THE MODE OF GROWING OF FOLIAGE-LEAVES, SHEATH-LEAVES AND BULB-DISC IN HYACINTHUS ORIENTALIS

By

MARTHA C. VERSLUYS.

(With plate n. I and II.)

(LABORATORY FOR PLANT-PHYSIOLOGICAL RESEARCH, WAGENINGEN, HOLLAND).

§ 1. Introductory.

During the research on 'The periodical circumferential growth of the bulbs of hyacinths' (A. H. Blaauw 1923) the question presented itself how the periodical growth in breadth of the foliage-leaves and sheath-leaves is effected; viz. whether it is due to cell-division and extension or to extension only.

This question was the starting-point for the following research. It being necessary to study the growth in breadth in connection with the growth in length, the latter was first examined.

On searching literature for publications on the growth of the monocotyledon-leaf, we only find, as far as I know, a paper by Stebler (1878), discussing the growth in length of the foliage-leaf down to its insertion-spot. On this paper the representation of the growth of the monocotyledon-leaf is based, as we know it from the text-books of Jost (see Benecke und Jost 1923, p. 30) and Palladin. On the growth in length of the scales (i. e. the bases of the foliage-leaves, one or more years after assimilating and of the older sheath-leaves), as described in Blaauw's above mentioned publication, I find nothing in older literature.

Let us now consider what Stebler communicates in his 'Untersuchungen über das Blattwachstum'. His great merit is his having studied the growth of a foliage-leaf of *Allium cepa* down to the insertion spot. Stebler himself mentions an older research by Münter (1843), in which it appeared that in Crocus- and Hyacinth-leaves the growth stops basipetally (see Blaauw 1920, p. 40). The division of growth of the portion of the leaf inside the bulb was not studied in his researches. Stebler did so by cutting away a quadrant of the scales. He does not mention which foliage-leaf he measures. One of the two bulbs the foliage-leaf of which he marked, was kept in 19 to 21° C. and was grown out in a fortnight. While the length amounted to 22.5 mms. on March 15, it amounted to 207 mms. after growing out. From the figures concerning this foliage-leaf it appears, that the growth in the leaf-blade continues longest near the base of the blade. Below the blade there is a leaf-sheath, in which the initially upper half grows more than the lower half. In this part of the leaf therefore a centrifugal cessation of growth may be stated. From the numbers it appears that the originally highest part of 2,5 mms., belonging to the sheath, grows slightly longer than the zone lying above it, which belongs to the blade according to Stebler. Apparently we have to deal here with a foliage-leaf the sheath of which grows in a fortnight from 5.0 to 39.3 mms. Stebler does not mention whether this sheath will persist for another year as a scale, but perhaps he measured one of the outer foliage-leaves, of which Irmisch (1850) p. 15 said, that during the flowering (ca. July) they have changed into thin, transparant membranes, whereas the inner foliage-leaves are still living and fleshy at the base.

It will appear in the following research, that when the leaf-sheath is destined to persist as a scale, as with the *Hyacinth*, the growth continues much longer and the division of growth over the leaf-sheath is different from what Stebler found in the case of *Allium*.

When Jost (see Benecke und Jost 1924) p. 30 says: 'Auch bei den langgestreckten Monokotylenblättern pflegt die Streckung basipetal vorzuschreiten meist unter Ausbildung eines ausgesprochenen interkalaren Vegetationspunktes an der Basis', and quotes the figures given by Stebler, he refers to an intercalary growing-point at the base of the leaf-part, lying above the sheath-part. Anatomically this growing-point was not ascertained by Stebler. For further details I refer to his publication.

In this paper the later scale of the foliage-leaf will not be indicated as a sheath, but as a reserve-organ, or as a starch-part or as a store-organ, while the rest of the foliage-leaf will not be indicated as the leaf-blade, but as the further foliage-leaf-part or the portion above the starch-part (see further § 5*b*).

§ 2. Division of growth in length.

In this paragraph I shall first discuss the growth in length of sheath-leaves, foliage-leaves and scales, as it may be ascertained from marks, put on those parts of the plant. Next in § 3 I shall separate that macroscopically ascertained growth in length into its component parts: cell-division and cell-extension with the aid of microscopic observations. That it is impossible to start with the discussion of the growth in breadth, which on account of the paper on 'The periodical circumferential growth of the bulb of Hyacinths' (Blaauw 1923) wants analysing most, appears already from the following. When namely the growth in breadth of a special portion is to be considered, equivalent regions of the parts of the plant should be compared on the various dates, which is impossible without marking, before the shifting of such a region in the longitudinal direction is known. Therefore a study of the growth in length should precede a study of the growth in breadth.

The variety used in this research is Queen of the Blues.

In order to study the growth in length of foliage-leaves, sheath-leaves and scales down to their insertion-spots, a great part of the scales had to be removed. Fig. 1 represents a scale (the base of the previous inmost foliage-leaf) after the surrounding scales have been removed down to the disc. The marks of black paint were put on with the aid of a thin piece of copper wire, ending in a small loop. A piece of a thin flexible steel measure was laid along the marks; the readings were usually taken with the aid of a magnifying-glass, the place of the lower side of the dots being dictated. The distance from each dot to the base of the organ was given in this way (see subjoined table 1st column) while afterwards the distance between every two successive dots was computed (see subjoined table 2nd column). The difference of the same zone on two dates (2nd and 3rd column) gives the increase in length of that zone during the time elapsed (4th column). That increase divided by the length of the zone on the first of the two dates, indicates, how many times the original zone has been lengthened (5th column).

Place of the marks on Mrch. 28 in mms.	Lengths of the zones on Mrch. 28 in mms.	Lengths of the zones on May 8 in mms.	Increase in length of the zones Mrch. 28 to. May 8 in mms.	Growth from Mrch. 28 to May 8 expressed in original length of zone.
base 0.5	0.5	6.0	5.5	11.0 ×
3.0	2.5	6.5	4.0	1.6 ×
5.0	2.0	3.5	1.5	0.7 ×
9.2	4.2	6.0	1.8	0.4 ×
apex 12.5	3.3	3.0	— 0.3	— 0.0 ×

When the growth is expressed in the zone-length of the

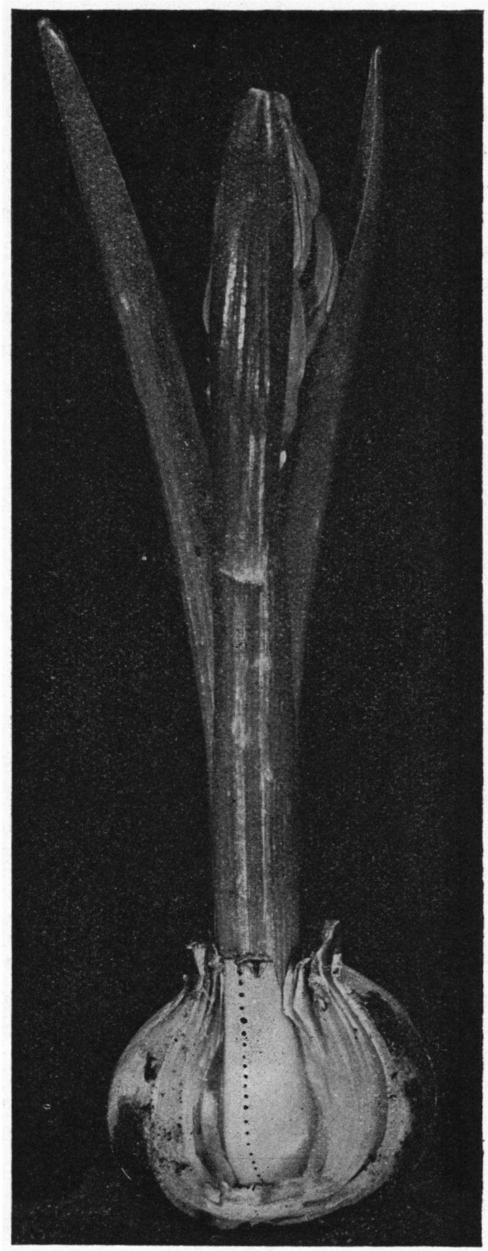

Fig. 1 (ca. nat. size).
Scale of an inmost foliage-leaf (a year after its assimalation) on March 2nd '23 after having been marked for the longitudinal measurements.

earlier of the two dates we compare, the difference in length of the initial zones need not be taken into account, when the vigour of the growth of successive zones is to be compared.

In order to give as few figures as possible, in some of the following tables only those zones will be given, into which the part of the plant is divided on the former of the two dates to be compared; in a next column the growth in that period expressed in the initial zone-lengths. Then the above table looks as follows:

March 28 zones in mms.	Growth of the zones from March 28 to May 8.
base 0.0 — 0.5	11.0 ×
0.5 — 3.0	1.6 ×
3.0 — 5.0	0.7 ×
5.0 — 9.2	0.4 ×
apex 9.2 — 12.5	— 0.0 ×

The macroscopic measurements of growth in length have been taken on three groups of bulbs, put in the greenhouse at four different points of time. The first group, consisting of 7 bulbs, being in their 4th year, marked A—G was lifted from the field on March 28th 1922 together with its roots with all possible care and planted into a pot in such a way, that the whole bulb showed above the soil (see fig. 1). The pots were put in a greenhouse, the temperature of which was oscillating between 15 and 21° C. The total length of the leaves, measured down to the bulb-disc, amounted at that time (March 28) to ca. 110 mms. On April 7 these bulbs were nearly in full flower, i. e. the apical flowers were still opening.

After removal of the scales and marking the bulbs was wrapped in wet cotton-wool to prevent drying up. Good care was taken that the cotton-wool did not touch the marks. It appeared that in spite of the rather radical operation of the bulbs the growth continued fairly well. The removal of the scales down to the disc caused a great quantity of moisture, which made it rather difficult to mark the bases of the scales, etc.

When the epidermis had remained uninjured, putting on the paint-marks usually had no injurious consequences, when injured however the growth strongly decreased and the marks were hard to discover, because the tissue formed little brown scales.

Moulding and rotting of the cut parts could be restrained by moistening the cotton wool but moderately.

On May 8 of the same year (1922) another 7 bulbs of a different group in their 5th year were put in the greenhouse. These bulbs have been indicated, H, J, K, L, M, N, and O.

On March 2nd 1923 10 bulbs (in their 4th year) were transferred from the garden to the greenhouse in the same way. By that time the length of the foliage-leaves amounted to ca 100 mms., the average height of the cluster being ca 20 mms. less. (see for this stage fig. 1). On March 14 these bulbs were in full flower. They have been indicated I up to and including X.

Besides on March 17th 1923 six bulbs of the same lot were transferred from the garden to the cold greenhouse facing North, where the temperature was usually kept at 12 or 13° C. These bulbs have deen indicated XI up to and including XVI. All bulbs indicated with characters therefore were measured in 1922, all bulbs indicated with Roman figures in 1923.

Each of the bulbs C, M, III, IV, V, IX, XII and XV was used in measuring the growth in length of the outmost sheath-leaf, enveloping the assimilating foliage-leaves.

Of the bulbs: A, B, D, E, F, G, H, J, K, O, I, VII, VIII, XI and XIV the growth in length of the outmost of the assimilating foliage-leaves was measured.

Of bulb L and II the growth in length was measured of the scale of the inmost foliage-leaf, which assimilated a year before. Of the bulbs N, XIII, VI and X the outmost sheath-leaf was used for measurements of breadth; the foliage-leaf of bulb O was used for the same purpose.

We may now proceed to discussing the results of these measurings and shall start with the growth in length of the sheath-leaves.

a. *Division of growth in length of the sheath-leaf.*

The outmost sheath-leaf of bulb C, divided into zones on March 28th 22 (table 1 column 1), appeared not to have grown on April 7th. On May 8 the total length had increased from 44.0 mms. to 55.5 mms. The basal portion only (from 0—9.2 mms.), appears to have been lengthened from 9.2 mms. to 22.0 mms., i.e. 12.8 mms. Of these

5.5	mms.	have	been	formed	by	the	zone	0.0	to	0.5	mm.	of	March	28
4	„	„	„	„	„	„	„	0.5	„	3.0	„	„	„	28
1.5	„	„	„	„	„	„	„	3.0	„	5.0	„	„	„	28
1.8	„	„	„	„	„	„	„	5.0	„	9.2	„	„	„	28
12.8														

The part of the sheath-leaf above 9.2 mms. i. e. 44 — 9.2 = 34.8 mms. has not been lengthened from March 28 to May 8; on the contrary it appears to have shrunk a little, so that the total lengthening is not 12.8 but 11.5 mms.

From this it follows, that only less than one fourth of the sheath-leaf was growing in that period and this appeared to be the basal part.

If we observe the division of growth in that period, it appears (table 1, col. 2), that the lowest, i.e.

the 1st	zone has increased			11.0 × its initial lenght of March 28.					
„ 2nd	„	„	„	1.6 ×	„	„	„	„	„ 28.
„ 3rd	„	„	„	0.7 ×	„	„	„	„	„ 28.
„ 4th	„	„	„	0.4 ×	„	„	„	„	„ 28.

From this we see better than from the figures given above, that it is especially the lowest very small zone of 0.0 to 0.5 mm. of March 28th, which has most been lengthened.

Considering the lengthening of this sheath-leaf from May 8 to June 20 we find that the apex of the sheath-leaf has shrivelled to 43.0 mms. from the base. Only the zone from 0.0 to 16.0 mms. on May 8th appears to have been lengthened to a total amount of 7.0 mms. From these

mms.											mms.			
4.0	have	been	formed	by	the	zone	0.0	to	6.0	of	May	8
2.5	„	„	„	„	„	„	6.0	„	12.5	„	„	8
0.5	„	„	„	„	„	„	12.5	„	16.0	„	„	8
7.0 mms.												

Expressed in the initial length of May 8 to June 20,

the 1st	zone has increased			0.6 ×	its length of May 8				
„ 2nd	„	„	„	0.3 ×	„	„	„	„	8
„ 3rd	„	„	„	0.1 ×	„	„	„	„	8

During the period from May 8 to June 20 it is at most a zone of 16 mms. from the base, which is still growing. Here too the strongest growth occurs in the most basal zone. The total lengthening of the growing portion of the sheath-leaf from March 28 to June 20 is 12.8 + 7.0 = 19.8 mms.; the lowest 9.2 mms. of March 28 have become 29 mms. on June 20, i. e. an increase in length of more than 2 × the initial length of March 28. The increase of 19.8 mms. is divided over the different zones as follows:

9.5	mms.	by	the	zone	0.0	to	0.5	mm.	of	March	28 =	19 ×	the	length	of	March	28
6.5	„	„	„	„	0.5	„	3.0	„	„	„	28 =	2.6 ×	„	„	„	„	28
2.0	„	„	„	„	3.0	„	5.0	„	„	„	28 =	1.0 ×	„	„	„	„	28
1.8	„	„	„	„	5.0	„	9.2	„	„	„	28 =	0.4 ×	„	„	„	„	28

It appears from all these figures, that during the assimilation-period of the foliage-leaves, the lowest part of the sheath-leaf (from 0 to 16 mms.) grows and that the growth of the most basal zone of that part is strongest.

In the abnormal greenhouse-conditions, we have ascertained for a Hyacinth-bulb a lengthening of the outmost sheath-leaf, enveloping the assimilating foliage-leaves, of 44.0 to 55.0 mms. in the period from March 28 to May 8. Moreover there was a growth of 7 mms. from May 8 to June 20; if therefore the sheath-leaf had not shrivelled at the apex, the length would have increased to 62.5 mms., i. e. an increase of 18.5 mms.

We should bear in mind that the dates cannot be directly compared with the data collected for bulbs grown outside in totally different outward circumstances. Yet, to get some idea, whether this increase is abnormally great or small, we shall compute the average length (M.) of 20 outmost sheath-leaves from a lot of bulbs (age 4th year), regularly sent from Lisse. These are the same figures as mentioned in Blaauw's publication (1923 Table 30).

Length of the outmost sheath-leaf in mms.

	M.		M.
April 5th 1922 . . .	34.5	May 17th 1922 . . .	42.0
April 25th 1922 . . .	35.8	June 16th 1922 . . .	56.5
May 3rd 1922 . . .	37.9	July 19th 1922 . . .	58.5

On July 19th the apex of these sheath-leaves was not always present, consequently the growth may have been a little more than the figures state.

It appears that the growth in the fields from April 5th 22 to June 16th 22 was 22 mms., whereas the sheath-leaf in the greenhouse from April 7 (for by that time the length was the same as on March 28) tot June 20th 22 grew 18.5 mms.

With another lot (age 5th year), examined by B l a a u w, see table 28 of that same publication (1923), the increase from April 7th tot June 25th was 36.5 tot 53.2 mms. = 16.7 mms. We may therefore assume the increase of the sheath-leaf in the greenhouse to have been fairly normal.

There being no increase of the sheath-leaf from March 28 to April 7 might be considered owing to the transmission from the fields to the greenhouse with the attending root-injury. If however we observe B l a a u w 's figures (1923) table 28, we see, that neither in this group, growing outside, any growth could be observed from March 26 to April 16.

Length of the outmost sheath-leaf in mms.

27 Febr. 1920	35.7	16 April 1920	36.2
13 March 1920	35.2	30 April 1920	41.1
26 March 1920	36.1	15 May 1920	47.2
7 April 1920	36.5	28 May 1920	49.9

The growth in length of the sheath-leaf from March to June was measured, because during that period the foliage-leaves assimilate and even then the greatest increase in breadth of the sheath-leaves and scales occurs. (see fig. 36 of the publication 1923 above-mentioned).

We shall now consider how far conformable results were obtained with the other sheath-leaves measured. The sheath-leaf of bulb M., transferred to the greenhouse on May 8th 1922, showed a growth of 44.5 tot 51.0 = 6.5 mms. from May 8th to June 21st. Strictly speaking the growth is 7.0 mms., but seems 6.5 mms., because one zone has shrunk 0.5 mms. This may be an error of observation in consequence of the measure having moved a little.

The growth from May 8 to June 20 of sheath-leaf C had also been 7 mms. In *M* however the division of growth does not seem so regular, probably because the sheath-leaf was injured on June 20.

So we find that of the 7.0 mms.:

mms.			mms.			
3.0	have been formed by the zone of	0.0	to	4.5	on May 8 = 0.6 ×	the zone-length of May 8
0.0	„ „ „ „ „ „ „	4.5	„	10.0	„ „ 8 = 0.0 ×	„ „ „ „ 8
0.0	„ „ „ „ „ „ „	10.0	„	12.0	„ „ 8 = 0.0 ×	„ „ „ „ 8
1.0	„ „ „ „ „ „ „	12.0	„	14.0	„ „ 8 = 0.5 ×	„ „ „ „ 8
1.0	„ „ „ „ „ „ „	14.0	„	15.5	„ „ 8 = 0.6 ×	„ „ „ „ 8
0.0	„ „ „ „ „ „ „	15.5	„	20.5	„ „ 8 = 0.0 ×	„ „ „ „ 8
1.0	„ „ „ „ „ „ „	20.5	„	22.5	„ „ 8 = 0.5 ×	„ „ „ „ 8
0.5	„ „ „ „ „ „ „	22.5	„	24.5	„ „ 8 = 0.2 ×	„ „ „ „ 8
0.5	„ „ „ „ „ „ „	24.5	„	26.0	„ „ 8 = 0.3 ×	„ „ „ „ 8
7.0						

The rest of the sheath-leaf i. e. 18.5 of the 44.5 mms. does not show any growth.

The growth of the lower zone is no less than in C., viz., 0.6 × the zonelength of May 8. The growth of other zones however appears to have been equally strong, so that 26.0 mms of May 8 take part in the growth of 7 mms. whereas in C only 16.0 mms took part. It is possible that the rather serious injury has caused the irregular division of growth, for it will appear with regard to the other sheath-leaves, that in many cases there does lie a maximum near the base — while the growing zone is usually smaller.

The outmost sheath-leaves of the group of bulbs, which were put in the greenhouse on March 2nd 23 and which were marked on March 8, on the whole appear to have grown less vigorously than the sheath-leaf C. Most of the sheath-leaves did not grow any more after May 12th or but very little. Apart from that slighter growth we shall see, that also in these sheath-leaves the most basal zones usually grow most vigorously and that the growth at the base continues longest.

In bulb IV (tab. 2 columns 1 and 2) the sheath-leaf has but grown from 28.0 to 30.5 mms. from March 20th to March 27th. The two undermost zones appear to have had the greatest share. Both zones have grown 100 %. The total increase is due to the lowest 10.5 mms. On March 27 new marks were put on. From March 27 to May 12 the growth amounted tot 8.6 mms. (20.4 to 29.0 mms.). The undermost zone appears to have added 3.3 × its length of March 27 in that period, the next zones a great deal less (columns 3 and 4).

The lowest 10 mms. of March 27 have formed the part that has been lengthened. Here again the growth was most vigorous at the base.

In bulb V (table 3 columns 1 and 2) the sheath-leaf has grown from 26.5 tot 29.5 mms., i. e. 3.0 mms from March 20th to March 27th. The lowest (1st zone) up to and including the third zone have yielded 2.0 mms. The very slight growth of 1 mms. is caused by the portion measuring 3.4 tot 18.0 mms. on March 20. From March 27 to April 12 there is a growth of 22.5 to 25.0 mms. The 2.5 mms' increase is effected by the zone 0.0 to 17.5 mms. of March 27 (columns 3 and 4): 1.2 mms. of it has been produced by the lowest zone. On April 12 the lowest 19.5 mms. of March 20 (the total length being 26.5 mms. by that time) has been lengthened to 25.0 mms., the rest being shrivelled up on April 12. From March 20 to April 12 therefore there is an increase of 5.5 mms. For its division of growth see col. 5. We notice that the lowest zone has added 2.1 × its initial length, while this lengthening is much less in the following zones.

In bulb III (table 4 columns 1 and 2) a similar increase of length appeared to have taken place from March 20 to April 12, viz. 6.0 mms.

