilar. On Feb. 26th, the flower-stalk, then an inch in length, was divided into two equal portions of 0·5 in. On the next day, when it had increased to 1·1 in., the lowest zone of 0·1 in. was marked off separately. By 10 P.M. on Feb. 29th this lowest zone (C+D) had increased to 0·7 in., or by 600 per cent. of its original length, while the two uppermost zones were still respectively only 0·55 and 0·5 in. long. The lowest zone was then again divided into two portions, the upper one being 0·5 and the lower 0·2 in. long. By 10 P.M. on March 3rd the lengths of the four zones, commencing from the top, were 0·8, 0·8, 0·75, and 0·75 in., giving a total of 3·1 in. At 10 P.M. on the 7th, the total length of 6·5 in. was distributed thus:—1·6, 1·5, 1·25, and 2·15 in.; and at 10 A.M. on the 13th, when the final length of 8·2 inches had been attained, the measurements were respectively 2·2, 1·75, 1·5, and 2·75 in. The following is the complete table:—

	A	B	C	D	Total.	Increase.
Feb. 26th, 9 A.M.	·5	·5	..	..	1·0	
10 P.M.	·5	·5	..	..	1·0	·0
27th, 1 P.M.	·5	·55	..	..	1·05	·05
10 P.M.	·5	·5	·1	..	1·1	·05
28th, 9 A.M.	·5	·5	·2	..	1·2	·1
3 P.M.	·5	·5	·2	..	1·2	·0
10 P.M.	·5	·5	·2	..	1·2	·0
29th, 9 A.M.	·55	·5	·45	..	1·5	·3
10 P.M.	·55	·5	·5	·2	1·75	·25
March 1st, 10 A.M.	·55	·55	·5	·3	1·9	·15
10 P.M.	·6	·55	·55	·3	2·0	·1
2nd, 9 A.M.	·6	·6	·55	·4	2·15	·15
6 P.M.	·65	·6	·55	·5	2·3	·15
3rd, 10 A.M.	·65	·65	·65	·6	2·55	·25
3 P.M.	·75	·75	·65	·65	2·8	·25
10 P.M.	·8	·8	·75	·75	3·1	·3
4th, 10 A.M.	·9	·9	·8	1·1	3·7	·6
10 P.M.	·9	·9	·85	1·25	3·9	·2
5th, 10 A.M.	1·0	1·0	1·0	1·25	4·25	·35
10 P.M.	1·05	1·1	1·1	1·25	4·5	·25
6th, 10 A.M.	1·2	1·25	1·1	1·55	5·1	·6
10 P.M.	1·35	1·3	1·2	1·75	5·6	·5
7th, 10 A.M.	1·5	1·5	1·25	1·85	6·1	·5
10 P.M.	1·6	1·5	1·25	2·15	6·5	·4
8th, 10 A.M.	1·65	1·5	1·25	2·15	6·55	·05
10 P.M.	1·7	1·55	1·35	2·15	6·75	·2
9th, 10 A.M.	1·85	1·6	1·4	2·15	7·0	·25
11 P.M.	2·0	1·65	1·4	2·35	7·4	·4
10th, 10 A.M.	2·0	1·65	1·4	2·45	7·5	·1
10 P.M.	2·0	1·65	1·4	2·45	7·5	·0
11th, 10 A.M.	2·0	1·65	1·45	2·55	7·65	·15
12th, 10 A.M.	2·15	1·7	1·5	2·75	8·1	·45
10 P.M.	2·15	1·7	1·5	2.75	8·1	·0
13th, 10 A.M.	2·2	1·75	1·5	2·75	8·2	·1
10 P.M.	2·2	1·75	1·5	2·75	8·2	·0