Besides the zone at the base, there are others which have been much lengthened. There appears to be a zone from 0.0 — 13.5 mms., which grows after March 20. Within this part we find no strikingly vigorous basal growth.

In the sheath-leaf of bulb IX (table 5) the growth from March 10 tot 19 amounts to 3.6 mms. (26.4 to 30.0 mms.). In this the three lower zones, measuring together 2.5 mms., take no part (columns 1 and 2). The growing portion is chiefly found between 2.5 and 12.0 mms. from the base, i. e. 3.0 mms. is added from March 10 to 19 by the zone mentioned, while there are 3 other zones, situated much higher, which have grown 0.6 mm. From March 19 to 27 there is growth at the base (columns 3 and 4). There is a total growth of 6.0 mms. produced by a piece, measuring 0.0 to 10.8 mms. on March 19. Besides the most basal zone, the zone 8.0 to 9.0 mms. of March 19 appears to have been much lengthened.

From March 27 to May 12 (columns 5 and 6) the growth is 3.2 mms. (36.0 tot 39.2 mms.). Of these 3.2 mms. a lenghtening of 2.8 mms. is produced by the lowest 19 mms. of March 27, while the part higher than 19 mms. gives an increase of 0.3 mm. Just as in the period from March 10 to 19 the upper part of the sheath-leaf has been slightly lengthened. From March 10 to May 12 the lowest 12.0 mms. (of March 10) have grown 11.9 mms.; the part lying higher than 12.0 mms. on March 10 but 0.9 mm.

Of the sheath-leaf of bulb XII (table 6) the lowest zone, 0.5 mm. long on March 20, grows most vigorously, viz. 2.4 × its length from March 20 to March 27. Only the lower 7.8 mms. grow from March 20 to 27 (totally 3.2 mms); above this there was no increase (columns 1 and 2). While the growth from March 27 to April 12 is least in the most basal zone (columns 3 and 4), it is just the reverse from April 12 to May 11 (columns 5 and 6). The total increase of the whole sheath-leaf from March 20 to May 11 amounts to 12.3 mms. (31.2 to 43.5 mms.). Of this amount 12.2 mms. have been formed by the zone 0.0. tot 7.8 mms. of March 20 (column 7).

The division of growth from May 12 tot July 18 (columns 8 and 9) again shows that the lowest zone of 2.5 mms. of May 12, is the one that has grown most vigorously. Of the total lengthening of 5.3 mms., 4.5 mms. have been yielded by the lowest 6.5 mms. of May 12, consequently there is a strong concentration of the growth-process at the base of the sheath-leaf.

The sheath-leaf of bulb XV (table 7) only shows a lengthening of the lowest 12 mms. from March 20 to April 12 to a total amount of 6.3 mms., whereas the 2nd zone from the base grew most vigorously, viz. 3 × its initial length, the lowest zone has not grown at all. For the rest the division of growth is irregular (columns 1 and 2).

From April 12 to May 11 only the lowest 5.5 mms. of April 12 have been lengthened, viz. 3 mms.

From March 20 to May 11 therefore there was a total growth of 9 mms. (column 5), in which only the lowest 12.0 mms. took part in the period from March 20 to April 12 and from April 12 to May 11 only the lowest 5.5 mms. After May 12, after putting on the new marks, there was a growth of 2 mms. till June 6, 1.3 mm. of which was formed by the basal zone of 0.0 to 2.2 mms. of May 12. The further lengthening of 0.7 mm. was produced by a piece measuring 7.5 mms. from the base.

From all these preceding data it appears, that *the growth in length of the outmost sheath-leaf enveloping the assimilating foliage-leaves during the assimilation-period of the foliage-leaves mainly takes place in the more basal part.*

For the length of this basal growing part we found:

C	from	March 28	to	May 8:	9.2	mms.	of	the	44.0	of	March 28	grew	; 34.8	mms.
„	„	May 8	„	June 20:	16.0	„	„	„	55.5	„	May 8	„	; 39.5	„
M	„	„ 8	„	„ 20:	26.0	„	„	„	44.5	„	„ 8	„	; 18.5	„
IV	„	March 20	„	March 27:	10.5	„	„	„	28.0	„	March 20	„	; 17.5	„
V	„	„ 27	„	April 12:	17.5	„	„	„	29.5	„	„ 27	„	; 12.0	„
	„	„ 20	„	„ 12:	16.5	„	„	„	26.5	„	„ 20	„	; 10.0	„
III	„	„ 20	„	„ 12:	13.5	„	„	„	26.0	„	„ 20	„	; 12.5	„
IX	„	„ 10	„	March 19:	26.2	„	„	„	26.6	„	„ 10	„	: 0.4	„
	„	„ 19	„	„ 27:	10.8	„	„	„	30.0	„	„ 19	„	; 19.2	„
	„	„ 27	„	May 12:	31.7	„	„	„	36.0	„	„ 27	„	; 4.3	„
XII	„	„ 20	„	March 27:	7.8	„	„	„	31.2	„	„ 20	„	; 23.4	„
	„	„ 20	„	May 11:	7.8	„	„	„	31.2	„	„ 20	„	; 23.4	„
	„	May 12	„	July 18:	14 2	„	„	„	43.5	„	May 12	„	; 29.3	„
XV	„	March 20	„	April 12:	12.0	„	„	„	30.0	„	March 20	„	; 18.0	„
	„	April 12	„	May 11:	5.5	„	„	„	33.0	„	April 12	„	; 27.5	„
	„	May 12	„	June 6:	7.5	„	„	„	39.0	„	May 12	„	; 31.5	„

from the apex show no lengthening.

Leaving the lengthening from March 10 to March 19 and March 27 to May 12 of IX out of consideration, because by far the greater part of the growth was effected by the lowest zone of 12 mms., we see that in all other cases the non-growing part from the apex amounts to 10 mms. at the least often considerably more, even up to 39.5 mms. So we notice strong individual differences here.

The growing basal portion of the sheath-leaf appears to vary between 5.5 mms. and 26.0 mms. *Yet we saw, that (excepting bulb M) the growing zone is as a rule not larger than 17 mms. and often appears to be smaller. In by far the most cases the most basal portion of that growing part again shows the most vigorous growth, while the growth continues longest there. The growth ceases basipetally.*

It is a remarkable fact that the basal part of the sheath-leaf which is stuffed with starch and consequently seems so stiff and little capable of growing, grows most vigorously, while the more transparent higher part is no more lengthened. We shall see later on, whether this growth of the sheath-leaves is only brought about by cell-extension or also by cell-division.

b. Division of growth in length of the foliage-leaf-scale.

It is already known, that in the one year older sheath-leaves, i. e. the sheath-leaves surrounding the leaves, which assimilated the year before, a new lengthening begins in spring (see Blaauw 1923. Table 31*b*). The same was ascertained with respect to the rest of the inner foliage-leaf in the year after its assimilation. (Blaauw 1923. Table 24.) This is a scale which except by its place in the bulb, is no more distinguished from the sheath-leaf-scales. A different behaviour as to their growth in length is no more to be expected of these scales, though they are of a different origin. On account of this the division of growth was only observed in a few foliage-leaf-scales, viz. in the scale of the inner foliage-leaf in the year after its assimilation in bulb II and bulb L (see fig. 1).

In bulb II (table 8) this scale has a length of 30 mms. on March 20; of these only the lowest 7.8 mms. grow from March 20 to 27, viz. 2.2 mms. (columns 1 and 2). From the division of growth it appears, that the three lower zones, forming the lowest 2.8 mms. on March 20 grow most vigorously all three of them at about the same rate. From March 27 to April 12 another 2.2 mms. are added, when the lowest zone is no more lengthened (columns 3 and 4). A portion of 11 mms. from the base takes part in the growth. In the whole period from March 20 to April 12 we ascertained a growth of 4.4 mms. (col. 5).

Though in this case not the undermost zone has been lengthened most, here too we find, just as in the case of the sheath-leaf, that the growing part lies at the base and the growth of that part has been most vigorous in the more basal zones.

In bulb L (table 9) the lengthening of the above-mentioned scale is 6.5 mms. (45.5 to 52.0 mms.) from May 8 to June 21. The lowest 22.5 mms. of May 8 have grown 8.5 mms. longer. This however does not appear in the total length, because the top part of this scale is shrivelled up on June 21, causing a shrinking of 2 mms. Only 22.5 mms. of the total length of 45.5 mms. took part in the growth, i.e. about half the scale was growing. A similar large growing zone we also found occasionally in the sheath-leaves. From table 9 col. 2 it is evident, that the undermost 11.5 mms. of May 8 grow most vigorously.

In the scale of the inmost foliage-leaf a year after its assimilation, we found the most vigorous growth at the base, just as in the outmost of the sheath-leaves, which surround the assimilating foliage-leaves.

c. *Division of growth in length of the foliage-leaf.*

We shall first examine the growth of the foliage-leaves during the assimilation-period with the aid of marks.

In bulb XIV the base of the outmost assimilating foliage-leaf did not show any enlargement or thickening with starch-aggregation on March 20th 23; it only appears that the insertion-spot is a little narrower, as is always the case in the foliage-leaves before the leaf-base grows into a reserve-organ. On the broadest spot i.e. 2 mms. from the base, a mark *a* was put on March 20th 23. On March 27 the foot of the foliage-leaf already appeared to be full of starch up to 3.5 mms. from the base, which is externally visible by the white colour.

The most swollen spot lay 1.5 mms. from the base and was marked *b*. On March 27 the mark *a* of March 20 was found at 3 mms. from the base i.e. it is still in the part of the foliage-leaf that is going to develop into a reserve-organ.

Bulb XIV.	Distance from *a* to the base in mms.	Distance from *b* to the base in mms.	Total height of the portion filled with starch in mms.	Total length of the foliage-leaf in mms.
20 March 23	2.0	—	—	201
27 March 23	3.0	1.5	3.5	277
12 April 23	7.0	3.5	8.0	360
11 May 23	18.0	10.0	21.0	385

From the above figures we see, that on March 27 the reserve-organ is 3.5 mms. long, on April 12th 8 mms., on May 11th 21 mms.

The mark *a* lying at 3 mms.' distance from the base on March 27, we find at 7 mms. on April 12 and on May 11 at 18 mms.' distance from the base. From March 27 to May 11 that zone has increased 3 to 18 mms. = 15 mms. = 5 × its initial length. The distance of this mark *a* to the upper limit of the starch-part amounted to 0.5 mm. on March 27 and to 3 mms. on May 11, i.e. an increase of 2.5 mms. or 5 × the initial length. This small piece therefore has grown in proportion to the lowest part. From this we see, that the limit of the starch-part and the further foliage leaf-part has remained quite the same on the various dates. When a small portion at the base is to be distinguished as thickened and filled with starch, the limit of the further foliage-leaf and the reserve-organ is fixed. *This reserve-organ therefore does not grow, or in other words the scale does not originate, because a greater and greater part of the foliage-leaf is turned into reserve-organ by aggregation of starch, no, it is an originally small portion differentiating at the base of the foliage-leaf and growing from those originally narrow bounds* (e. g. the 3.5 mms. of March 27) *to a large reserve-organ* (e.g. 21 mms.' length on May 11 as mentioned above).

Before examining the division of growth of this starch-part of the foliage-leaf, I wish to point out a few cases, from which it likewise appeared, that the limit between the starch-part of the foliage-leaf and the further foliage-leaf-part is a fixed line. For instance in bulb I the starch-part is 4.5 mms. long on March 19, 6 mms. on March 27 and 9 mms. on April 12, yet this reserve-organ is formed by the same zones.

Bulb I.	Zones on March 19.		The same zones on March 27.		The same zones on April 12.	
Base	0.0 to 0.5	Length starch-part 4.5 mms.	0.0 to 1.5	Length starch-part 6.0 mms.	0.0 to 2.0	Length starch-part 9.0 mms.
	0.5 „ 1.5		1.5 „ 2.8		2.0 „ 3.5	
	1.5 „ 2.5		2.8 „ 4.5		3.5 „ 6.2	
	2.5 „ 3.5		4.5 „ 5.5		6.2 „ 8.0	
Apex	3.5 „ 5.0		5.5 „ 8.8		8.0 „ 13.3	

From these figures it appears, that a little more than the four lower zones continue forming the starch-part and there is no higher zone, which afterwards takes part in forming this reserve-organ or conversely that there is no zone which afterwards loses the character of reserve-organ.

(I wish to point out that the transition between the opaque snow-white starch-part and the more transparent yellow-white rest of the foliage-leaf is usually rather gradual; on account of this it only can be determined, accurately down to 1 mm.)

The same is proved by the following figures:

Bulb VII.	Zones on March 19.	The same zones on March 27.	The same zones on April 12.
	0.0 — 0.2	0.0 — 0.5	0.0 — 1.5
	0.2 — 1.0	0.5 — 1.8	1.5 — 5.0
	1.0 — 2.0	1.8 — 0.5	5.0 — 9.0
	2.0 — 3.3	5.0 — 8.0	9.0 — 13.8
	3.3 — 4.5	8.0 — 12.0	13.8 — 18.3
Length of starch-part.........	4.0 mms.	ca. 7.0 mms.	ca. 14.0 mms.

Bulb VIII.	Zones on March 19.	The same zones on March 27.	New zones on March 27.	These new zones on April 12.
	0.0 — 1.0	0.0 — 3.0	0.0 — 1.0	0.0 — 2.5
	1.0 — 3.1	3.0 — 5.2	1.0 — 3.3	2.5 — 5.2
	3.1 — 4.8	5.2 — 8.5	3.3 — 4.5	5.2 — 6.5
	4.8 — 6.8	8.5 — 13.0	4.5 — 6.0	6.5 — 9.5
			6.0 — 8.0	9.5 — 12.3
			8.0 — 9.5	12.3 — 14.5
			9.5 — 12.5	14.5 — 18.2
Length of starch-part.........	6.0 mms.	10.0 mms.	10.0 mms.	ca. 15.0 mms.

Bulb XI.	Zones on March 27.	The same zones on April 12.	New zones on April 12.	These new zones on May 11.
	0.0 — 0.1	0.0 — 0.1	0.0 — 1.3	0.0 — 5.0
	0.1 — 1.1	0.1 — 1.8	1.3 — 3.0	5.0 — 8.0
	1.1 — 2.0	1.8 — 4.0	3.0 — 5.0	8.0 — 11.5
	2.0 — 3.8	4.0 — 8.0	5.0 — 6.8	11.5 — 15.2
	3.8 — 5.8	8.0 — 15.0	6.8 — 10.5	15.2 — 24.0
Length of starch-part.........	4.0 mms.	ca. 9 mms.	ca. 9 mms.	ca. 18. mms.

Now that we know, that the starch-part is enlarged by growth within its own bounds, we shall trace the division of growth in this starch-part and the foliage-leaf-part above it. Returning to bulb XIV of which I gave some figures above, we see that the dot *b*, initially lying midway between mark *a* and the base on March 27, persists in this same position on April 12. On May 11 the zone from the base to mark *b* is 10 mms. long and from *b* to *a* 8 mms. Mark *a* being near the end of the starch-part, it appears, that the lower half of the starch-part has grown 2 mms. more than the upper half, a fairly equal increase of the two halves during this period. This is quite different from what has been found for the sheath-leaf, where only a larger or smaller piece at the base was growing, while the rest of the sheath-leaf was taking no part in it or was even shrinking. From all the following figures, we shall see that growth may usually be observed over the whole length of this starch-part of the foliage-leaf. We know however that a year later as a scale, this starch part of a foliage-leaf will only grow just as a sheath-leaf in the more basal part (tables 8 and 9).

From the following data it will appear, that though *in the beginning* after the experimental bulbs had been taken to the greenhouse, indeed the upper part (sometimes the middle of this starch-part) was most lengthened, yet later on during the assimilation-period the base of this part usually grows most vigorously. In this way the fact, that only the basal part of this organ grows a year later as it has become a foliage-leaf-scale, is made comprehensible.

We shall now subject the figures to a closer examination.

In bulbs I, VII and VIII, put into the greenhouse on March 2nd 1923, the total length of the foliage-leaves was about 100 mms. On March 8 sectors were cut from the scales, so that the outer foliage-leaves could be marked down to the bulb-disc. While on March 8 there is no question of a store-organ, the length of that starch-containing part appears to amount to 4.5 mms., 4 mms. and 6 mms. respectively in I, VII and VIII (in the greenhouse) on March 19.

In bulb I about 2.5 of the lower zones form the starch-part of March 19. The undermost millimeter does not grow from March 8 to March 19 (table 10 columns 1, 2, 3), while the 2nd zone grows 1.4 mms., i. e. 1.2 × its initial length. The third zone, the lowest part of which only contains starch on March 19, grows less.

In bulb VII the lower three zones form the store-organ of March 19. Only the middle one has been lengthened from March 8 to March 19, viz. 0.7 mm. (table 11, columns 1,2 and 3).

In bulb VIII (Tab. 12. columns 1, 2 and 3) again the ca. 2.5 lower zones contain starch on March 19. Here again the undermost zone of 1 mm. has not been lengthened from March 8 to 19, whereas the 2nd zone has increased its length with 2.3 mms., and the 3rd zone with 1.7 mms., i. e. with 1.5 × and 1.1 × the initial zone-length. While on March 8 the lower 3 mms. of the outmost foliage-leaf of these three bulbs show nothing particular, those three mms. appear to belong to the starch-part of the foliage-leaf on March 19. As the basal zone was not lengthened in these bulbs, it is evident that the store-organ is originated by events inside already existing zones of the leaf and not by the bulbs-disc. There is no question of a growing out of the store-organ from the bulb-disc by cell-division, the limit between foliage-leaf and bulb-disc being a fixed line. Thin pieces of copper- or silver-wire stuck into the tissue on that spot, remained on the limit of foliage-leaf and bulb-disc. after vigorous growth, even of the most basal zone. The same obtains for the limit of sheath-leaves and bulb-disc, scales and bulb-disc.

Consequently both towards the base and towards the apex the starch-part of the foliage-leaf is an independent whole, inside which growth takes place.

Initially that growth appeared to be slightest at the base and strongest in the middle of the starch-part in bulbs I, VII and VIII from March 8 to 19.

In bulbs I and VIII however we observe the most vigorous growth at the base from March 19 to 27 (see tables 10 and 12. columns 4, 5, 6).

In bulb VII the middle part even takes a more important part in the lengthening from March 19 tot 27, (table 11, columns 4.5 and 6) and not before March 27 to April 12 (columns 7.8 and 9) the two basal zones of the starch-part appear to have been most lengthened. On our observing the growth from March 19 to April 12 the undermost zone of 0.2 mm. appears to have added 6.5 × its length of March 19, whereas the following have respectively increased with 3.3, 3.0 and 2.6 × their original lengths (table 11, columns 10 and 11).

While in bulb I the lengthening of the most basal zone was greatest from March 19 to 27, there may be observed a stronger growth in the upper half of the starch-part from March 27 to April 12 (table 10, colums 7,8 and 9), yet the total lengthening of the basal zone from March 19 to April 12 has been 3 × its length, of the following zones 0.5 ×, 1.7 × and 0.8 ×. Only the basal part of the next zone belongs to the starch-part.

On examining the total lengthening of the lowest and upper halves, as we did in the case of bulb XIV, we find that the starch-part of bulb I has grown from 4.5 to 9 mms. from March 19 to April 12. The dot lying 2.5 mms. from the base on March 19 (see p. 20) i. e. only 0.25 mm. above the middle of the starch-part, lies 6.2 mms. from the base on April 12, i. e. 1.7 mm. above the middle of the starch-part. If the 0.25 mm. had grown as much as the total starch-part, this piece had become $2 \times 0.25 = 0.5$ mm. long, so that the starch-part up to the dot at 6.2 mms. still lies $1.7 - 0.5 = 1.2$ mm. too high above the middle of the starch-part. From this we may conclude, that the lower half of the starch-part has grown out to 5.7 mms., the upper half to 3.3 mms.

In a similar way we find that in bulb VII (p. 20) the lower- and upper halves, having a length of 2.0 and 2.0 mms. on March 19, have a length of 9.0 and 5.0 mms. respectively on April 12. In bulb VIII (p. 21) lower and upper half of the starch-part are 3.1 and 2.9 mms. on March 19; 5.2 and 4.8 mms. on March 27.

In bulb XI (p. 21) the lengths of lower and upper half amounting to 2.0 and 2.0 mms. on March 27, amount to 4.0 and 5.0 mms. respectively on April 12. From April 12 to May 11 the lower has grown about 1.5 mm. more than the upper half.

In bulb XI, taken to the cold greenhouse a fortnight later, viz. March 17, the most basal zone of the outmost foliage-leaf did not grow in the beginning, just as with bulbs I, VII and VIII. The undermost zone indeed is but 0.1 mm., but even when leaving this out of consideration, it nevertheless appears, that from March 20 tot April 12 the growth increases towards the top of the starch-part (table 13. columns 1 to 8). This is in accordance with the fact, that from March 27 to April 12 the upper half of the starch-part has grown ca. 1 mm. more than the lower half. From April 12 to May 11 the growth in the most basal zone appears to have been most vigorous (see table 13, columns 8,9 and 10), so that the increase in growth of the successive zones was 2.8 ×, 0.7 ×, 0.7 ×, 1.0 × and 1.3 × the initial length of April 12. The result is, that during that period the lower half of the starch-part has been lengthened by ca. 1.5 mm. more than the upper half. This may be inferred from the figures of bulb XI p. 21.

From May 11 to June 6 the division of growth in the starch-part seems to have been rather irregular, (table 13, columns 11, 12 and 13), the result is, that in the total increase of 5.8 mms. the lower half has taken about as great a part as the upper half.

Summarizing we may conclude that with respect to the bulbs I, VII, VIII, XI and XIV, the reserve-organ attained a length of 9.0 mms., 14.0 mms., 15.0 mms., 18.0 mms., 22 mms. and 21 mms. respectively, and that in the whole period of growth, even in those which were lengthened most (XI and XIV) the growth of *the lower half of the starch-part amounted to at most ca. 2 mms. more than of the upper half. This is due to the fact, that the part* *with the strongest growth initially lies some distance above the base and is not found at the base until later on.*

In the bulbs *O*, *J* and *K*, (table 19), which in 1922 were only put in the greenhouse on May 10, the most vigorous growth appeared to take place directly at the base of the reserve-organ by that time, just as was found for the foliage-leaves in 1923 after the initial development of the reserve-organ. *This decrease in growth in the starch-part of the foliage-leaves from the base towards the top, is in accordance with the behaviour of this reserve-organ a year later,* as we saw with respect to the scale of bulb II and bulb *L*.

We shall now examine the growth of the foliage-leaf-part lying above the store-organ.

In bulbs VII and VIII the greatest lengthening of this leaf-part is found from March 8 to 19. (March 8 to 19 means 6 to 17 days after the plants were put in the greenhouse). Next the growth decreases.

In bulb I the growth from March 8 to 19 is slighter. In bulb XI we find the greatest lengthening of this foliage-leaf-part from March 27 to April 12 i.e. during a period from 10 tot 26 days after removal to the greenhouse, in this case a temperature of 12 to 13° C.

On our observing the division of growth, it appears that in bulb VII (table 11) the zone lying 4.1 tot 5.3 mms. from the base on March 8, has been lengthened most till March 19, viz 6.3 × its length on March 8. From that region the growth decreases towards the top and towards the base, (col. 3). It may be calculated, that on March 8 the future limit of the part that will be accumulating starch, lay at ca. 3.3 mms. from the base. The zone 4.1 tot 5.3 mms. which has been maximally lengthened in this period, lay on March 8 still 0.8 mm. above the future limit of the reserve-organ. On March 19 this zone of the most vigorous growth lies 10.0 to 18.8 mms. from the base, i.e. 6.0 to 14.8 mms. above the 4 mm. long starch-part.

In bulb VIII (table 12) the zone lying 5.5 tot 6.5 mms. from the base on March 8, had grown most on March 19, viz. 6.0 × its length. On March 19 it lies between 13 and 20 mms., i.e. 7 to 14 mms. above the 6 mm. long starch-part. The zone 4.0 tot 5.5 mms., lying on March 19 still above the starch-accumulating part has grown much less, i.e. 2.3 × its length of March 8. It may be computed that on March 8 the future limit of the part that will be accumulating starch, lay at ca. 3.2 mms. The zone 5.5 to 6.5 mms. which has been maximally lengthened from March 8 to 19, lay still 2.3 mms. above the future limit of the reserve-organ on March 8.

Though in bulb I the growth was slighter and the maximal lengthening only amounts to 2.2 and 2.4 × the length on March 8, here too we find that the zones 4.8 to 6.5 and 6.5 to 8.2 mms. from the base have been maximally lengthened, (table 10 columns 1,2 and 3). The zone below it of 3.3 to 4.8 mms. on March 8 still lies 0.4 mm. above the part growing out to reserve-organ. Yet this zone has only increased 0.8 ×. Here too the zone directly above the starch-part is not the one that has been maximally lengthened.

The lower limit of the maximally growing zones of the foliage-leaf-part lying above the store-organ, lies in bulbs VII, VIII and I, in the period in which the starch aggregation is going to begin, on March 8 at least 0.8, 2.3 and 1.9 mms. above the future starch-part.

In bulb XI (table 13 columns 1,2 and 3) the lengthening from March 20 to 27 is strongest in the zone lying 6.8 to 7.8 mms. from the base on March 20. The lower limit of this zone surely lies 2.3 + 1.3 = *3.6 mms, above the starch-part,* for besides the zones 5.2 to 6.8 mms. and 4.5 tot 5.2 mms. (together 2.3 mms.) we must add by far the greater part, viz. 1.3 mm. of the zone 3.0 to 4.5 mms., because it appears, that on March 27 only 0.2 mm. of that zone belongs to the starch-part and on March 20 there certainly did not belong more to it.

From March 27 to April 12 (columns 4,5 and 6) the maximal lengthening (i. e. 4.6 ×) is attained by the zone 5.8 to 7.3 mms. of March 27, that is *the lower side of this zone is still 1.8 mm. above the starch-part.* From that maximally growing zone the growth decreases towards the top both from March 20 to 27 and from March 27 to April 12.

From March 19 to 27 we find the greatest lengthening in bulb I (table 10 columns 4, 5, 6 and 7) in the zone 7.8 to 9.0 mms., i. e. in a zone of which the lower side is *3.3 mms. above the starch-part.*

During this period the maximal lengthening in bulb VII (table 11, columns 4, 5, 6 and 7) appeared in the zone still partly belonging to the starch-part on March 19, viz. the zone 3.3 to 4.5 mms., while the zone 1.0 to 2.0 mms. in the starch-part grows about equally fast. Here therefore there is but a slight maximum above the starch-part.

In bulb VIII (table 12, columns 4, 5 and 6) from March 19 to 27 the zone 6.8 to 8.5 mms. lying 0.8 mm. above the starch-part with its lower side on March 19 has added 1.9 × its length, the two above it 1.5 and 2.0 × their initial lengths. Here too the maximum is less pronounced.

In bulb XI (table 13, columns 8, 9 and 10) in the period of April 12 to May 11 the slight maximum of 1.6 × is attained by the zone lying on April 12th 15.0 to 17.3 mms. from the base, i. e. 6 to 8.3 mms. above the starch-part.

If the growth of the foliage-leaf-part lying above the store-organ becomes still slighter as in bulbs I, VII and VIII in the period from March 27 to April 12, there is only in the case of I a lengthening worth mentioning in the zones lying no farther than 9.0 mms. from the starch-part on March 27. The zone partly belonging to the starch-part, shows the most vigorous growth (table 10, columns 7, 8 and 9).

In bulb VII where the growth is also very slight in this period there is a slight growth in the zones lying no more than 8.0 mms. from the starch-part (table 11 columns 7, 8 and 9). In bulb VIII at least we find most growth in the zones lying no farther than 12.5 mms. above the starch-part on March 27 (table 12, columns 7, 8 and 9).

It is evident, that when the growth of the foliage-leaf-part above the reserve-organ is arrested, it is longest continued in the zones lying close above the reserve-organ. The growth in this leaf-part therefore diminishes basipetally.

On considering the growth of the whole foliage-leaf once more during the assimilation-period, we appear to have to deal with two parts. *An initially small zone of some millimeters' length differentiates into 'reserve-organ by growth, initially strongest in the middle or in the highest part bordering on the further leaf-part, while later on at the base that growth is strongest and continues longest.*

Of the foliage-leaf-part above the reserve-organ the zones with maximal growth with respect to this whole foliage-leaf-part lie very close to the top of the starch-part, but during the period that the leaf is growing vigorously there was a zone of 0.8 to 3.6 mms. between the zone of maximal growth and the reserve-organ, which was lengthened to a lesser degree. The cessation of growth is accompanied by the disappearance of a conspicuous maximum, only the zones immediately above the starch-part continue lengthening by that time. Both in the starch-part and the foliage-leaf-part above it, the growth ceases basipetally.

Hitherto we examined the division of growth of the two parts of the foliage-leaf separately, but it is also necessary to examine what the division of growth of the foliage-leaf as a whole may look like.

In this connection I shall refer to similar results (in tables), already found in 1922, but which I shall no more discuss separately.

The division of growth of both foliage-leaf-parts may be such in different periods, that 3 typical cases should be distinguished.

1. The maximum in the reserve-organ lies in its top-part and is slighter than the maximum in the further foliage-leaf. In this case *in the whole foliage-leaf* we find *one maximum lying close above the starch-part* and thence a decrease of growth towards the base and towards the apex, e. g. table 12 col. 3; table 13, columns 3 and 6; column 3 in tables 14, 15, 16, 17 and 20.

2. The maximum of the starch-part lies in the middle or at the base of this part, while in the further foliage-leaf a 2nd maximum may be observed, e. g. table 10, columns 3 and 6; table 11 col. 3.

Both these cases are met in the period that the foliage-leaf above the starch-part is still growing vigorously. In this period we likewise see, that the growth extends to the apex of the foliage-leaf, though the growth decreases towards the apex, e. g. col. 3 in tables 14, 15, 16, 17, 18 and 20 (see also Blaauw 1920 p. 40).

3. If the foliage-leaf above the reserve-organ ceases growing, it may occur that only one maximum may be ascertained at the base of the reserve-organ and thence a decrease of growth to a region above the reserve-organ, e. g. table 11, col. 9; table 14, col. 6; table 15, col. 6; table 16, col. 6; table 17, col. 6.

These three cases are extremes; of course there are transitions between them.

From the data on the growth in length of the foliage-leaf mentioned by Blaauw (1920 p. 40) it appeared, that the foliage-leaf-part inside the bulb always grows most vigorously. This part inside the bulb however had not been closer examined. We now know, that what appears from the bulb is the sum of growth of the reserve-organ (the future scale) and of the further foliage-leaf-part.

§ 3. Cell-division and cell-extension.

a. *Cell-division and cell-extension of the sheath-leaf.*

We shall now investigate in how far the measured growth in length of the sheath-leaves depends upon cell-division and in how far on cell-extension. For this purpose there will be used 5 sheath-leaves of May 3rd 22 and June 16th 22 from the group IV bb (see Blaauw 1923), having about the average length. The number of their cells will be counted and the size of the cells ascertained in the longitudinal direction of the sheath-leaf. From the number of cells may be derived whether any cells have been added, and if so, how many, while from the size of the cell it may be inferred whether extension has occurred.

For this purpose series of freehand sections were made of the middle portion, i. e. the longest part of the sheath-leaf. One middle strip of the sheath-leaf, e. g. of 4 cm. length was divided into 4 pieces each of about 1 cm. and next a series of longitudinal sections (cutting the surface at right angles) was made of each piece. On account of the great quantity of starch-grains the cell-walls were hard to distinguish especially at the base. For that reason the preparations were first stained with a watery solution of aniline-blue, in which process the walls and the nuclei were stained: next the water was removed with alcohol and they were put in clove-oil. (Strasburger (1923). *Das botanische Praktikum* p. 138). In consequence of the altered refraction the starch-grains are hardly visible and the cell-walls are better discernible.

Especially with sections of the higher part of the sheath-leaf this rather round-about treatment is not necessary and it is sufficient to tap the sections carefully with the back of your pincette. When the preparations are in a sufficient quantity of water a great many of the starch-grains will spread in the surrounding water, leaving the cell-walls visible.

Determining the size of the cell as well as counting the cells only occurred with the 3rd tier of dorsal cells under the epidermis. Morphologically dorsal refers to the under side and in the case of hyacinth-leaves therefore the side turned towards the outside of the bulb. This side may usually be distinguished in the preparations by the fact that a definite portion of the back of the sheath-leaf is concave or convex. If the piece is perfectly straight, we should keep an eye on the backside in cutting. If there is a vascular bundle in the preparations, the back is also determined, for the liber lies turned towards the back.

The cell-size was determined with a Zeiss microscope, provided with an A objective and a micrometer ocular 2 of Leitz. The whole scale of the micrometer (= 10 grades) coincides with 1.6 mm. of the preparation.

It was observed how many cells were found in each successive 10 grades. So the number of cells was found and likewise the average size of the cells lying within each successive 10 grades.

Of each part at least 3 sections were counted and the figures of the section nearest to the average were used to compute the total number of cells of the whole sheath-leaf.

In this way we found *on May 3rd 22:*

Length of the sheath-leaf.	Number of cells of the 3rd tier under the epidermis.
33.4 mms.	425
33.8 „	381
31.3 „	366
33.4 „	408
35.9 „	428
average 33.5 mms.	401 cells

and on *June 16th 22:*

Length of the sheath-leaf.	Number of cells.
50.8 mms.	544
51.5 „	535
50.9 „	565
61.2 „	619
52.0 „	578
average 53.2 mms.	570 cells

From May 3 to June 16 the increase in length of the outer sheath-leaf, as an average of 5 sheath-leaves is 19.7 mms., while in that period an average number of 169 cells has been added. This proves, that the cells of the sheath-leaves, stuffed as they are with starch are capable of dividing. It might be supposed that cells were added by division from a layer of the bulb-disc, but in observing the outward marks it has been sufficiently clear, that this is out of the question. (see p. 23).

We must try to ascertain where the cell-division takes place.

On our observing the lengths of the cells (of the mentioned tier) of a definite sheath-leaf, the number of cells contained in 10 grades of the micrometer appears to grow smaller towards the apex, consequently the cell-size increases. The apical part is an exception to this, especially because the sheath-leaf is getting so thin on that spot, or the cells are inwardly so crumpled and torn, that in counting we are restricted to the 2nd or 1st tier of cells under the epidermis or even to the epidermis itself. A sheath-leaf of May 3rd 22 was transversely divided into 3 pieces and of each piece a series of longitudinal sections (cutting the surface at right angles) was made from the middle portion. Of each series the figures have been given below concerning those preparations the results of which were nearest to the average.

macroscopic: 0 to 10.8 mms.

	grades	cells
base	10	41.0
	10	33.0
	10	27
	10	22
	10	18
	10	19
	8	13
10.88 mms. =	68	173

10.8 to 23.0 mms.

	grades	cells
	10	18
	10	16
	10	15
	10	16
	10	14.5
	10	13
	10	14.5
12.16 mms. =	76	115

23.0 to 33.4 mms. = apex.

	grades	cells
	10	16
	10	16.5
	10	17.5
	10	15
	10	16
	10	26
apex	5	14
10.4 mms. =	65	121

The smaller cells at the base already make us surmise that the nucleus-and cell-divisions mainly take place in the most basal zones. In order to find out in what zones most nucleus-and cell-divisions take place, we shall subject the microtome-sections of these sheath-leaves of May 3rd 22 to a closer examination. The middle-strip of the sheath-leaves has been fixed in pieces of ca. 10 mms. in acetic-alcohol (two parts absolute alcohol and one part of glacial acetic acid) and has subsequently been stained with the triple combination safranin, gentian-violet, orange G.

All microtome-preparations of this research have been made by Miss Luyten. The nuclear divisions were recorded as such only then, when chromosomes were distinctly visible. The first stages of division were not recorded because most nuclei looked granulous to such a degree, that confusion with the prophasis could hardly be avoided.

In the series of longitudinal sections through the undermost 10 mms. of a sheath-leaf there were found;

11	nuclear-divisions	between	. . .	0	to	10	grades
11	„	„	. . .	10	„	20	„
4	„	„	. . .	20	„	30	„
2	„	„	. . .	30	„	40	„
0	„	„	. . .	40	„	50	„
0	„	„	. . .	50	„	60	„
1	„	„	. . .	60	„	70	„

From the above it follows, that in this sheath-leaf of May 3rd most nuclear divisions take place in the lowest 20 grades, i. e. in the lowest 3.2 mms. Up to 10.5 mms. (66 grades) from the base a nuclear-division was observed. On such a height it usually appeared to be a nuclear-division in an epidermis-cell or in a cell of the 1st tier under the epidermis.

In two other sections of the same series of this sheath-leaf I found in the lowest 11 mms.:

14	20	nuclear-divisions	between	0	to	10	grades.
1	12	„	„	„	10	„	20	„
2	2	„	„	„	20	„	30	„
1	2	„	„	„	30	„	40	„

In microtome-sections through the lowest 7 mms. of an other sheath-leaf I found in 3 preparations:

16	15	13	nuclear-divisions	between	0	to	10	grades.
3	2	2	„	„	„	10	„	20	„
2	0	0	„	„	„	20	„	67	„

From the various sections of these two sheath-leaves it appears, that by far the most nuclear divisions are to be found below 3.2 mms.

In micritome-sections through the portion 10 to 20 mms. from the base not a single nuclear division was found.

We may safely assume that after May 3rd no cell-division has occurred in these sheath-leaves above 10 mms. from the base.

Now that we have inferred from the division of growth as well as from the cell-size and the nuclear-divisions, that the nuclear divisions and the accompanying cell-divisions take place close to the base, we shall trace what part of the average increase in length (19.7 mms.) of the five sheath-leaves from May 3 to June 16 is only due to cell-extension and what part to division and extension.

We know that on June 16th 22 there are 169 cells more than on May 3rd 22. As an extreme case we might assume that those 169 cells originate from one cell of May 3, so that on June 16 there are 170 new cells. It will depend upon the place of that one cell of May 3rd, how great the increase in length, caused by these 170 cells, is. The length of the cells at the base appears to be least; if therefore we wish to assume the share of the new cells in the increase in length to be as small as possible, we must accept the undermost cell of May 3rd (cell-tier above-mentioned) to have developed into the 170 lowest cells of June 16. In the five sheath-leaves mentioned these 170 cells had a length of 80, 83, 82, 80.7 and 88 grades, i. e. an average of 82.7 grades = 82.7 × 0.16 mm. = 13.2 mms. on June 16.

At least 13.2 mms. of the total increase in length of 19.7 mms., i. e. at least $^2/_3$ of the increase is due to the length of the new cells.

This was an extreme case because we assumed those 170 cells to have arisen from one cell. It is however a highly improbable assumption, because we know that on May 3rd most nuclear divisions are to be found below 20 grades, i. e. over a length of 66 cells. It is much more probable therefore, that e. g. 66 cells have taken part in the divisions.

Assuming this figure, we again ascribe the smallest share in the increase in length to the cell-increase, when we accept that the 66 *undermost* cells of May 3 divide.

It appears namely that the length of every 50 cells at the base is not very different on May 3 and June 16, but diverges more and more towards the apex (the highest zones where no divisions occur, may be left out of account). The increase in length therefore is the slighter, according as the cells to be compared, are lower down. It seems right to assume that the 66 *lower* cells of May 3 measuring

20 grades, have increased by their divisions to 66 + 169 = 235 *lower* cells of June 16, (there being 169 cells more by that time). In the five sheath-leaves on June 16 these 235 cells have a length of 130.4, 123.2, 123, 136 and 120 grades, i. e. an average of 126.5 grades. We commenced with 66 cells measuring 20 grades. Those 126.5 — 20 = 106.5 grades = 17 mms. therefore are at least the lengthening caused by the meristematic 66 lower cells. The objection to this supposition is, that this number of 66 cells is a possibility, but cannot be ascertained with certainty, because it might occur that part of those cells below 20 grades do not divide from May 3 to June 16.

This number not being fixed it cannot be made out, how great the absolute share of the meristematic cells is. By assuming that the cells added had originated from 1 cell, we could however decide, how large the *least* share in the increase in length was for the cells which still divide after May 3. This share appeared to be at least $^2/_3$ of the lenthening.

It is certain that the greater part of the increase in length of the sheath-leaf in the period from May 3 to June 16 is due to cell-increase, at best for a very small part to extension of cells which do no more divide after May 3.

Besides by marking it is also possible to conclude from the size of the cells in what part the cells do no more extend. For this purpose we shall compute the average length of every successive 50 cells of the five sheath-leaves on May 3 and June 16, beginning at the base and ending at 57.5 and 63 grades (ca. 10 mms.) from the apex, because there counting the cells meets with the objections abovementioned.

To get a survey of the whole period of growth the same observations will be made on an outmost sheath-leaf of March 9th 22 of the same lot.

Length of every 50 successive cells of the 3rd dorsal tier under the epidermis of the outmost sheath-leaves (10 grades = 1.6 mms.).

		March 9 n = 1	May 3 n = 5		June 16 n = 5
base	1st 50 cells	10.6 grades	13.6 gr.	9.6 mms.	13.7 grades
↓	2nd 50 „	19.0 „	20.2 „		23.1 „
	3rd 50 „	27.8 „	26.2 „		32.0 „
apex	4th 50 „	31.6 „	28.3 „		33.8 „
	5th 50 „	32.0 „	31.5 „		34.2 „
	6th 50 „	26,0 „	30.5 „		34.6 „
	7th 50 „				34.0 „
	8th 50 „	(next a rest	(next a rest		32.3 „
	9th 50 „	of 93 cells	of 106 cells		30.5 „
		together	together		(next a rest of
		47 gr.)	57.5 gr.)		124 cells together 63 gr.)

The 9th group of 50 cells on June 16 is comparable with the 6th group of May 3, those 50 cells lying at about an equal distance from the apex. The then following 8th and 7th groups of June 16 are comparable with the 5th and 4th groups of May 3, the 4th group of May 3 also lying above the portion where cell-divisions take place.

The 4th group of 50 cells of May 3 has extended 5.7 grades = 0.91 mm.
„ 5th „ „ 50 „ „ „ 3 „ „ 0.8 „ = 0.12 „
„ 6th „ „ 50 „ „ „ 3 „ „ 0.0 „

As the 5th group reaches to 14.1 mms. from the base, we may say, that *above ca. 15 mms. no extension has taken place in these sheath-leaves from May 3 to June 16.* The average length on May 3 being ca. 33.5 mms., 18.5 mms. from the apex did not show any extension.

This tallies with the results of the macroscopic longitudinal measurements of the sheath-leaves, where (p. 16) we ascertained that the growing zone was as a rule not larger than 17 mms. and often smaller.

b. Cell-division and cell-extension of the foliage-leaf.

We shall now investigate whether nuclear-divisions and cell-divisions take place in the *foliage-leaf* and for this purpose we shall first subject to a closer examination the part that grows out to a reserve-organ and behaves as a separate whole as appears from the macroscopic growth-measurements.

We shall examine the results of the series hand- and microtome-sections of the inmost, sometimes of the outmost foliage-leaf of bulbs of the same lot (IV*bb*) as the one of which we just examined the sheath-leaves.

The counts were again made on the 3rd dorsal tier of cells under the epidermis. When the counts were made on microtome-sections, that column has been provided with an ✱. When the figures denoting the number of cells of every 10 micr. grades are the averages of diverse counts, the number of counts (n) is mentioned. The preparations not always ending with 10 micr. grades, the number of grades procede the number of cells in that case.

While on March 8th 22 no starch-part is as yet to be found at the base of the inmost foliage-leaf it has on May 3rd (table 21 Ser. A) a length of *25 grades = 4 mms.* and consists of averagely *95 cells.*

On May 16 (Ser. B) the starch part is *75 grades = 12.0 mms.* long and consists of *255 cells.* Consequently 160 cells have been added from May 3 to 16.