Starting from the measurement at 10 P.M. on Feb. 27th, the lowest of the three zones, which then measured 0·1 in., had increased by March 13th so as to make up the two zones C & D together 4·25 in., or 4150 per cent. of its original length, while the remainder had only increased from 1·0 to 3·95, or at the rate of 295 per cent. Again, starting from 10 P.M. on March 29th, when the four zones were first marked off, the ultimate increase of the lowest was from 0·2 to 2·75 in., or 1275 per cent.; the next greatest energy was displayed by the uppermost, which increased from 0·55 to 2·2, or just 300 per cent.; next came the second zone from the top, which showed an increase from 0·5 to 1·75, or 250 per cent.; and finally the third from the top, showing an increase from 0·5 to 1·5 in., or exactly 200 per cent. The curve B in the accompanying diagram (p. 141) illustrates the total energy of growth of Section D as compared with that of Sections A, B, and C taken together, the former being, as in the case of the previous curve, in excess during almost the whole period of growth. The rate of growth was again subject to great irregularities, which will be seen to correspond to a considerable extent to those of curve A, and were no doubt attributable mainly to changes in temperature. Making the division between day and night as before at 10 A.M. and 10 P.M., the total amount of growth was again not very different in the two; but instead of being, as in the previous case, slightly in favour of the day, was rather more decidedly in favour of the night; of the 6·5 in. growth from Feb. 29th to March 13th, 3 inches was by day, and 3·5 inches by night.

It will therefore be seen that, as far as these observations on the relative growth of different portions of the same internode go, they are entirely in accord with the statement of Prof. Sachs (*vide ante*, p. 135), in regard to that of different internodes on the same branch, that the maximum energy of growth is exhibited at a period considerably below the *punctum vegetationis*, though it is here much nearer the base than in the cases measured by Sachs. This brings out into still stronger relief the opposite phenomenon displayed by the elongated submerged flower-stalk of *Vallisneria*, the energy of growth of which is manifested mainly in the apical portion. The elongation of the peduncle of the Hyacinth continues considerably after the complete expansion of the flowers, until the lowest in the raceme begin to fade.

These observations differ in several points from those on the flower-stalk of the Hyacinth recorded by Münter in the 'Botanische Zeitung' for 1843, Feb. 24; but as he gives no measurements, I cannot think that these latter are of very great weight. He describes its growth as not centrifugal, like that of most flower-stalks, but centripetal; that is, it ceases to grow first near the flower and finally at the base. It will be seen that my two experiments (and I think the care with which the measurements were made precludes any possibility of mistake) agree in this, that while the energy of growth is greatest in the basal portion, the apical portion continues to grow for very nearly or quite as long. The growth of the flower-stalk of *Pelargonium* he describes, on the other hand, as centrifugal, the growth of each zone ceasing before the one next above it.

With regard to the relative amount of growth by day and by night, Münter also gives no measurements, but states that in the daytime the plant grows at first five times, then four times, and then three times stronger than by night. This differs materially from

the general law as stated by Sachs ('Text-book,' English ed. p. 749 *et seq.*), that "the plant will, according to circumstances, sometimes grow more quickly by day, sometimes by night, without exhibiting any exactly recurrent periodicity," the difference, however, being never so great as that stated by Münter. My own observations are more in accordance with this.

Since writing the above, my attention has been called by Prof. Sachs to a series of papers by Reinke in the 'Botanische Zeitung' for the present year, on the phenomena of growth of stems. His experiments were made entirely on the flower-stems of Endogens, chiefly *Juncus*, *Scirpus*, and *Narcissus*; but the only point that bears on the present inquiry is the statement that "the part of *Narcissus* in which growth takes place is entirely beneath the earth, and of the rushes within the leaf-sheath, all the parts which rise above the earth having already completed their growth." Unfortunately Reinke does not give the measurements on which he founds this statement; and, if correct, it presents a singular want of harmony with the law of growth exhibited in the Hyacinth. The point seems to deserve further careful investigation.

A very few measurements which I made on the leaves of the Hyacinth indicate that the increase in length in them takes place *entirely* in the basal portion, at least after they have attained a considerable length (see Sachs, 'Text-book,' English ed. p. 137). Whether, however, the cell-division is carried on actually beneath the surface of the soil, as stated by Reinke to be the case in the stem of *Narcissus*, I am unable to say.