If as in the case of the sheath-leaves, we make the most unfavorable supposition, viz. that the undermost, i. e. the smallest cells have been added by one cell, the length of those 160 + 1 = 161 new cells amounts to 42.5 grades

= *6.8 mms.* (table 21) in Ser. A and B on May 16. The total increase in length of this reserve-organ amounts to 4.0 to 12.0 = *8.0 mms.*

From this it must be concluded, that *from May 3 to 16 at least* $\frac{100}{117}$ *= ca.* $\frac{5}{6}$ *of the increase in length of the reserve-organ of the foliage-leaf is effected by cell-increase and* $\frac{1}{6}$ *at most by extension of those cells that do no more divide after May 3.*

Without calculation we may derive this in some degree from table 21 for each number of cells of the inmost foliage-leaf of May 3 and May 16, forming 10 grades, decreases but little from the base towards the apex; the higher cells therefore are but little lengthened, so that the greater part of the lengthening is due to cell-increase.

On June 16 the store-organ of the inmost foliage-leaf has a length of 211.2 grades = *33.7 mms.* and consists of *415 cells.* From May 16 to June 16 therefore 415 — 255 = 160 cells have been added. Reasoning in the same way as with the sheath-leaves we find that the 160 + 1 = 161 lowest cells have a length of 67 grades = *10.7 mms.* on June 16. The total increase in length of the store-organ amounts to 12.0 to 33.7 mms. = *21.7 mms.* Of this 21.7 mms'. increase in length from May 16 to June 16 at least 10.7 mms. or nearly half of the increase in length is owing to cell-increase.

On comparing May 3 and June 16, as has been done in the case of the sheath-leaves, we see (table 21) that the increase in length amounted to 4.0 to 33.7 = *29.7 mms.*, while 95 to 415 = 320 cells were added. On June 16 the 320 + 1 = 321 lowest cells have a length of 163 grades = 26 mms.: or on choosing the smallest cells also partly found at the top of the store-organ on June 16, those 321 cells have a length of 156 grades = *24.9 mms.* on June 16.

Summarising we find that *at least 24.9 of the 29.7 mms'.*

increase in length of the store-organ from May 3 to June 16 is due to cell-division after May 3, i. e. at least $\frac{100}{119}$ = ca. $\frac{5}{6}$ *of the total increase in length is due to cell-increase after May 3 and at most* $\frac{1}{6}$ *to the extension of cells which do no more divide after May 3.*

In the sheath-leaf at most $\frac{1}{5}$ of the increase in length from May 3 to June 16 appeared to be due to extension of cells which do no more divide after May 3. *In the formation of the store-organ of the inmost foliage-leaf the cell-division seems to play a still more important part in that period from May 3 to June 16, than in the growth of the outmost sheath-leaf, surrounding the assimilating foliage-leaves.*

We shall now investigate where the nuclear-divisions in the starch-part of the inmost foliage-leaf are to be found. In longitudinal microtome-preparations of a portion of ca. 10 mms. from the base of the inmost foliage-leaf *on May 16th 22,* I found in a section (all sections were always taken from the middle part, not near the edges)

17	nuclear	divisions	in	the	zone	from	0	to	10	grades.
17	„	„	„	„	„	„	10	„	20	„
2	„	„	„	„	„	„	20	„	30	„
3	„	„	„	„	„	„	30	„	40	„
2	„	„	„	„	„	„	40	„	50	„
0	„	„	„	„	„	„	50	„	60	„

Further I found in the then following 10 mms. in various sections.

0—1 or 2	nuclear	divisions	in	the	zone	from	0	to	10	grades
0—0 „ 2	„	„	„	„	„	„	10	„	20*	„
0—0 „ 1	„	„	„	„	„	„	20	„	30	„
0—0	„	„	„	„	„	„	30	„	60	„

* Limit starch-part at 15 grades.

In an other inner foliage-leaf about the same thing was found. From these data it appears, that the nuclear-divisions in the starch-part of the inner foliage-leaf chiefly take place in the lowest 20 grades = *3.2 mms.*, as has also been ascertained with respect to the sheath-leaf.

On the limit of the starch-part and the further foliage-leaf-part we find no greater number of nuclear-divisions on May 16th 1922 in the inner foliage-leaf, which was also corroborated with regard to an outmost foliage-leaf of May 16.

On *May 3rd 1922*, when the length of the starch-part is but 4 mms. (25 grades), I find in microtome preparations e. g.

17	nuclear divisions	of	0	to	10	grades	limit starch-part at 25 grades
14	„ „	„	10	„	20	„	
2	„ „	„	20	„	30	„	
2	„ „	„	30	„	40	„	
1	„ „	at			56	„	

In the greater part of the store-organ therefore many nuclear-divisions, but here too on the limit of the store-organ and the further foliage-leaf-part no increase in number of nuclear-divisions.

On *June 16th 1922* the starch-part has a length of about 34 mms. Only in the basal part of the lower 10 mms., but 1 to 2 nuclear-divisions could be found per section. On this date the spot where the foliage-leaf will break off from the store-organ is macroscopically visible. Above that line, i. e. in the foliage-leaf-part, which is soon to die away, the nuclei are coloured to a lesser degree than below it.

On *July 21st 1922* no more nuclear divisions were found.

From these facts we must conclude, that on no date whatever a great number of nuclear divisions can be stated on the limit of the starch-part (future scale) and the further foliage-leaf-part. Neither does the tissue look meristematic. This is already sufficient reason to accept, that the strong growth in length of the foliage-leaf above the store-organ is about exclusively due to extension.

We think it desirable to determine this also by counting the number of cells in a longitudinal direction of the whole foliage-leaf-part above the store-organ.

We shall again use the 3rd dorsal tier of cells under the epidermis.

In order to make these counts no too circumstantial, pieces of ca. 15 mms. were counted and the number of cells between 2 such pieces was computed from the average of those two. In Tab. 22 we find a statement of the number of cells of an inner foliage-leaf of the same lot of May 3rd '22 and of June 16th '22. When the number of cells was not counted, but computed from the mean of the adjacent pieces, it has been mentioned.

From these figures it appears, that the above-mentioned 3rd tier of cells in the leaf of May 3 consists of 1101 cells and in the leaf of June 16 of 1166 cells. A difference therefore of 65 cells, while the length has been increased by 101.5 mms. in that period. That increase can only for a very small part be attributed to those 65 cells, for if we assume, that those cells have been added on the limit of the starchpart and the further foliage-leaf-part, the length of the 65 lower cells amounts to 15 mms. at most (Tab. 22) on June 16.

From the columns with the average cell-length in this table it appears, that on May 3rd '22 the number of small cells above the starch-part was much greater than on June 16th '22. The increase in size of cell in the further foliage-leaf-part also appears from this. It stands to reason, that table 22 cannot give a complete picture, as on every date only 1 foliage-leaf was examined. Our intention was but to control whether without nuclear-divisions that is without cell-divisions, the increase in length from May 3 to June 16 of the foliage-leaf above the starch-part could be explained.

From the above figures it appears, that after the originating of the starch-part *the growth of the higher part of the foliage-leaf from May 3 to June 16 is due for by far the greater part to extension of the existing cells.* This is in accordance with the small number of nuclear divisions, that was found on the limit of the starch-part and the further foliage-leaf-part on May 3 and May 16.

§ 4. Growth in breadth.

a. *Modification of shape of the sheath-leaf.*

When we examined the growth in length of the outmost sheath-leaves surrounding the assimilating foliage-leaves it has been pointed out (p. 16) that a portion of at least 10 mms. from the apex was not lengthened. From the longitudinal counts (p. 38) it could be calculated, that from May 3 to June 16th '22 the outer sheath-leaf of the group IV bb did not show any extension in a longitudinal direction down to 18.5 mms. from the apex.

We shall now investigate how matters stand in the last group of sheath-leaves as to the growth in breadth. Fig. 2 shows a photo of an outmost sheath-leaf on March 9th '22, April 5th '22, May 3rd '22, May 16th '22 and June 16th '22 of the group IV bb. A side-view of the sheath-leaves is given. In this photo it is already obvious, that the apical portion increases its breadth far less than the more basal part on the successive dates. The figures below show, that at a distance of 10 mms. from the apex the average breadth from March 9 to May 16 has remained nearly the same.

The figures of June 16th even point at a shrinking. At

15 mms. from the apex there also seems to have occurred a shrinking from May 16 to June 16. In spite of the slight number of observations (4) this shrinking is fairly certain, as on June 16th '22 the apex happened to be quite shrivelled or even had quite disappeared.

At 15 mms. from the apex the average breadth appears not to differ very much from April 5 to May 16. At 20 mms. from the apex an increase in breadth appears to take place from April 5 to June 16.

At 30 mms.' distance from the apex the increase in breadth is greatest.

The insertion-spot and consequently the base of the sheath-leaf is likewise broadened.

	Average length of the sheath-leaf in mms.		Average breadth of the sheath-leaf in mms.									
			at 10 mms. from apex.		at 15 mms. from apex.		at 20 mms. from apex.		at 30 mms. from apex.		on the insertion spot.	
		n		*n*		*n*		*n*		*n*		*n*
Mrch. 9th '22	29	(1)	16	(1)	—		25	(1)	—			
April 5th '22	32	(9)	16	(9)	22	(9)	25	(9)	29	(1)	22	(7)
May 3rd '22	35	(3)	16	(3)	—		27	(3)	36	(2)	29	(1)
May 16th '22	40	(9)	16	(10)	24	(11)	29	(10)	47	(10)	31	(8)
June 16th '22	54	(2)	13	(4)	19	(4)	30	(4)	66	(2)	42	(2)

From these data it appears, that *a certain part of the apex does no more grow in breadth, no more than it grew in length.*

Though the insertion-spot broadens, while the disc grows proportionally, the greatest increase in breadth is found higher.

In this way the peculiar shape arises (see fig. 2) with the narrower base, the strongly swollen part above it and the narrower apex (see further p. 48).

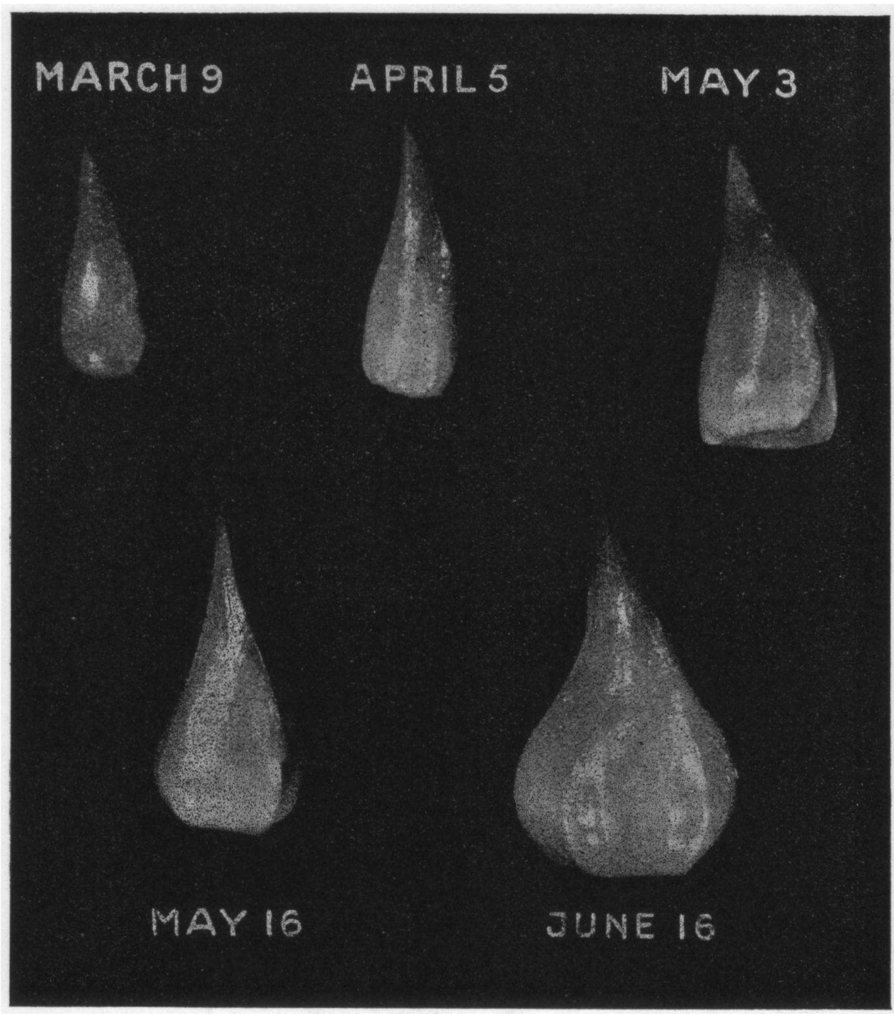

Fig. 2. (nat. size).
Outmost sheath-leaf surrounding the assimilating foliage-leaves of the group IV bb in 1922,

Now the question arises *whether the spot which is initially broadest, continues broadest.*

That in consequence of the growth in length the broadest spot does not continue at the same distance from the base, is already visible in fig. 2 (cf. May 16 and June 16), but this is no satisfactory answer to the question.

From the data on the growth of the marked sheath-leaves it follows in many cases, that the broadest spot is formed after a certain time by a zone formerly lying 1 to 2 mms. below the then broadest spot. As an example I give the sheath-leaf of bulb XV, where the broadest part (indicated with an *), lying 7 mms. from the apex on March 20, 9 mms. on April 12, and 11 mms. on May 11 has got to a zone which was initially lower, as appears from the subjoined list.

March 20 zones in mms.	April 12 the same zones.	May 11 the same zones.
4.7 — 5.8	7.8 — 9.0	*10.8 — 12.0
5.8 — 6.8	*9.0 — 11.3	12.0 — 14.0
*6.8 — 7.8	11.3 — 12.5	14.0 — 15.5

Besides from these direct observations we can also indirectly derive something concerning the broadest spot from the modification in shape of the outmost sheath-leaf surrounding the assimilating foliage-leaves.

On April 5 the average was computed of 8 sheath-leaves of the group IV bb. The broadest spot appeared to be 5.8 mms. from the base and 26.1 mms. from the apex, the total length being 31.9 mms.

In 8 sheath-leaves on May 16, the broadest part appears to lie averagely 6.1 mms. from the base; in these sheath-leaves this means 34.9 mms. from the apex. It we assume that the broadest spot has remained broadest, the portion beneath 5.8 mms. bas been lengthened 0.3 mm. and the portion above 5.8 mms. 8.8 mms.

Let us compare this division of growth to what we found in the sheath-leaf of bulb *C* with respect to the growth in length.

We found that with a lengthening of 19.8 mms. from March 28 to June 20

mms.		mms.	
16.0	had been formed by the zone 0.0 to	3.0	of March 28
2.0	„ „ „ „ „ „ 3.0 „	5.0	„ „ 28
1.8	„ „ „ „ „ „ 5.0 „	9.2	„ „ 28

For further data on the great share the initially lowest 5 mms. took in the lengthening of the sheath-leaf I refer to the results of the growth in length of the other sheath-leaves. Keeping these figures in mind, it appears to be inconceivable, that the lowest 5.8 mms. of April 5 would only have been lengthened 0.3 mm. and the rest of the sheath-leaf 8.8 mms.

From this we must conclude, that the supposition on which this calculation was based, was not correct and the initially broadest spot did not continue broadest.

As a result both of these observations and those on the longitudinal measurements we may accept, that during definite periods of growth *the broadest spot of the sheath-leaf is formed by a zone, which initially was lying nearer the base, therefore lower than the then broadest spot.*

How the surface of such a sheath-leaf alters during 2 years we see in fig. 4, even better than in fig. 2.

The breadth of the outer sheath-leaf was plotted on a level plane at distance of 5 mms. each. A curved line was drawn through the points obtained.

When we first observe the solid lines, referring to the outer sheath-leaves surrounding the assimilating foliage-leaves, we see what the surfaces look like on April 5, May 16, June 16 and July 21. All measures refer to the group IV bb mentioned above. On June 16 the type does not represent the one which most approaches the average, but the two most diverging sheath-leaves, viz. the sheath-leaf the broadest part of which lay lowest (10 mms. from the base) and highest (18 mms. from the base). Of this latter foliage-leaf from the same bulb the outer, one year old er sheath-leaf has been represented by a dotted line. This sheath-leaf surrounds the foliage-leaves, which assimilated the year before. In this older sheath-leaf the broadest spot found at 20 mms. from the base, i. e. but 0.2 mm. higher than in the one year younger sheath-leaf. In order to show how this older sheath-leaf looked some months before, i. e. at the beginning of the new growing-period, two outer sheath-leaves of the same generation of April 5, greatly differing in breadth, have been represented likewise in dotted lines. The apexes of these older outher sheath-leaves had already dissappeared; the sheath-leaves have been represented so far as they were present.

This figure gives a good idea of the broadening of the outmost sheath-leaf and of the further modification in shape, even better than the photo (fig. 2). The broadening of the base should be noted, i. e. the insertionspot of the sheath-leaves on the bulb-disc.

Now that we know, that the broadest spot of the sheath-leaf is formed by originally lower zones and therefore does not persist on the same spot, it follows, that in derterminations of breadth in which the *broadest* spot is measured Blaauw (1923) not always the *same* spot is measured. (Blaauw 1923) already pointed out, that though this is not quite correct, yet in this way the increase in breadth is surely not exaggerated.

Though this method of determining the increase in breadth is not quite correct, another than the broadest spot could hardly be compared, because as a rule it cannot be accurately made out, what zone has grown out into the broadest spot. In spite of this inaccuracy we had better compare the broadest spot on various dates in order to get a picture of the increase in breadth.

b. Division of growth of the sheath-leaf in transverse direction.

On March 20th '23 marks were put in bulb XIII on the outmost sheath-leaves surrounding the assimilating foliage-leaves in transverse direction, 5 mms. from the base, i. e. the lowest spot of the broadest portion on March 20.

The breadth on the spot where the marks had been put, was 32.5 mms. on March 20; 35.5 mms. on March 27; 44.8 mms. on April 12 and 56.0 mms. on May 11.

On our examining the division of growth in Tab. 23 it appears from colums 2 and 4, that there is no question about it that a stronger growth accurs near the edges, as might be suspected, when, on cutting the bulbs in two, we see how those edges of the scales overlap.

The length of the first zone, which has not grown, only being 0.5 mm. (table 23) it may be left out of account. From the other figures it follows, that the growth of the sheath-leaf has rather been stronger in the middle than at the sides.

In 4 other bulbs (VI, X, *M* and *N*) the division of growth in transverse direction was investigated. The marks had been put closer together than in the case of bulb XIII, so that the zones were small. The division of growth appeared to be rather variated in the different zones without there being any regularity to be observed (table 24 bulb X). Yet e. g. in bulb X there was an increase in breadth of 25 mms. to 42.5 mms. = 17.5 mms. This would. point to a rather irregular growth over the whole breadth.

We shall see that the size of cells in transverse direction does not vary much, which points to a rather regular division of growth in transverse direction. The irregularities stated above, probably are the result of the many marks.

c. *How the growth in breadth is effected in the sheath-leaf and the basal part of the foliage-leaf.*

How the growth in breadth is effected, virtually follows from the conclusions made with respect to the growth in length. We ascertained, that *the nuclear-divisions in the sheath-leaf chiefly occur below 3.2 mms., higher zones therefore can only broaden hardly but by means of extension. We know from the preceding, that the broadest spot in successive periods is formed by zones lying initially lower. As long as those zones lay in the meristematic part, i. e. below 3.2 mms. they could broaden through cell-division, so that these zones get a larger number of cells at their disposal, but when they have been shoved out of the dividing zone in consequence of growth in length, the broadening occurs by extension only.*

We shall now examine the cell-breadth and the number of cells on the broadest spot of the sheath-leaf on the various dates, in order to get a more actual representation of the growth in breadth. A series of transverse sections was made of the outmost sheath-leaf of 5 year old bulbs on April 16th 1920 and on June 11th 1920 in such a way, that the 3rd dorsal layer of cells under the epidermis could be counted and measured from one edge to the other. As to its dimensions each sheath-leaf was an average on the dates mentioned.

On April 16th 3 series of sections were necessary, but on June 11 the sheath-leaf had to be divided into 5 pieces in its transverse direction, lest the preparations should become too long, so that 5 series of sections were obtained.

On April 16 the layer mentioned in the broadest part of the sheath-leaf, appeared to exist of 614 cells (Tab. 25 col. 1) and on June 11 of 691 cells (col. 2).

On June 11 we find a greater number of cells in the broadest part than on April 16. We might feel inclined to think, that on the broadest spot cell-increase has taken place. We know however, that on the broadest spot, which on April 16 already lay 7 to 9 mms. from the base, no cell-divisions occur. This greater number of cells on the broadest spot can only be effected indirectly by cell-division, viz. by the growing out of a lower zone with a greater number of cells, which zone on April 16 was still situated below the then broadest spot, to the broadest spot on June 11. Only in this way the greater number of cells on the broadest spot in successive periods may be explained.

On April 16 the broadest spot lay 28 tot 26 mms. from the apex. If on June 11 we make a series of transverse sections in transverse direction at the same distance from the apex, we find, that the whole breadth consists of 512 cells (Tab. 25 col. 3), while at the same distance from the apex 614 cells were found on April 16. Here, we compare a zone at the same distance from the apex on two dates.

On April 16 the length of the sheath-leaf is 35 mms., on June 11 50 mms.; consequently the part above the broadest spot of April 16 must have stretched. The zone where on June 11th 1920 we found only 512 cells, cannot be compared with the broadest spot of April 16, but must already have been *above the broaded spot* on April 16, i. e. have consisted of a smaller number of cells than the broadest spot.

The number of cells at various heights of the sheath-leaf on June 11 is made comprehensible by the following facts:

1°. that the broadest spot in successive periods is formed by originally lower zones;

2°. that the cell-increase chiefly occurs in the lowest millimeters, in consequence of which the number of cells grows larger in that portion.

The *cell-breadth* on the broadest spot on April 16 is averagely 0.419 grade = *0.067 mm.* (Table 25) and on June 11th 0.659 grade = *0,105 mm.* Higher at 28 to

26 mms. from the apex the average cell-breadth is also larger than on April 16th viz 0.739 grade = *0.118 mm.*

It follows, that even above the broadest spot the cells have increased in breadth after April 16, which we have also ascertained with macroscopic transverse measurements.

If we restrict ourselves to June 11, the cells appear to have a breadth of *0.105 mm.* at 10 to 13 mms. from the base i.e. on the broadest spot and at 19 to 21 mms. from the base i.e 28 to 26 mms. from the apex the breadth is *0.118 mm.* On the broadest spot the cells appear not to be broadest. *Only by the greater number of cells, viz. 691 cells on the broadest spot compared with 512 cells on the higher spot, the greater breadth is attained, whilst the cells of the higher zones are averagely broader. From this it appears what important part the cell-increase indirectly plays in the growth in breadth.*

From the number of cells of June 11 of which each successive 10 grades consist in transverse direction (Tab. 25), it appears, that there is a variation in the cell-size even in the 3rd dorsal tier of cells under the epidermis, which consists of fairly regular cells. Close to the edges the cells are smaller, because the leaf grows so thin, that in counting we have to pass on to other tiers of cells and finally to the epidermis-cells.

These figures do not point to a greater extension of the zones in the middle of the sheath-leaf, as the macroscopic observations on bulb X made us suspect. These figures rather point to a fairly uniform broadening over the whole breadth.

As in the foliage-leaves just as in the sheath-leaves the great majority of nuclear divisions were found below 3.2 mms., we cannot expect any other growth in breadth in the foliage-leaves after the first formation of the starch-

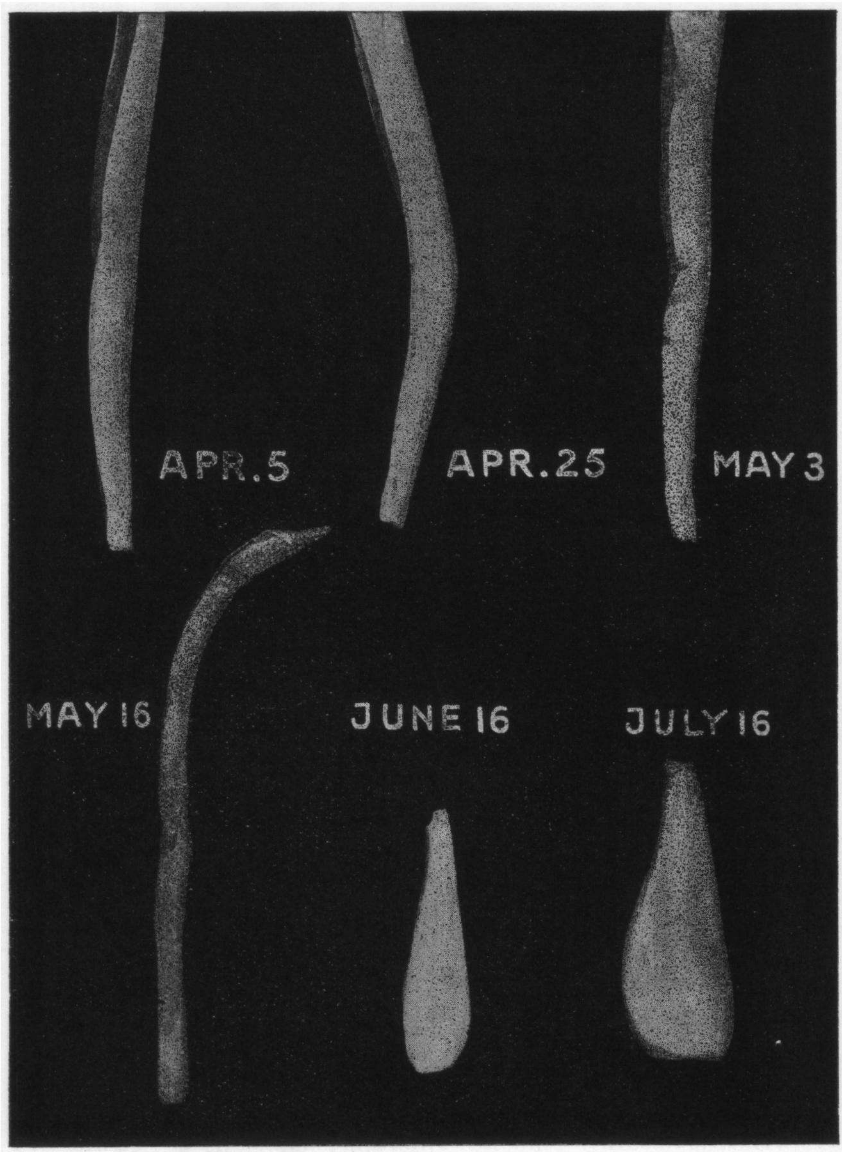

Fig. 3 (nat. size).
Basal portion of the inmost foliage-leaf of the group IV bb in 1922.

part has been effected, than the one of which a detailed description was given with respect to the sheath-leaf. The same obtains for the scales.

For the modifications in shape of the store-organ of the foliage-leaf during its assimilation-period, see fig. 3. These photos represent the inner foliage-leaves of the group IV bb. Especially from May 16 to July 16 the store-organ has grown out.

On June 16 and July 16 only the store-organ (scale) of the foliage-leaf is present. On the other dates only part of the further foliage-leaf-part was given.

§ 5. Growth in thickness.

a. Growth in thickness of the basal part of the foliage-leaf.

On examining the thickness of an outer foliage-leaf, assimilating on May 17th 22 (Tab. 26 A), we see from a microtome-section of 14 mms.' length, that close to the insertion-spot the thickness in the middle part of the foliage-leaf amounts to 7 grades.

The maximum thickness found was 11 grades at 30 grades from the base, i. e. 3.0×1.6 mm. $=$ 4.8 mms. from the base. Next the thickness decreacess and at 88 grades $=$ 14.0 mms. from the base the thickness is again 7 grades, just as at the base. Up to 75 to 78 grades we can find starch, though but a few extremely small grains; at 88 grades we are therefore at least 1.6 mms. above the starch-part.

On counting at equal distances of 5 grades $=$ 0.8 mm. farther from the base the number of cells of which this foliage-leaf consists in thickness, it appears to amount to 27 cells at the base, increase to a maximum of 34 and next decrease, so that above the store-organ the foliage-leaf only consists of 21 cells in that direction. On our subjecting these figures in Table 26 to a closer examination, it appears (columns 1, 2, 3 and 4) that the greatest thickness of leaf coincides with the greatest number of cells, but that already lower than 4.8 mms., namely 15 grades = 2.4 mms. from the base the maximum of 34 cells has been attained. From this it is obvious, that the cell-increase in this direction must also take place in the most basal zones, in this case below 2.4 mms. Above this the cells become larger, but the number no more increases.

The number of 21 cells, found on May 17 in the leaf-part above the store-organ, probably was the number, that could be counted at the base before the formation of the starch-part began. When this formation commenced, cell-divisions took place in the thickness.

In consequence of growth in length, these cells got farther from the base; at the base however the divisions continued and thus the increase in number of cells is found, on passing from the further leaf-part to the base of the starch-part. Very close to the base (Tab. 26) the number is smaller, because in the part above it the divisions continue and the number of cells increase in that portion.

The number of cells in this 3rd direction corroborates the fact, that cell-divisions mainly occur in a zone but a few mms. long, at the base.

In this outmost foliage-leaf we saw with respect to the thickness, that at 2.4 mms. from the base the greatest number of cells could be found, that the greatest *leaf-thickness* however was at 4.8 mms. from the base. On our examining the average *cell-thickness* at the various distances from the base, we see the cell-size increase from the base, but on the spot of the greatest leaf-thickness the cells are but 0.32 grade and above it 0.36 to 0.37.

This thickest spot therefore may be expected to grow thicker. *A similar insight, as given us by the counts into the growth in breadth we get into the growth in thickness* *by these counts and measurements, viz. that the cells of the more basal zones, though they may attain only the same cell-size as those lying above them, yet by their greater number will be capable of causing a greater total thickness of the scalepart when their turn for maximum extension has come.*

For the sake of control the thickness, the number of cells in that direction and the cell-size was determined, on freehand sections of an outmost foliage-leaf of May 17th 22. (B tab. 26. columns 5, 6, 7 and 8).

Two series of sections were necessary to obtain preparations of 17.6 mms. length. A transverse line in Tab. 26. indicates where the 2nd preparation began. As the second preparation will not have been exactly above the other, it is comprehensible, that the 2nd preparation differs at its base somewhat in thickness from the upper end of the lower portion. A preparation cut through a longer piece as in the microtome-preparation is always better, but the small cells at the base oblige us to be satisfied with shorter sections when cut by hand. This remark obtains for following preparations. Meanwhile these hand-sections of May 17 corroborate that already 33 cells were found at 15 grades from the base. Only once 34 cells were found at 50 grades from the base. A slightly higher number may occur, for while the counts were usually made on sections in which no vascular bundle occured, on some spots a vascular bundle is touched. The cells round a vascular bundle always appearing to be smaller, we arrive at a slightly larger number. This difficulty was avoided as much as possible by not using the sections containing a vascular bundle for the counts.

Consequently not too great a value should be attached to that one spot with 34 cells and it appears that at 2.4 mms. (15 grades) from the base the maximum number of cells in the thickness was attained.

The thickest leaf-part lay a little higher at 50 grades = 8.0 mms. from the base, and the maximum average cell size was also greater, viz. 0.43 grade and was found at 60 to 65 grades. The starch-part of this foliage-leaf appeared to be thicker, the thickest portion appeared to be further from the base, the cells were larger, *but the maximum number of cells was also found close to the base.*

We shall now consider the state of the *inmost* foliage-leaf. If the counts have been made on microtome-preparations, the column was provided with an ✱. (table 27).

On May 3rd 22 the inmost foliage-leaf, that, like the outmost foliage leaves of May 17, was taken from the lot IV bb, appears to consist but of one cell less in the tickness at the extreme base than at 20 and 40 grades from the base. This corroberates the supposition of p. 56, that in no starch-part or but a small portion the number of cells at the base corresponds with the number in the further foliage-leaf-part. Only at 5 and 10 grades from the base, i. e. 0.8 to 1.6 mm. from the base cell-increase has taken place in this direction, so that there are 5 to 3 cells more than at 20 to 60 grades. Up to 24 grades from the base a little starch may be found; about the middle of the starch-part now but 24 grades = 3.8 mms. high most cells are found. The highest portion of the starch-part is thickest and there the cells are largest. (table 27 with the results of two preparations of the same foliage-leaf).

On May 17 the greatest number of cells, viz. 31 cells is to be found at 10 grades = 1.6 mm. from the base in the inner foliage-leaf (table 28). In the top-part lying 60 grades = 9.6 mms. from the base, and forming the end of the starch-part, we find 18 cells. The cell-size is maximal, viz. 0.28 grade, just above the thickest part.

It also appears from the number of cells in the thickness of an inner foliage-leaf of June 16th 22 (table 29) that the cell-divisions at the base are limited to a few millimeters. In columns 1 and 2 we see further, that the thickest part of this foliage-leaf lies between 40 and 75 grades i.e. 6.4 to 12 mms. from the base. The largest cells are found above this thickest part, viz. in the zone lying 12.0 to 18.4 mms. from the base (col. 4). The layer where the foliage-leaf will break off from the starch-part is visible in this foliage-leaf at 211 grades from the base. This is the same foliage-leaf on which the counts have been made in a longitudinal direction (table 21). The cells in a longitudinal direction (table 21 last column) appear to be small at the base; next they increase in size, so that from 10.4 to 23.2 mms. the cells are largest in a longitudinal direction, whereas the cells from that point to the separation-layer grow smaller again.

Likewise in the third direction the cell-size first increases, so that in a zone from 12.0 to 22.4 mms. the cells are not smaller than 0.5 grade whereas higher than 22.4 mms. the cells grow smaller and smaller.

We observed therefore:

1. that the greatest number of cells is never found more than 3.2 mms. from the base;

2. that in the inner foliage-leaf on May 3 the thickest spot lay at 1.6 tot 3.2 mms., on May 17 at 3.2 to 4.0 mms. and on June 16 at 6.4 to 12.0 mms., so that the thickest spot gets farther from the base, just as the broadest spot of the starch-part;

3. that the thickest cells were always found above the thickest portion, just as the broadest cells were found above the broadest portion;

4. that on June 16 the thickness of the cells from the base first increases, to decrease again towards the end of the starch-part, as could be ascertained with respect to the cell-length.

The correspondence between the manner of growing in breadth and in thickness, is demonstrated by all this.

b. The separation-layer in the foliage-leaf.

Above I have mentioned a separation-layer, along which the further foliage-leaf will break off from the starch-part.

As is known from the researches by Mohl (1860) and from later researches, e.g. by Lee (1911), such a separation layer at the foot of the petiole is usually found before the fall of the leaf.

In the Hyacinth-leaves of the lot IV bb the leaf was already broken off from the starch-part (the scale) in many cases on June 16th 22, but in other leaves this leaf-part wass still present and the separation-layer was already externally visible as a transparent line across the leaf. A microphoto of a hand-section stained with methylene green (fig. 6) shows, that this separation layer (S) is some layers of cells thick and is not continued in the wood-and sieve-tubes. On one side of the separation layer we see the extended cells of the leaf-part that is to disappear (B) and on the other side the more compact cells of the leaf-scale (S. C.).

In this paper I have hitherto spoken of a starch-part or store-organ without entering into the morphology of this basal foliage-leaf-part. I shall refrain from a judgement in this question and refer to new researches by Agnes Arber (1920), who considers the whole leaves of the Hyacinth the leaf-bases, i.e. the leaf-sheaths of the Dicotyledon-leaves. According to her the rounded apex of the Hyacinth-leaf constitutes the rest of the petiole. On her view about other Monocotyledons see 1922.

The foliage-leaf-part lying above the starch-part and containing no starch except in the guardian-cells of the stomata, I have not given a name and only indicated as the foliage-leaf-part above the store-organ or as the further foliage-leaf-part. We might be inclined to regard *the basal portion of this further foliage-leaf-part*, lying above the store-organ, as a leaf-sheath, 1. because of the sheath-like shape of this leaf-part, 2. because of the lack of chlorophyll. Both phenomena however are partly due to the fact that the bulbs are usually planted deep. When the foliage-leaf down to the bulb is constantly free and exposed to light, the sheath-like shape disappears for the greater part and chlorophyll is found. Close to the bulb the green colour is faint, but we should not wonder at that, because this piece was the last to be pushed from the bulb and consequently has been least exposed to light. In all this I don't see occasion to regard the lowest portion of the foliage-leaf-part lying above the store-organ as a separate whole. Nor do the red spots occuring especially in the lowest portion of this further foliage-leaf-part during and after flowering plead for a special character of this part, as also on the peduncle on the same level as on the leaves red spots may occur and also the scales when exposed to light may show this phenomenon.

On our considering what this research has taught both anatomically and physiologically about the growth, it appears, that the whole leaf-part above the store-organ behaves as one whole.

On the other hand an obvious difference has appeared to exist between the store-organ and the rest of the foliage-leaf both in function and in manner of growing.

The separation-layer in the Hyacinth-leaf also occurs between the starch-part and the further foliage-leaf-part. This feature may be of value for comparative morphology, because in the dicotyledon-foliage-leaves with a pronounced leaf-sheath, the separation-layer often lies above that sheath.

We also find this in exotic orchids (Velenovsky p. 491, von Bretfeld 1879) and in Bambusa (Wiesner 1905, p. 180).

Though I leave the decision to the morphologists, the manner of growing seems to prove, that the starch-part (future scale) and the whole further foliage-leaf-part represent a leaf-sheath and a lamina respectively, which is not in accordance with Agnes Arber's view.

c. *Growth in thickness of the sheath-leaf.*

We still have to investigate whether any peculiarities occur with respect to the thickness of *the sheath-leaves.*

From the figures of table 30 it might be concluded that the number of cells at the base of the outmost sheath-leaf of May 3rd 22 is greatest, remains stationary to 86 grades = 13.7 mms. from the base or 20.8 mms. from the apex and then decreases. The figures of a microtome-preparation given in the same table show an increase of the number of cells in the lowest 13 grades. In microtome-preparations of another outer sheath-leaf of May 3 the number of cells in a section at the base appeared to be 19, whereas 5 grades higher already 22 cells were found and still higher 23 cells at most were found.

In an outmost sheath-leaf of June 16 (table 31) 27 cells appeared to lie at the insertion-spot, while at 35 and 40 grades 28 cells were found as a maximum.

In the sheath-leaf therefore only very close to the base cell-division occurs in the thickness.

In order to show that *both on May 3 and on June 16* sheath-leaves occur, consisting in their thickest portion of 20 to 22 cells and other sheath-leaves showing 25 to 27 cells in that portion (from which it appears that this difference in number of cells in the various sheath-leaves is but a question of variation) counts were made on 2 sheath-leaves on each date (tables 30 and 31).

On May 3 the outmost sheath-leaf of table 30 appears to be thickest at 70 to 86 grades i.e. 11.2 to 13.7 mms. from the base.

The broadest spot even appeared to lie only at 5 to 7 mms. from the base on May 16 so that the thickest part apparently lies higher than the broadest. On June 16 the thickest part lies 29.6 mms. = 185 grades from the base, whilst the broadest part lies at 10 to 18 mms. from the base. *The broadest and the thickest spots do not coincide in the outmost sheath-leaf.* On May 3 the thickest cells appear to lie 96 grades = 15.3 mms. from the base, i.e. just above the thickest part. On June 16 the cells at 147 to 220 grades = 23.5 to 35.2 mms. from the base are of about equal size, so that on the thickest spot 29.6 mms. from the base, the thickest cells are found.

On our comparing the spots where the cells have the greatest thickness and those where they have the greatest length (see p. 38) it appears that on May 3 the greatest length for 50 cells, viz. averagely $\frac{31.5}{50} = 0.63$ grades per cell occurs at 88.3 to 119.8 grades = 14.1 to 19.1 mms. from the base.

The greatest thickness viz. 0.6 grade we find 96 grades = 15.3 mms. from the base on May 3.

On June 16 the greatest length for 50 cells is 34.6 grades, i.e. 0.69 grade per cell. These cells we find at 136.8 to 171.4 grades = 21.8 to 27.4 mms. from the base. The greatest thickness viz. 0.73 grade we find 23.5 to 35.2 mms. from the base on June 16.

As the greatest thickness denotes the average thickness of all cells, viz. large and small cells in that direction, not therefore the cell-thickness of the 3rd cell-layer under the epidermis, as was the case with respect to the cell-length, we can only conclude from these figures, that *on the whole* the cells are thicker in the parts where the cells of the 3rd cell layer under the epidermis are longer.

§ 6. Discussion of the growth in length, breadth and thickness.

The periodical growth in length, breadth and thickness of the sheath-leaves, sheath-leaf-scales and foliage-leaf-scales as ascertained by Blaauw (1923), appeared to be due to periodical nuclear- and cell-divisions, followed by extension. In the most basal part of the sheath-leaves and foliage-leaves (i.e. directly above the insertion-spot) we have to deal with a meristematic tissue, which is capable of a periodical cell-formation for years together.

What this meristematic tissue looks like, e.g. on May 3rd 22, we see at S. C. in fig. 7, which shows the insertion of the scales on the bulb-disc in a longitudinal microtome-section. Here in the basal part of the scales the cells are rather irregularly scattered; cell-divisions take place in various directions. Consequently we do not get the typical cambium-picture with its tangential walls. This meristematic tissue is a rest of the primary meristem of the vegetation-point, which continues meristematic in the lower part of foliage-leaves and sheath-leaves.

The growth in breadth is strictly periodical (trom April to the end of June; Blaauw 1923). In accordance with this is the fact, that in longitudinal microtome-sections on July 19th 1919 nuclear divisions were only to be found in the vegetation-point and the young foliage-leaflets surrounding it, whilst in the sheath-leaf of the young bud and in the scales of the newly decayed foliage-leaves nuclear divisions are already no more found. Yet the cells at the bases of the scales do not grow out after the division-period, but remain small and only divide in the next spring under normal external conditions. We have to deal here with a meristematic tissue in the basal part of leafy organs, which is strictly periodical in its cell-formation for some years. This phenomenon is quite noteworthy with respect to leafy organs. (See for the duration of life of the scales Blaauw 1923). Here therefore we have to deal with a rest of the primary meristem with periodical activity. It is not my intension to decide whether we have to regard the result of this activity as a secondary or a primary growth in length, breadth and thickness. About the idea primary and secondary opinions differ.

On the one hand Haberlandt (1918) and Went (1923) base the distinction between primary and secondary meristems on the difterence in mode of origin of the meristems. Went p. 56 says: "Secondary meristems are those which arise from adult-cells, which rejuvenate and regain the power of dividing".

On the other hand originating from an adult cell is not used as a criterion for regarding a tissue secondary, as appears from the following quotation from Strasburger's Lehrbuch der Botanik (1923 p. 40) viz: "secundäre meristemen sind meristemen, die aus untätig gewordenen Resten von Urmeristemen durch neue Teilungen ihrer Zellen *oder* als Neubildungen aus Dauerzellen entstehen" etc. In this text-book the difference between primary and secondary is rather based on the period in which the meristem acts. Neither does Schouten (1903 p. 57 a. o.) especially call the attention to the fact, whether the tissue arises from an adult cell or not, but to the fact whether the tissue originates *before* or *after* the surrounding tissues have ceased growing in length.

Nor is the distinction between primary and secondary based on the difference in origin in Gray's Botanical Text Book. We find p. 105: "In the further growth of an organ, especially in plants which are to live more than a single year, or which have a well-defined period of rest, remarkable changes may take place in its structure, especially by the introduction of new elements. Such changes are known as secondary and give rise to the secondary structure of the organ". The expression "by the introduction of new elements" is very vague. In my opinion none of the definitions mentioned is quite satisfactory.

Only Haberlandt and Went think the difference due to the way in which the new meristems originate. Theoretically this division is best, for as well as the vegetation-points are rests of the primary meristem and its formations are regarded as primary, the other rests of the primary meristem e. g. the cambia in the vascular bundles with their formations should be regarded as primary. Yet this definition leads to difficulties. The cambium e. g. between the phloem and xylem of the dicotyledonous vascular bundle, directly to be derived from the primary meristem, is according to that definition virtually a primary—, the interfascicular cambium a *secondary* meristem and yet the formations of both of them are called secondary tissue later on.

Went's definition makes us ask whether the originating of a tissue from a cell, derived either through an uninterrupted series of young cells from the young cells of the germ, or from an adult cell, may be supposed of such an importance, that the division of primary and secondary tissues may be based upon it. In the Dicotyledons we often find that the result of the activity of the fascicular cambium (originated through an uninterrupted series of young cells) and the interfascicular cambium (originated from adult cells) is the same, so that two tissues arisen in the two different manners mentioned above, may yield the same at the same points of time. There is little reason therefore to distinguish these formations, of the cambium and of the interfascicular cambium respectively as primary and secondary.

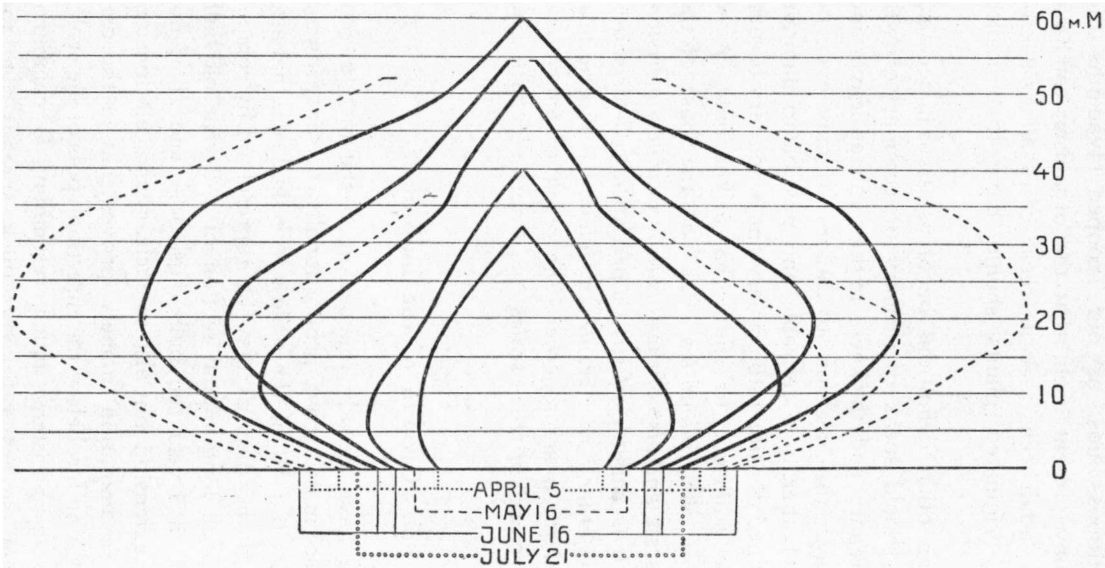

Fig. 4 (nat. size).
The solid lines ——— represent the surface of the outmost sheath-leaf, surrounding the assimilating foliage-leaves (group IV bb 1922). The broken lines - - - - - - represent the same in a one year older generation. See further the text.

Moreover in all organisms propagated by regeneration from adventitious buds, as our scooped Hyacinths, the peculiarity may present itself, that the organisms can have arisen from 'adult cells'; — in *these* cases *all* tissues of vegetatively originated plants should have to be called secondary.

Neither can other definitions be of use to us in deciding whether we should speak of primary or secondary growth in length, breadth and thickness in these foliage-leaves and scales. I leave the decision to others. It may even be questioned whether it is desirable and possible to maintain a strictly defined division into primary and secondary tissues.

It will be sufficient to state, that *at the base of the starch-part of the foliage-leaf,* i. e. at the base of the foliage-leaf scale *and also of the sheath-leaf-scale a meristem occurs, which is capable of strictly periodical cell-formation for years together; the result of which is a periodical cell-formation for years together; the result of which is a periodical growth of the scales in length, breadth and thickness.*

§ 7. Growth of the bulb-disc.

Before we have already touched upon the fact (p. 45), that the disc must grow proportionally to the growing insertion-spots (fig. 4) of the scales. We shall see, that also the growth of the disc, as may be represented by comparison of a radial longitudinal section of a 2-year old bulb with one of a 4-year old bulb (figs. 5 *A* and *B*) is not only due to extension but also to nuclear- and cell-division. Microscopic examination namely proves that in the disc of Hyacinths not far below the insertion-spots of the scales there occurs a meristem, much resembling a cambium. This cambium, several cell-layers thick, spreads over the disc like a cope, and is only pierced by the vascular bundles of the foliaceous parts and of the peduncle. With respect to the course of the vascular bundle in the bulb-disc according to the so called palm-type, see Falkenberg p. 178. Such a cambium in the bulb-disc has been represented in the microphoto fig. 7 at *C*. A vascular bundle *V* breaks partly through this cambium. A stronger magnification of the spot, denoted by *C'*, shows even clearer the cambial character of these cells (fig. 8). These microphotos have been taken of a disc of the lot IV bb on May 3rd 22. On this date a great many divisions take place in the cambium in a tangential direction, while deeper in the disc, i. e. in the central cylinder no cell-divisions occur. As the cambium persists fairly close below the insertion-spot of the leafy parts (fig. 5 *A* and *B*), it follows, that the new cells are chiefly formed towards the inside, by divisions in a tangential direction.

The fact that the growth effected by this cambium does not much show externally, is due to the small dimensions of the plant and to the periodical decay of the lower part of the bulb-disc. Especially the lengthening of the stalk compressed into a disc hardly strikes the eye.

Blaauw already found that about May the lower part of the bulb-disc of the Hyacinth is no more filled with starch to such a degree as the part above it. That part finally loses all its starch, dries up towards the end of summer and persists for some time at the bottom of the disc as a suberised cake. It appeared to me, that when the starch has withdrawn from the lower part a *separation-layer* appears between those two parts such as we also ascertained in the foliage-leaf on the limit of the starch-containing and the further foliage-leaf-part. Macroscopically this layer is also perceptible, namely as a transparent line.

The longitudinal section of the bulb on July 19th 1919 (fig. 5 *B* at *S*) shows this separation-layer, lying as high as the top of the vascular bundle complex of the old peduncle (P') after it has entered obliquely into the disc. Such a peduncle initially stood central on the disc, but in consequence of the periodical growth of the disc and of the fact that every new lateral bud with its leaf-whorl will stand central in successive years, the old flowerstalk is pushed towards the outside of the bulb.

To the part of the bulb-disc that is to die down (*W* in figs. 9 and 5 B), belongs the vascular bundle system of the old decayed flower-stalk (P' in fig. 5 *B*), which flowered a year before in spring, and the vascular bundle system of the scales inserted on this part of the disc. At *S. C.* in fig. 5 *B* the rests of a few old scales are visible.

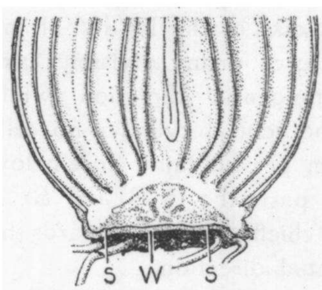

Fig. 5 A. magn. 2 ×
Longitudinal section of a 2 year old bulb.
S = separation-layer.
W = decayed portion.

A microphoto (fig. 9) shows the separation-layer in a bulb of the same lot, likewise of July 19th 19. In this separation-layer a few nuclear divisions were found, a.o. at *O*. In most bulbs the suberised old portion of the disc initially sticks to the disc, but is easily loosened. The separation-layer (*S*) and the old portion of the disc (*W*) already dried up in a 2 year old bulb is shown in fig. 5 *A*.

In fig. 5 *B* where the vascular bundles of the peduncle, which flowered in the spring (*P*), are also visible, those vascular bundles already show the spot, where the next separation-layer is to appear about the middle of July of the following year. Together with such a portion of the disc, the bases of the roots which have functionated that year, disappear. New roots (*R*) are already in formation close to the cambium (fig. 5 *B*) and these will die in their turn the next year.

I shall give further details concerning that root-formation in a later publication.

It appears that the cambium we found in the bulb-disc merges into the meristematic cells of the vegetation-point under the young bud, i.e. near the top of the compressed stalk gradually. This cambium therefore does not arise from adult cells, but from young cells, which through an

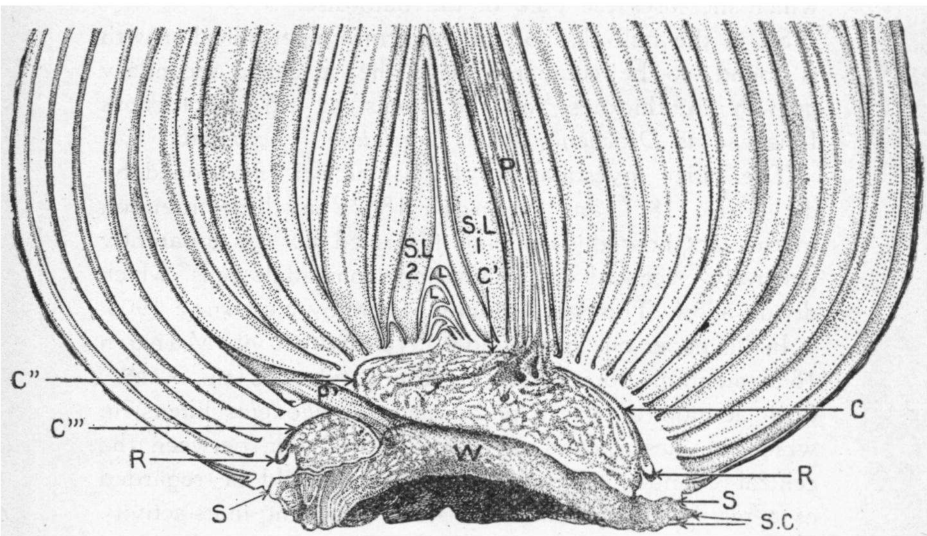

Fig. 5 B. magn. 2 ×
Longitudinal section of a 4 year old bulb. 19 July 19.
S and W as in 5 A. C = Cambium. R = Root. S. C. = Rests of old scales.
P = Peduncle. S. L. = Sheath-leaves of the new bud. L = Foliage-leaves of the new bud.

uninterrupted series of meristematic cells can be derived from the young cells of the germ, or in vegetative propagation as in this case, from adventitious buds. If we regard the piece of cambium C" above the peduncle (P') of the previous year in fig. 5 *B*, it will appear that this spot must have functionated the year before, just as C' above this year's peduncle, is doing this year. C" therefore is in the second year of its activity and will function a 3rd year just as C''' is doing now. Not until the 4th year it will lose its cambial character and die off together with a part of the disc.

While the vegetation-point along with its subjacent meristematic tissue partly effects the elevation of the bulb-disc, it is also due to the cambium the coped shape of which increases the bulk of the bulb-disc.

So in the bulb-disc of the *Hyacinth* a periodical growth is found, to be compared with the so called secondary growth in thickness of the stems of e.g arboraceous Liliaceae as *Dracaena*, *Aloë*, *Cordyline*, *Yucca*, etc.

The older investigators of this subject (mentioned by de Bary 1877 and Mangin 1882) pay little attention to the fact how this cambium is formed, but it is apparently generally accepted as originating from adult cells, which divide anew. This same opinion is held by Schoute 1903.

In his paper one of the older investigators, viz. Mangin 1882 mentions some cases in Monocotyledons (a.o. *Antholyza* aethiopica, *Musa* paradisiaca, *Asphodelus* lutens) in which he describes a meristem in the stem between the central cylinder and the bark, which should be regarded as a rest of the primary meristem, persisting in its activity for some time. In fig. 5 of *Iris* sibirica and fig. 23 of *Curcuma* elata and fig. 35 of *Convallaria* majalis he shows how this meristem may be traced into the meristematic part under the vegetation-point, just a I found with respect to the Hyacinth. Mangin goes on to say that in *Dracaena* and *Yucca* the secondary meristem as to its origin is identical to the so called 'couche dictyogène' and on p. 278 he says about the couche dictyogène that this secondary meristem is formed from the primary meristem without stagnation. According to him the secondary meristem in *Dracaena* and *Yucca* is not originated by division of adult cells. In this case in *Dracaena* and *Yucca* just as in the *Hyacinth* we should have to deal with a meristem, being a rest of the primary meristem and remaining active amidst cells that have ceased dividing.

According to Went's definition this cambium in the bulb-disc of the *Hyacinth* should have to be regarded as a primary meristem, because the cells of this cambium are to be derived through an uninterrupted series of young cells from the young germ-cells. After writing this paper it appeared to me that besides Mangin also Lindinger (1909 p. 219) pointed out, that the so called secondary meristem in *Aloë arborescens* and various *Cordyline-* and *Dracaena*-species is directly connected with the primary meristem, so that there is no limit between the primary- and secondary meristems. His conclusions are even more general. He says: 'The Primary meristem merges uninterruptedly into the secondary meristem in all Liliaceae-stems with growing faculty'. Lindinger also mentions *Hyacinthus orientalis* as a disc in which secondary growth in thickness occurs.

After what I found in the disc of *Hyacinthus* and in connection with the data of Mangin and especially of Lindinger (see other literary data) it is evident to me that the so called secondary meristems, at least of many Monocotyledon-stems have not originated from adult cells.

Neither shall we enter in this case into the question whether the cambium in the bulb-disc of the *Hyacinth* shall be called a primary or a secondary meristem.

§ 8. Summary of the results.

1. The periodical growth in length of the sheath-leaves and scales continues longest in the basal zones. The growth ceases basipetally. By far the greater part of this increase in length of the sheath-leaf during the assimilation-period of the foliage-leaves is effected by an initially very small zone at the base.

2. After the first differentiation at the base of the foliage-leaves the later foliage-leaf-scale appears to be an independent whole, developing within that initially small zone through growth, so that not any piece of the further foliage-leaf-part will belong to the starch-part later on or conversely.

3. Initially the *whole* starch-part that differentiates at the base of the foliage-leaves, grows in length, but afterwards only the most basal zones continue growing just as in the case of the sheath-leaves and the scales of the foliage-leaves a year after assimilation.

4. The foliage-leaf, initially growing over its whole length, continues growing longest after the differentation of the starch-part in the zones lying close above that starch-part.

Consequently what appears from the bulb is the sum of the individual growth of the reserve-organ (the later scale) and the growth of the basal zones of the further foliage-leaf-part.

5. It appeared that at least $^2/_3$ of the increase in length of the sheath-leaf from May 3rd to June 16th '22 is due to the action of cells still meristematic on May 3 and for $^1/_3$ at most to extension of cells that no more divide.

6. In the sheath-leaf and the starch-part of the foliage-leaf nuclear divisions almost exclusively occur within 3.2 mms. from the base.

On the limit of the starch-part and the further foliage-leaf-part no strongly dividing tissue is found. After differentation of the starch-part the increase in length of the further foliage-leaf-part is chiefly owing to extension of existing cells.

7. At least $^5/_6$ of the increase in length of the store-organ of the foliage-leaf from May 3rd to June 16th 22 appeared to be due to the action of meristematic cells and $^1/_6$ at most of the increase in length was due to

extension of cells that had ceased dividing after May 3rd.

8. As to the growth in breadth on the broadest spot and higher it is due to extension only, but in the more basal parts, i. e. below 3.2 mms. strong cell-division takes place and seeing that these lower zones containing initially meristematic cells are moved upwards through growth in length, especially these zones produce the greatest growth in breadth.

9. Before the further foliage-leaf-part is loosened from the starch part a separation-layer is formed.

10. The periodical growth in length, breadth and thickness of the sheath-leaves, sheath-leaf-scales and foliage-leaf-scales is due to a meristem at the base of those leaf-parts. This meristem should be regarded a rest of the primary meristem.

11. Besides by the vegetation-points at the apex the growth of the bulb-disc is effected by the periodical activity of a cambium, spreading copeshaped close below the insertion-spot of the scales. Under the vegetation-point this cambium loses-itself in the meristematic cells of the meristem, which are more irregularly scattered.

12. Part of the bulb-disc periodically dies off at the lower side. This phenomenon is attended by the appearance of a separation-layer in the bulb-disc about July 15th.

Wageningen, June 1924.

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TABLE 1.

Outmost sheath-leaf of bulb C.

Zones on March 28.	Growth of the zones from March 28 to May 8 expressed in the zone-lenghts of March 28.	Growth of the zones from March 28 to June 20 expressed in the zone-lengths of March 28.	Zones on May 8	Growth of the zones from May 8 to June 20.
base 0.0 to 0.5	11.0 ×	19.0 ×	0.0 to 6.0	0.6 ×
0.5 „ 3.0	1.6 ×	2.6 ×	6.0 „ 12.5	0.3 ×
3.0 „ 5.0	0.7 ×	1.0 ×	12.5 „ 16.0	0.1 ×
5.0 „ 9.2	0.4 ×	0.4 ×	16.0 „ 22.0	0.0 ×
9.2 „ 12.5	0.0 ×	0.0 ×	22.0 „ 25.0	0.0 ×
12.5 „ 16.5	— 0.1 ×	— 0.1 ×	25.0 „ 28.5	—
16.5 „ 20.5	— 0.1 ×	—	28.5 „ 32.0	—
20.5 „ 24.5	0.2 ×	—	32.0 „ 37.0	—
24.5 „ 27.5	0.0 ×	—	37.0 „ 40.0	—
27.5 „ 31.5	— 0.2 ×	—	40.0 „ 43.0	—
31.5 „ 34.5	0.1 ×	—	43.0 „ 46.5	—
34.5 „ 37.5	— 0.1 ×	—	46.5 „ 49.0	—
37.5 „ 41.0	0.1 ×	—	49.0 „ 53.0	—
41.0 „ 44.0*	— 0.1 ×	—	53.0 „ 55.5*	—

* = apex.

TABLE 2.

Outmost sheath-leaf of bulb IV.

Zones on March 20.	Growth from March 20 to 27 expressed in the zone-lengths of March 20.	New zones on March 27.	Growth from March 27 to May 12 expressed in te zone-lengths of March 27.
base 0.0 to 1.0	1.0 ×	0.0 to 0.8	3.3 ×
↓ 1.0 „ 1.7	1.1 ×	0.8 „ 2.0	1.0 ×
1.7 „ 2.5	0.2 ×	2.0 „ 3.5	1.3 ×
apex 2.5 „ 3.5	0.0 ×	3.5 „ 4.2	1.1 ×
3.5 „ 5.0	0.1 ×	4.2 „ 5.5	0.3 ×
5.0 „ 6.0	0.1 ×	5.5 „ 7.0	0.4 ×
6.0 „ 7.2	0.2 ×	7.0 „ 8.5	0.2 ×
7.2 „ 8.3	— 0.3 ×	8.5 „ 10.0	0.2 ×
8.3 „ 9.5	0.2 ×	10.0 „ 11.3	0.0 ×
9.5 „ 10.5	0.2 ×	—	—
10.5 „ 11.8	0.0 ×	—	—

TABLE 3.

Outmost sheath-leaf of bulb V.

Zones on March 20.	Growth from March 20 to 27 expressed in the zone-lengths of March 20.	Zones on March 27.	Growth from March 27 to April 12 expressed in the zone-lengths of March 27.	Growth from March 20 to April 12 expressed in the zone-lengths of March 20.
base 0.0 to 1.1	1.0 ×	0.0 to 2.3	0.5 ×	2.1 ×
↓ 1.1 „ 2.5	0.2 ×	2.3 „ 4.0	0.1 ×	0.4 ×
2.5 „ 3.4	0.8 ×	4·0 „ 5 7	0.0 ×	0.8 ×
apex 3.4 „ 5.0	— 0.1 ×	5.7 „ 7.0	0.2 ×	0.0 ×
5.0 „ 6.5	0.0 ×	7.0 „ 8.5	— 0.2 ×	0.2 ×
6.5 „ 8.0	0.1 ×	8.5 „ 10.2	0.2 ×	0.3 ×
8.0 „ 9.8	0.0 ×	10.2 „ 12.0	0.0 ×	0.0 ×
9.8 „ 11.2	0.0 ×	12.0 „ 13.5	0.1 ×	0.2 ×
11,2 „ 12.5	0.1 ×	13.5 „ 15.0	0.0 ×	0.1 ×
12.5 „ 13.8	0.1 ×	15.0 „ 16.5	— 0.2 ×	0.0 ×
13.8 „ 15.0	— 0.1 ×	16.5 „ 17.5	0.8 ×	0.5 ×
15.0 „ 16.5	0.2 ×	17.5 „ 19.3	0.0 ×	0.2 ×
16.5 „ 18.0	0.1 ×	19.3 „ 21.0	0.0 ×	0.1 ×
18.0 „ 19.5	0.0 ×	21.0 „ 22.5	0.0 ×	0.0 ×

TABLE 4.

Outmost sheath-leaf of bulb III,

Zones on March 20.	Growt from March 20 to April 12 expressed in the zone-lengths of March 20.
base 0.0 to 1.0	1.0 ×
↓ 1.0 „ 2.0	0.0 ×
2.0 „ 2.8	1.5 ×
apex 2.8 „ 3.5	0.7 ×
3.5 „ 4.5	0.3 ×
4.5 „ 6.0	0.0 ×
6.0 „ 7.2	0.6 ×
7.2 „ 8.8	0.1 ×
8.8 „ 10.0	0.8 ×
10.0 „ 11.0	0.5 ×
11.0 „ 12.0	0.0 ×
12.2 „ 13,5	0.3 ×

TABLE 5.

Outmost sheath-leaf of bulb IX.

Zones on March 10	Growth from March 10 to 19 expressed in the zone-lengths of March 10.	Zones on March 19.	Growth from March 19 to 27 expressed in the zone-lengths of March 19.	Zones on March 27.	Growth from March 27 to May 12 expressed in the zone-lengths of March 27.
base 0.0 to 1.0	0.0 ×	0.0 to 1.0	1.5 ×	0.0 to 2.5	0.2 ×
↓ 1.0 „ 1.8	0.0 ×	1.0 „ 1.8	0.8 ×	2.5 „ 4.0	
1.8 „ 2.5	0.0 ×	1.8 „ 2.5	0.8 ×	4.0 „ 5.3	0.1 ×
apex 2.5 „ 3.2	0.4 ×	2.5 „ 3.5	0.7 ×	5.3 „ 7.0	0.1 ×
3.2 „ 4.0	0.8 ×	3.5 „ 5.0	0.3 ×	7.0 „ 9.0	0.0 ×
4.0 „ 5.2	0.2 ×	5.0 „ 6.5	— 0.2 ×	9.0 „ 10.2	0.6 ×
5.2 „ 6.2	0.5 ×	6.5 „ 8.0	0.2 ×	10.2 „ 12.0	— 0.1 ×
6.2 „ 7.0	0.2 ×	8.0 „ 9.0	1.2 ×	12.0 „ 14.2	— 0.1 ×
7.0 „ 8.0	0.0 ×	9.0 „ 10.0	0.3 ×	14.2 „ 15.5	0.3 ×
8.0 „ 8.8	0.0 ×	10.0 „ 10.8	0.8 ×	15.5 „ 17.0	0.0 ×
8.8 „ 9.8	0.2 ×	10.8 „ 12.0	— 0.1 ×	17.0 „ 18.0	0.5 ×
9.8 „ 10.5	0.4 ×	12.0 „ 13.0	0.0 ×	18.0 „ 19.0	0.3 ×
10.5 „ 11.5	0.0 ×	13.0 „ 14.0	0.0 ×	19.0 „ 20.0	0.0 ×
11.5 „ 12.0	1.0 ×	14.0 „ 15.0	0.0 ×	20.0 „ 21.0	0.1 ×
12.0 „ 12.8	0.0 ×	15.0 „ 16.0	0.0 ×	21.0 „ 22.0	— 0.1 ×
12,8 „ 14.0		16.0 „ 17.0	0.0 ×	22.0 „ 23.0	0.2 ×
14,0 „ 15.0	0.0 ×	17.0 „ 18.0	0.0 ×	23.0 „ 24.0	0.0 ×
15.0 „ 16.0	0.0 ×	18.0 „ 19.0	0.0 ×	24.0 „ 25.0	— 0.2 ×
16.0 „ 17.0	0.0 ×	19.0 „ 20.0	0.0 ×	25.0 „ 26.0	0.2 ×
17.0 „ 18.0	0.0 ×	20.0 „ 21.0	0.0 ×	26.0 „ 27.0	0.0 ×
18.0 „ 19.0	0.0 ×	21.0 „ 22.0	0.0 ×	27.0 „ 28.0	0.0 ×
19.0 „ 19.8	0.2 ×	22.0 „ 23.0	0.0 ×	28.0 „ 29.0	0.0 ×
19.8 „ 20.8	0.0 ×	23.0 „ 24.0	0.0 ×	29.0 „ 30.0	0.0 ×
20.8 „ 21.8	0.0 ×	24.0 „ 25.0	0.0 ×	30.0 „ 30.8	0.2 ×
21.8 „ 22.5	0.4 ×	25.0 „ 26.0		30.8 „ 31.7	0.1 ×
22.5 „ 23.5	0.0 ×	26.0 „ 27.0		31.7 „ 32.8	— 0.0 ×
23.5 „ 23.5	0.0 ×	27.0 „ 28.0		32.8 „ 33.8	0.0 ×
24.5 „ 25.5	0.0 ×	28.0 „ 29.0		33.8 „ 34.8	0.0 ×
25.5 „ 26.2	0.1 ×	29.0 „ 29.8		34.8 „ 35.5	0.0 ×
26.2 „ 26.4	0.0 ×	29.8 „ 30.0		35.5 „ 36.0	

TABLE 6.

Outmost sheath-leaf of bulb XII.

	Zones on March 20.	Growth from March 20 to 27 expressed in the zone-lengths of March 20.	Zones on March 27.	Growth from March 27 to April 12 expressed in the zone-lengths of March 27.	Zones on April 12.	Growth from April 12 to May 11 expressed in the zone-lengths of April 12.	Growth from March 20 to May 11 expressed in the zone-lenghts of March 20.	New zones on May 12.	Growth from May 12 to July 18 expressed in the zone-lengths of May 12.
base	0.0 to 0.5	2.4 ×	0.0 to 1.7	0.0 ×	0.0 to 1.7	2.5 ×	11.0 ×	0.0 to 2.5	1.0 ×
↓	0.5 „ 1.0	0.6 ×	1.7 „ 2.5	0.6 ×	1.7 „ 3.0	0.1 ×	2.0 ×	2.5 „ 4.0	0.3 ×
	1.0 „ 1.5	0.4 ×	2.5 „ 3.2	0.4 ×	3.0 „ 4.0	0.0 ×	1.0 ×	4.0 „ 5.0	0.3 ×
apex	1.5 „ 2.2	0.1 ×	3.2 „ 4.0	0.2 ×	4.0 „ 5.0	0.0 ×	0.4 ×	5.0 „ 6.5	0.6 ×
	2.2 „ 3.2	0.3 ×	4.0 „ 5.3	0.3 ×	5.0 „ 6.8	0.2 ×	1.3 ×	6.5 „ 7.5	—0.1 ×
	3.2 „ 4.2	0.5 ×	5.3 „ 6.8	0.4 ×	6,8 „ 9,0	0.0 ×	1.2 ×	7.5 „ 9.2	
	4.2 „ 5.0	0.5 ×	6.8 „ 8.0	0.0 ×	9.0 „ 10.3	0.5 ×	1.5 ×	9.2 „ 10.5	0.2 ×
	5.0 „ 6.0	0.0 ×	8.0 „ 9.0	0.5 ×	10.3 „ 11.8	0.0 ×	0.5 ×	10.5 „ 11.8	0.0 ×
	6.0 „ 7,0	0.0 ×	9.0 „ 10.0	0.2 ×	11.8 „ 13.0	0.0 ×	0.2 ×	11.8 „ 13.0	0.0 ×
	7.0 „ 7.8	0.2 ×	10.0 „ 11.0	0.0 ×	13.0 „ 14.0	0.3 ×	0.6 ×	13.0 „ 14.2	0.0 ×
	7.8 „ 8.8	0.0 ×	11.0 „ 12.0	0.0 ×	14.0 „ 15.0	0.0 ×	0.0 ×	14.2 „ 15.5	0.1 ×
	8.8 „ 10.0	— 0.1 ×	12.0 „ 13.0	0.5 ×	15.0 „ 16.5	— 0.2 ×	0.0 ×	15.5 „ 17.0	
	10.0 „ 11.3	0.1 ×	13.0 „ 14.5	0.0 ×	16.5 „ 18.0	0.0 ×	0.2 ×	17.0 „ 18.2	
	11.3 „ 12.5	0.0 ×	14.5 „ 15.8	— 0.0 ×	18.0 „ 19.2	0.0 ×	0.0 ×	18.2 „ 20.0	
	12.5 „ 14.0	— 0.0 ×	15.8 „ 17·2	0.1 ×	—	—	—	20.0 „ 21.2	0.0 ×
								21.2 „ 26.2	

TABLE 7.

Outmost sheath-leaf of bulb XV.

	Zones on March 20.	Growth from March 20 to April 12 expressed in the zone-lengths of March 20.	Zones on April 12.	Growth from April 12 to May 11 expressed in the zone-lengths of April 12.	Growth from March 20 to May 11 expressed in the zone-lengths of March 20.	Zones on May 12 new marks.	Growth from May 12 to June 6 expressed in the zone-lengths of May 12.
base	0.0 to 0.5	0.0 ×	0.0 to 0.5	1.0 ×	1.0 ×	0.0 to 2.2	0.5 ×
↓	0.5 „ 1.0	3.0 ×	0.5 „ 2.5	1.0 ×	7.0 ×	2.2 „ 3.8	0.0 ×
	1.0 „ 1.8	0.8 ×	2.5 „ 4.0	0.0 ×	0.8 ×	3.8 „ 5.0	0.0 ×
apex	1.8 „ 2.8	0.5 ×	4.0 „ 5.5	0.3 ×	1.0 ×	5.0 „ 6.2	0.2 ×
	2.8 „ 3.5	0.0 ×	5.5 „ 6.2	0.0 ×	0.0 ×	6.2 „ 7.5	0.1 ×
	3.5 „ 4.7	0.3 ×	6.2 „ 7.8		0.3 ×	7.5 „ 9.0	0.0 ×
	4.7 „ 5.8	0.0 ×	7.8 „ 9.0	0.0 ×	0.0 ×	9.0 „ 10.0	
	5.8 „ 6.8	1.3 ×	9.0 „ 11.3	0.0 ×	1.3 ×	10.0 „ 11.8	0.0 ×
	6.8 „ 7.8	0.5 ×	11.3 „ 12.5		0.5 ×	11.8 „ 13.0	0.0 ×
	7.8 „ 9.0	0.5 ×	12.5 „ 14.3	0.0 ×	0.5 ×	—	—
	9.0 „ 10.0	0.7 ×	14.3 „ 16.0	0.0 ×	0.7 ×	—	—
	10.0 „ 11.2	0.0 ×	16.0 „ 17.2	0.0 ×	0.0 ×	—	—
	11.2 „ 12.0	0.3 ×	17.2 „ 18.3		0.3 ×	—	—
	12.0 „ 13.0	0.0 ×	18.3 „ 19.5		0.0 ×	—	—

TABLE 8.

Scale of the inmost foliage-leaf of bulb II in the year after its assimilation.

	Zones on March 20.	Growth from March 20 to 27 expressed in the zone-lengths of March 20.	Zones on March 27.	Growth from March 27 to April 12 expressed in the zone-lengths of March 27.	Growth from March 20 to April 12 expressed in the zone-lengths of March 20.
base	0.0 to 0.8	0.6 ×	0.0 to 1.3	0.0 ×	0.6 ×
↓	0.8 „ 1.7	0.6 ×	1.3 „ 2.8	0.6 ×	1.7 ×
	1.7 „ 2.8	0.5 ×	2.8 „ 4.5	0.0 ×	0.5 ×
apex	2.8 „ 4.0	— 0.1 ×	4.5 „ 5 5	0.3 ×	0.0 ×
	4.0 „ 5.0	0.2 ×	5.5 „ 6.7	0.0 ×	0.2 ×
	5.0 „ 6.0	0.1 ×	6.7 „ 7.8	0.0 ×	0.2 ×
	6.0 „ 6.8	0.2 ×	7.8 „ 8.8	0.3 ×	0.6 ×
	6.8 „ 7.8	0.2 ×	8.8 „ 10.0	0.2 ×	0.5 ×
	7.8 „ 8.8	0.0 ×	10.0 „ 11.0	0.2 ×	0.2 ×
	8.8 „ 9.8	0.0 ×	11.0 „ 12.0	0.0 ×	0.0 ×

TABLE 9.

Scale of the inmost foliage-leaf of bulb *L* in the year after its assimilation.

Zones on May 8.		Growth from May 8 to June 21 expressed in the zone-lengths of May.
base 0.0 to 2.5		0.6 ×
2.5 „ 4.5		0.75 ×
4.5 „ 6.0		0.6 ×
6.0 „ 8.0		0.4 ×
8.0 „ 10.0		0.3 ×
10.0 „ 11.5		0.6 ×
11.5 „ 13.5		0.0 ×
13.5 „ 16.0		0.2 ×
16.0 „ 18.5		0.2 ×
18.5 „ 20.5		0.2 ×
20.5 „ 22.5		0.2 ×
22.5 „ 25.5		0.0 ×
25.5 „ 28.0	withered on June 21	0.0 ×
28.0 „ 30.5		0.0 ×
30.5 „ 33.0		— 0.2 ×
33.0 „ 35.5		0.0 ×
35.5 „ 37.5		— 0.2 ×
37.5 „ 40.0		— 0.2 ×
40.0 „ 42.0		0.0 ×
42.0 „ 43.5		0.0 ×
43.5 „ 45.5*		— 0.2 ×

* = apex.

TABLE 10.

Outmost foliage-leaf of bulb I.

Zones on March 8.	Growth from March 8 to 19.	Growth from March 8 to 19 expressed in the zone-lengths of March 8.	New Marks. Zones on March 19.	Growth from March 19 to 27.	Growth from March 19 to 27 expressed in the zone-lengths of March 19.	Zones on March 27.	Growth from March 27 to April 12.	Growth from March 27 to April 12 expressed in the zone-lengths of March 27.	Growth from March 19 to April 12 expressed in the zone-lengths of March 19.	Zones on April 12.
base 0.0 to 1.0	0.0	0.0 × starch-	0.0 to 0.5	1.0	2.0 ×	0.0 to 1.5	0.5	0.3 ×	3.0 ×	0.0 to 2.0
↓ 1.0 „ 2.1	1.4	1.2 × part of	0.5 „ 1.5	0.3	0.3 ×	1.5 „ 2.8	0.2	0.1 ×	0.5 ×	2.0 „ 3.5
2.1 „ 3.3	0.5	0.4 × March 19.	1.5 „ 2.5 starch-part 4.5 mms.	0.7	0.7 ×	2.8 „ 4.5 starch-part 6.0 mms.	1.0	0.5 ×	1.7 ×	3.5 „ 6.2 starch-part 9.0 mms.
apex 3.3 „ 4.8	1.3	0.8 ×	2.5 „ 3.5	0.0	0.0 ×	4.5 „ 5.5	0.8	0.8 ×	0.8 ×	6.2 „ 8.0
4.8 „ 6.5	3.8	2.2 ×	3.5 „ 5.0	1.8	1.2 ×	5.5 „ 8.8	2.0	0.6 ×	2.5 ×	8.0 „ 13.3
6.5 „ 8.2	4.3	2.4 ×	5.0 „ 6.5	1.7	1.1 ×	8.8 „ 12.0	0.5	0.1 ×	1.4 ×	13.0 „ 17.0
8.2 „ 10.0	1.7	0.9 ×	6.5 „ 7.8	1.7	1.3 ×	12.0 „ 15.0	1.0	0.3 ×	2.0 ×	17.0 „ 21.0
Length foliage-		further marks	7.8 „ 9.0	2.1	1.7 ×	15.0 „ 18.3	0.0	0.0 ×	1.7 ×	21.0 „ 24.3
leaf 242.0 mms.		disappeared.	9.0 „ 10.5	1.2	0.8 ×	18.3 „ 21.0	0.0	0.0 ×	0.8 ×	24.3 „ 27.0
			10.5 „ 11.8	2.0	1.5 ×	21.0 „ 24.3	0.2	0.06 ×	1.6 ×	27.0 „ 30.5
			11.8 „ 13.0	1.5	1.2 ×	24.3 „ 27.0	0.3	0.1 ×	1.5 ×	30.5 „ 33.5
			13.0 „ 14.0	0.5	0.5 ×	27.0 „ 28.5	0.0	0.0 ×	0.5 ×	33.5 „ 35.0
			14.0 „ 15.5	1.0	0.6 ×	28.5 „ 31.0	0.0	0.0 ×	0.6 ×	35.0 „ 37.5
			15.5 „ 16.8	0.7	0.5 ×	31.0 „ 33.0	0.0	0.0 ×	0.5 ×	37.5 „ 39.5
			16.8 „ 18.5	0.8	0.4 ×	33.0 „ 35.5	0.0	0.0 ×	0.4 ×	39.5 „ 42.0
			18.5 „ 20.0	0.5	0.3 ×	35.5 „ 37.5	0.0	0.0 ×	0.3 ×	42.0 „ 44.0
			20.0 „ 21.5	0.3	0.2 ×	37.5 „ 39.3	0.2	0.1 ×	0.3 ×	44.0 „ 46.0
			21.5 „ 23.0	0.7	0.4 ×	39.3 „ 41.5	0.3	0.1 ×	0.6 ×	46.0 „ 48.5
						Length foliage-leaf 275 mms.				

TABLE

Outmost foliage-

Zones on March 8.	Growth from March 8 to 19.	Growth from March 8 to 29 expressed in the zone-lengths of March 8.	New marks. Zones on March 19.	Growth from March 19 to 27.	Growth from March 19 tot 27 expressed in the zone-lengths of March 19.
base 0.0 to 1.0	0.0	0.0 × starch part of	0.0 to 0.2 starch	0.3	1.5 ×
↓ 1.0 „ 1.3	0.7	2.3 × March 19	0.2 „ 1.0 part	0.5	6.2 ×
1.3 „ 2.8	0.0	0.0 × ca. 4.0 mms.	1.0 „ 2.0 ca. 4.0	2.2	2.2 ×
apex 2.8 „ 4.1	5.2	4.0 ×	2.0 „ 3.3 mms.	1.7	1.3 ×
4.1 „ 5.3	7,6	6.3 ×	3.3 „ 4.5	2.8	2.3 ×
5.3 „ 6.7	7.8	5.5 ×	4.5 „ 6.0	1.5	1.0 ×
6.7 „ 8.2	8.5	5.6 ×	6.0 „ 7.3	1.7	1.3 ×
8.2 „ 9.5	6.2	5.7 ×	7.3 „ 8.5	1.3	1.0 ×
9.5 „ 11.3	7.2	4.0 ×	8.5 „ 10.0	0.5	0.3 ×
11.3 „ 12.8	4.5	3.0 ×	10.0 „ 11.0	1.5	1.5 ×
12.8 „ 14.0	4.3	3.5 ×	11.0 „ 12.5	0.5	0.3 ×
14.0 „ 15.1	3.4	3.0 ×	12.5 „ 14.0	0.5	0.3 ×
15.1 „ 16.5	3.1	2.2 ×	14.0 „ 15.0	1.5	1.5 ×
16.5 „ 18.0	3.0	2.0 ×	15.0 „ 16.5	1.0	0.6 ×
18.0 „ 20.0	3.5	1.7 ×	16.5 „ 18.2	0.8	0.4 ×
20.0 „ 21.5	2.5	1.6	18.2 „ 19.7	0.8	0.5 ×
21.5 „ 22.5	1.0	1.0 ×	19.7 „ 21.0	0.9	0.6 ×
22.5 „ 24 0	1.5	1.0 ×	21.0 „ 25.2	1.8	0.4 ×
24.0 „ 25.5	2.0	1.3 ×	25.2 „ 32.5	2.7	0.3 ×
25.5 „ 27.0	2.5	1.6 ×	32.5 „ 34.0	0.5	0.3 ×
27.0 „ 28.0	1.0	1.0 ×	34.0 „ 35.5	0.7	0.4 ×
28.0 „ 29.5	1.5	1.0 ×	35.5 „ 37.0	0.8	0.5 ×
29.5 „ 30.7	1.3	1.0 ×	37.0 „ 38.5	0.5	0.3 ×
30.7 „ 32.2	1.5	1.0 ×	38.5 „ 41.5	1.5	0.5 ×
32.2 „ 33.5	0.7	0.5 ×	41.5 „ 43.0	0.5	0.3 ×
33.5 „ 35.0	1.0	0.6 ×	43.0 „ 44.8	0.7	0.3 ×
35.0 „ 36.0	1.0	1.0 ×	44.8 „ 46.8	0.3	0.1 ×
36.0 „ 37.2	0.8	0.6 ×	46.8 „ 48.2	0.3	0.2 ×
37.2 „ 38.8	0.9	0.5 ×			
38.8 „ 40.3	1.5	1.0 ×			
40.3 „ 41.5	1.1	0.9 ×			
41.5 „ 43,0	0.7	0.4 ×			
43.0 „ 44.5	1.0	0.6 ×			
44.5 „ 45.8	0.7	0.5 ×			
45.8 „ 47.0	0.8	0.6 ×			
47.0 „ 48.3	1.2	0.9 ×			
48.3 „ 50.0	0.6	0.3 ×			
50.0 „ 51.5	0.5	0.3 ×			
51.5 „ 53.0	0.2	0.1 ×			

11.

leaf of bulb VII.

Zones on March 27.		Growth from March 27 to April 12.	Growth from March 27 to April 12 expressed in the zone-lengths of March 27.		Growth from March 19 to April 12.	Growth from March 19 to April 12 expressed in the zone-lengths of March 19.	Zones on April 12.		Growth from April 12 to May 12.
0.0 to 0.5	starch part ca. 7.0 mms.	1.0	2.0 ×	starch part of April 12 ca. 14 mms	1.3	6.5 ×	0.0 to 1.5	starch part.	4.5
0.5 „ 1.8		2.2	1.6 ×		2.7	3.3 ×	1.5 „ 5.0		0.0
1.8 „ 5.0		0.8	0.2 ×		3.0	3.0 ×	5.0 „ 9.0		
5.0 „ 8.0		1.8	0.6 ×		3.5	2.6 ×	9.0 „ 13.8		
8.0 „ 12.0		0.5	0.1 ×		3.3	2.7 ×	13.8 „ 18.3		
12.0 „ 15.0		0.2	0.1 ×		1.7	1.1 ×	18.3 „ 21.5		
15.0 „ 18.0		0.0	0.0 ×		1.7	1.3 ×			
18.0 „ 20.5		0.0	0.0 ×		1.3	1.0 ×			
20.5 „ 22.5		0.0	0.0 ×						
22.5 „ 25.0		0.0	0.0 ×						
25.0 „ 27.0									
27.0 „ 29.0									
29.0 „ 31.5									
31.5 „ 34.0									
34.0 „ 36.5									
36.5 „ 38.8									
38.8 „ 41.0									
41.0 „ 47.0									
47.0 „ 57.0									
57.0 „ 59.0									
59.0 „ 61.2									
61.2 „ 63.5									
63.5 „ 65.5									
65.5 „ 68.5									
68.5 „ 72.0									
72.0 „ 74.5									
74.5 „ 76.8									
76.8 „ 78.5									
Total length 315 mms.									

TABLE

Outmost foliage-

	Zones on March 8.	Growth from March 8 to 19.	Growth from March 8 tot 19 expressed in the zone-lengths of March 8.		New marks. Zones on March 19.		Growth from March 19 tot 27.
base	0.0 to 1.0	0.0	0.0 ×	starch part March 19.	0.0 to 1.0	starch part 6.0 mms.	2.0
↓	1.0 „ 2.5	2.3	1.5 ×		1.0 „ 3.1		0.1
	2.5 „ 4.0	1.7	1.1 ×		3.1 „ 4.8		1.6
apex	4.0 „ 5.5	3.5	2.3 ×		4.8 „ 6.8		2.5
	5.5 „ 6.5	6.0	6.0 ×		6.8 „ 8.5		3.3
	6.5 „ 8.2	6.3	3.6 ×		8.5 „ 12.0		5.5
	8.2 „ 10.0	4.7	2.6 ×		12.0 „ 14.0		4.0
	10.0 „ 11.5	5.0	3.3 ×		14.0 „ 17.0		3.0
	11.5 „ 13.0	3.5	2.3 ×		17.0 „ 19.2		2.8
	13.0 „ 14.8	3.2	1.7 ×		19.2 „ 21.0		2.2
	14.8 „ 16.2	3.1	2.2 ×		21.0 „ 24.5		2.5
	16.2 „ 17.5	2.4	1.8 ×		24.5 „ 27.0		2.0
	17.5 „ 19.2	2.6	1.5 ×		27.0 „ 28.5		1.0
	19.2 „ 21.0	1.9	1.0 ×		28.5 „ 31.5		2.0
	21.0 „ 22.5	2.3	1.5 ×		31.5 „ 34.0		1.0
	22.5 „ 24.0	1.7	1.1 ×		34.0 „ 35.5		0.8
	24.0 „ 25.5	1.8	1.2 ×		35.5 „ 38.5		2.2
	25.5 „ 27.0	1.0	0.6 ×		38.5 „ 42.0		1.0
	27.0 „ 29.0	1.8	0.9 ×		42.0 „ 47.0		2.5
	29.0 „ 31.2	1.5	0.6 ×		47.0 „ 52.0		1.5
	31.2 „ 33.3	1.9	0.9 ×		52.0 „ 56.0		2.0
	33.3 „ 35.3	1.3	0.6 ×		56.0 „ 60.0		1.0
	35.3 „ 37.0	1.0	0.5 ×		60.0 „ 64.0		1.0
	37.0 „ 39.5	1.5	0.6 ×		64.0 „ 68.5		2.0
	39.5 „ 41.5	1.0	0.5 ×		68.5 „ 72.0		0.5
	41.5 „ 43.8	1.4	0.6 ×		72.0 „ 75.5		0.5
	43.8 „ 46.0	1.1	0.5 ×		75.5 „ 78.5		1.0
	46.0 „ 48.3	1.5	0.6 ×		78.5 „ 81.3		0.4
	48.3 „ 50.7	0.3	0.1 ×		81.3 „ 85.0		1.6
	50.7 „ 53.0	1.0	0.4 ×		85.0 „ 89.0		0.7
	53.0 „ 55.0	0.7	0.3 ×		89.0 „ 96.0		0.1
	55.0 „ 57.2	0.8	0.3 ×		96.0 „ 99.0		0.2
	57.2 „ 59.5	0.7	0.3 ×		99.0 „ 106.5		0.5
	59.5 „ 62.0	0.3	0.1 ×		106.5 „ 109.5		0.5
	62.0 „ 64.3	0.7	0.3 ×		109.5 „ 112.5		0.5
	64.3 „ 66.5	0.7	0.3 ×		112.5 „ 119.0		0.5
	66.5 „ 69.0	0.2	0.0 ×		119.0 „ 122.0		0.0
	69.0 „ 71.5	0.5	0.2 ×		122.0 „ 125.0		0.0
					125.0 „ 139.5		0.0
					139.5 „ 142.0		0.0
					142.0 „ 145.0		0.0

12.

leaf of bulb VIII.

Growth from March 19 to 27 expressed in the zone-lengths of March 19.	New marks. Zones on March 27.	Growth from March 27 to April 12.	Growth from March 27 to April 12 expressed in the zone-lengths of March 27.	Growth from March 27 to May 12.	Growth from March 27 to May 12 expressed in the zone-lengths of March 27.
2.0 ×	0.0 to 1.0	1.5	1.5 ×	2.5	2.5 ×
0.04 ×	1.0 „ 3.3	0.4	0.1 ×	0.2	0.08 ×
0.9 ×	3.3 „ 4.5	0.1	0.0 ×	0.1	0.08 ×
1.2 ×	4.5 „ 6.0 starch part 10 mms.	1.5 starch part.	0.0 ×	1.7 starch part.	0.11 ×
1.9 ×	6.0 „ 8.0	0.8	0.4 ×	1.0	0.5 ×
1.5 ×	8.0 „ 9.5	0.7	0.4 ×	0.5	0.3 ×
2.0 ×	9.5 „ 12.5	0.7	0.2 ×	1.5	0.5 ×
1.0 ×	12.5 „ 14.2	1.1	0.6 ×	0.8	0.4 ×
1.2 ×	14.2 „ 17.0	0.5	0.1 ×	2.2	0.7 ×
1.2 ×	17.0 „ 19.5	1.2	0.4 ×	1.2	0.4 ×
0.7 ×	19.5 „ 22.5	1.0	0.3 ×	0.8	0.2 ×
0.8 ×	22.5 „ 25.0	0.0	0.0 ×	0.1	0.4 ×
0.6 ×	25.0 „ 31.8	0.5	0.07 ×	further died away.	
0.6 ×	31.8 „ 34.0	0.0	0.0 ×		
0.4 ×	34.0 „ 38.0	0.5	0.1 ×		
0.5 ×	38.0 „ 40.5	0.0	0.0 ×		
0.7 ×	40.5 „ 43.5	0.0	0.0 ×		
0.2 ×	43.5 „ 49.0	0.0	0.0 ×		
0.5 ×	49.0 „ 55.2	0.3	0.04 ×		
0.3 ×	55.2 „ 59.5	0.2	0.04 ×		
0.5 ×	59.5 „ 62.0	0.0	0.0 ×		
0.2 ×	62.0 „ 67.0	0.3	0.06 ×		
0.2 ×	67.0 „ 70.0	0.7	0.2 ×		
0.4 ×	70.0 „ 72.0	0.3	0.1 ×		
0.1 ×	72.0 „ 77.3	0.4	0.07 ×		
0.1 ×	77.3 „ 82.0	0.3	0.06 ×		
0.3 ×	82.0 „ 89.0	0.5	0.07 ×		
0.0 ×	89.0 „ 96.0	0.5	0.07 ×		
0.4 ×	96.0 „ 102.0	0.0	0.0 ×		
0.1 ×	102.0 „ 107.0	0.3	0.06 ×		
0.01 ×	107.0 „ 112.0	0.7	0.1 ×		
0.06 ×	112.0 „ 117.3	0.2	0.03 ×		
0.07 ×	117.3 „ 122.0	0.1	0.02 ×		
0.1 ×	122.0 „ 130.2	0.0	0.0 ×		
0.1 ×	130.2 „ 133.3	0.2	0.06 ×		
0.07 ×	133.3 „ 138.0	0.0	0.0 ×		
0.0 ×	138.0 „ 147.0	0.0	0.0 ×		
0.0 ×	147.0 „ 158.5	0.0	0.0 ×		
0.0 ×	158.5 „ 161.5	0.0	0.0 ×		
0.0 ×	161.5 „ 165.5	0.0	0.0 ×		
0.0 ×	165.5 „ 197.0	0.0	0.0 ×		
	197.0 „ 199.5	0.0	0.0 ×		
	199.5 „ 202.5	0.0	0.0 ×		
	Total length 294.5 mms.				

TABLE

Outmost foliage-

	Zones on March 20.	Growth from March 20 to 27.	Growth from March 20 to 27 expressed in the zone-lengths of March 20.		Zones on March 27.		Growth from March 27 to April 12.	Growth from March 27 to April 12 expressed in the zone-lengths of March 27.
base	0.0 to 0.1	0.0	0.0 ×	starch part of March 27.	0.0 to 0.1	starch part 4.0 mms.	0.0	0.0 ×
↓	0.1 „ 1.0	0.1	0.1 ×		0.1 „ 1.1		0.7	0.7 ×
	1.0 „ 1.8	0.1	0.1 ×		1.1 „ 2.0		1.3	1.4 ×
apex	1.8 „ 3.0	0.6	0.5 ×		2.0 „ 3.8		2.2	1.2 ×
	3.0 „ 4.5	0.5	0.3 ×		3.8 „ 5.8		5.0	2.5 ×
	4.5 „ 5.2	0.8	1.1 ×		5.8 „ 7.3		7.0	4.6 ×
	5.2 „ 6.8	1.6	1.0 ×		7.3 „ 10.5		12.3	3.8 ×
	6.8 „ 7.8	2.0	2.0 ×		10.5 „ 13.5		7.0	2.3 ×
	7.8 „ 9.0	1.8	1.5 ×		13.5 „ 16.5		5.5	1.8 ×
	9.0 „ 10.0	1.7	1.7 ×		16.5 „ 19.2		4.1	1.5 ×
	10.0 „ 11.3	2.2	1.6 ×		19.2 „ 22.7		6.2	1.7 ×
	11.3 „ 12.8	2.0	1.3 ×		22.7 „ 26.2		5.0	1.4 ×
	12.8 „ 14.2	1.9	1.3 ×		26.2 „ 29.5		4.2	1.2 ×
	14.2 „ 15.5	1.7	1.3 ×		29.5 „ 32.5		3.5	1.1 ×
	15.5 „ 17.0	2.0	1.3 ×		32.5 „ 36.0		3.0	0.8 ×
	17.0 „ 18.3	1.7	1.3 ×		36.0 „ 39.0		3.0	1.0 ×
	18.3 „ 19.8	1.8	1.2 ×		39.0 „ 42.3		2.7	0.8 ×
	19.8 „ 21.5	2.0	1.1 ×		42.3 „ 46.0		2.3	0.6 ×
	21.5 „ 23.0	1.5	1.0 ×		46.0 „ 49.0		2.3	0.7 ×
	23.0 „ 24.8	1.2	0.6 ×		49.0 „ 52.0		1.7	0.5 ×
	24.8 „ 26.0	1.6	0.3 ×		52.0 „ 54.8		2.0	0.7 ×
	26.0 „ 27.5	1.2	0.8 ×		54.8 „ 57.5		2.0	0.7 ×
	27.5 „ 29.0	1.3	0.8 ×		57.5 „ 60.3		1.7	0.6 ×
	29.0 „ 30.7	0.8	0.4 ×		60.3 „ 62.8		1.5	0.6 ×
	30.7 „ 32.1	1.0	0.7 ×		62.8 „ 65.2		1.6	0.6 ×
	32.1 „ 33.8	0.6	0.3 ×		65.2 „ 67.5		1.2	0.5 ×
	33.8 „ 35.2	1.1	0.7 ×		67.5 „ 70.0		1.5	0.6 ×
	35.2 „ 37.0	1.0	0.5 ×		70.0 „ 72.8		1.7	0.6 ×
	37.0 „ 38.5	1.2	0.8 ×		72.8 „ 75.5		1.3	0.4 ×
	38.5 „ 40.5	0.5	0.2 ×		75.5 „ 78.0		1.5	0.6 ×
	40.5 „ 42.5	1.0	0.5 ×		78.0 „ 81.0		2.0	0.6 ×
	42.5 „ 44.8	1.0	0.4 ×		81.0 „ 84.3		1.7	0.5 ×
	44.8 „ 47.0	1.0	0.4 ×		84.3 „ 87.5		1.3	0.3 ×
	47.0 „ 49.0	1.0	0.5 ×		87.5 „ 90.5		1.5	0.5 ×
	49.0 „ 51.0	1.0	0.5 ×		90.5 „ 93.5		1.0	0.3 ×
	51.0 „ 53.0	0.8	0.4 ×		93.5 „ 96.3		1.2	0.4 ×
	53.0 „ 55.0	1.2	0.6 ×		96.3 „ 99.5		0.8	0.2 ×
	55.0 „ 58.0	1.0	0.3 ×		99.5 „ 103.5		1.3	0.3 ×
	58.0 „ 60.0	0.8	0.4 ×		103.5 „ 106.3		0.9	0.3 ×
					Total length 265 mms.			

13.

leaf of bulb XI.

Growth from March 20 to April 12 expressed in the zone-lengths of March 20.	New marks. Zones on April 12.		Growth from April 12 to May 11.	Growth from April 12 to May 11 expressed in the zone-lengths of April 12.	New marks. Zones on May 11.		Growth from May 11 to June 6	Growth from May 11 to June 6 expressed in the zone-lengths of May 11.
0.0 ×	0.0 to 1.3	starch	3.7	2.8 ×	0.0 to 1.5		2.0	1.3 ×
0.8 ×	1.3 „ 3.0	part	1.3	0.7 ×	1.5 „ 3.5		— 1.0	— 0.5 ×
1.7 ×	3.0 „ 5.0	ca. 9	1.5	0.7 ×	3.5 „ 5.2		0.0	0.0 ×
2.3 ×	5.0 „ 6.8	mms.	1.9	1.0 ×	5.2 „ 6.2		1.3	1.3 ×
3.6 ×	6.8 „ 10.5		5.1	1.3 ×	6.2 „ 7.4		0.1	0.0 ×
11.1 ×	10.5 „ 12.8		2.2	0.9 ×	7.4 „ 9.0		0.4	0.2 ×
8.6 ×	12.8 „ 15.0		1.3	0.5 ×	9.0 „ 10.3		— 0.1	— 0.0 ×
9.0 ×	15.0 „ 17.3		3.7	1.6 ×	10.3 „ 12.0	starch part.	0.3	0.1 ×
6.0 ×	17.3 „ 19.2		1.3	0.6 ×	12.0 „ 13.5		0.5	0.3 ×
5.8 ×	19.2 „ 21.3		0.7	0.3 ×	13.5 „ 14.8		1.2	0.9 ×
6.4 ×	21.3 „ 23.5		0.8	0.3 ×	14.8 „ 16.5		0.8	0.4 ×
4.6 ×	23.5 „ 25.8		0.7	0.3 ×				here the foli-
3.7 ×								age-leaf dies
4.0 ×								off on June 6.
3.3 ×					16.5 „ 18.2		0.3	0.1 ×
3.6 ×					18.2 „ 20.0		0.2	0.1 ×
3.0 ×					20.0 „ 22.0		0.0	0.0 ×
2.5 ×					22.0 „ 29.0		0.0	0.0 ×
2.5 ×					29.0 „ 31.8		0.2	0.0 ×
1.6 ×					31.8 „ 34.0		1.3	0.5 ×
3.0 ×					34.0 „ 39.0		0.0	0.0 ×
2.1 ×					39.0 „ 43.0		0.0	0.0 ×
2.0 ×								
1.3 ×					116.0 „ 250.0		0.1	0.0 ×
1.8 ×	Total length				Total length			
1.0 ×	381 mms.				410 mms.			
1.8 ×								
1.5 ×								
1.6 ×								
1.0 ×								
1.5 ×								
1.1 ×								
1.0 ×								
1.2 ×								
1.0 ×								
1.0 ×								
1.0 ×								
0.7 ×								
0.8 ×								

TABLE 14.

Outmost foliage-leaf of Bulb A.

Zones on March 28.	Growth from March 28 to April 7.	Growth from March 28 to April 7, expressed in the zone-lengths of March 28.	Zones on April 7.	Growth from April 7 to May 8.	Growth from April 7 to May 8, expressed in the zone-lengths of April 7.
base 0.0 to 2.5	0.0	0.0 ×	0.0 to 2.5	9.5	3.8 ×
2.5 „ 5.0	3.0	1.2 ×	2.5 „ 8.0	10.5	1.8 ×
5.0 „ 9.0	9.5	2.3 ×	8.0 „ 21.5	12.5	0.9 ×
9.0 „ 13.0	9.5	2.3 ×	21.5 „ 35.0	3.5	0.2 ×
13.0 „ 17.8	8.2	1.7 ×	35.0 „ 48.0	0.0	0.0 ×
17.8 „ 22.0	2.3	0.5 ×	48.0 „ 54.5	3.0	0.4 ×
22.0 „ 26.5	3.0	0.6 ×	54.5 „ 62.0	0.5	0.0 ×
26.5 „ 31.0	2.5	0.5 ×	62.0 „ 69.0	0.0	0.0 ×
31.0 „ 35.0	4.5	0.6 ×	69.0 „ 77.5	1.0	0.1 ×
35.0 „ 45.8	4.7	0.4 ×	77.5 „ 93.0	0.5	0.0 ×
45.8 „ 51.0	2.8	0.5 ×	93.0 „ 101.0	0.0	0.0 ×
51.0 „ 56.0	2.5	0.5 ×	101.0 „ 108.5	0.5	0.0 ×
56.0 „ 61.0	2.5	0.5 ×	108.5 „ 116.0	0.0	0.0 ×
61.0 „ 66.0	2.5	0.5 ×	116.0 „ 123.5	0.0	0.0 ×
66.0 „ 71.0	3.0	0.6 ×	123.5 „ 131.5	— 0.5	— 0.0 ×
71.0 „ 77.0	2.5	0.4 ×	131.5 „ 140.0	0.0	0.0 ×
77.0 „ 83.0	3.5	0.5 ×	140.0 „ 149.5	0.0	0.0 ×
83.0 „ 89.0	1.5	0.2 ×	149.5 „ 157.0	0.0	0.0 ×
89.0 „ 94.0	1.0	0.2 ×	157.0 „ 163.0	— 0.5	— 0.0 ×
94.0 „ 99.0	1.0	0.2 ×	163.0 „ 169.0	0.0	0.0 ×
99.0 „ 104.2	1.3	0.2 ×	169.0 „ 175.5	0.0	0.0 ×
104.2 „ 109.0	0,7	0.1 ×	175.5 „ 181.0	0.5	0.0 ×
109.0 „ 114.0*	0.5	0.1 ×	181.0 „ 186.5	— 0.5	— 0.0 ×

* = apex.

TABLE 15.

Outmost foliage-leaf of bulb B.

	Zones on March 28.	Growth from March 28 to April 7.	Growth from March 28 to April 7 expressed in the zone-lengths of March 28.	Zones on April 7.	Growth from April 7 to May 8.	Growth from April 7 to May 8 expressed in the zone-lengths of April 7.
base	0.0 to 0.5	0.0	0.0 ×	0.0 to 0.5	7.5	15.0 ×
↓	0.5 „ 3.5	3.0	1.0 ×	0.5 „ 6.5	13.0	2.1 ×
	3.5 „ 7.0	6.0	1.7 ×	6.5 „ 16.0	16.5	1.7 ×
apex	7.0 „ 10.5	8.5	2.4 ×	16.0 „ 28.0		
	10.5 „ 15.5	6.0	1.2 ×	28.0 „ 39.0	22.0	0.7 ×
	15.5 „ 20.0	4.5	1.0 ×	39.0 „ 48.0		
	20.0 „ 25.5	3.5	0.6 ×	48.0 „ 57.0	— 1.0	— 0.1 ×
	25.5 „ 30.0	5.5	1.2 ×	57.0 „ 67.0	1.0	0.0 ×
	30.0 „ 35.0	5.0	1.0 ×	67.0 „ 77.0		
	35.0 „ 40.5	4.0	0.7 ×	77.0 „ 86.5	0.0	0.0 ×
	40.5 „ 45.5	2.5	0.5 ×	86.5 „ 94.0	0.0	0.0 ×
	45.5 „ 51.0	2.5	0.4 ×	94.0 „ 102.0	1.0	0.1 ×
	51.0 „ 56.0	3.0	0.6 ×	102.0 „ 110.0	1.0	0.1 ×
	56.0 „ 61.5	2.5	0.4 ×	110.0 „ 118.0	0.5	0.0 ×
	61.5 „ 66.0	1.0	0.2 ×	118.0 „ 123.5	0.0	0.0 ×
	66.0 „ 71.0	2.0	0.4 ×	123.5 „ 130.5	0.0	0.0 ×
	71.0 „ 77.0	1.5	0.2 ×	130.5 „ 138.0	0.0	0.0 ×
	77.0 „ 81.5	2.5	0.5 ×	138.0 „ 145.0	0.5	0.0 ×
	81.5 „ 87.5	1.5	0.2 ×	145.0 „ 152.5	0.5	0.0 ×
	87,5 „ 92.5	2.0	0.4 ×	152.5 „ 159.5	— 0.5	— 0.0 ×
	92.5 „ 97.5	1.5	0.3 ×	159.5 „ 166.0	— 0.5	— 0.0 ×
	97.5 „ 102.0	1.5	0.3 ×	166.0 „ 172.0	0.5	0.0 ×
	102.0 „ 107.0	1.0	0.2 ×	172.0 „ 178.0	— 0.5	— 0.0 ×
	107.0 „ 110.5	0.5	0.1 ×	178.0 „ 182.0	0.5	0.1 ×
	110.5 „ 114.5	1.0	0.2 ×	182.0 „ 187.0	— 1.0	— 0.2 ×

TABLE 16.

Outmost foliage-leaf of bulb D.

Zones on March 28.	Growth from March 28 to April 7.	Growth from March 28 to April 7 expressed in the zone-lengths of March 28.	Zones on May 8.	Growth from April 7 to May 8.	Growth from April 7 to May 8 expressed in the zone-lengths of April 7.
base 0.0 to 2.5	0.0	0.0 ×	0.0 to 10.5	8.0	3.2 ×
2.5 „ 5.5	1.5	0.5 ×	10.5 „ 19.0	4.0	0.8 ×
5.5 „ 8.5	5.0	1.6 ×	19.0 „ 32.0	5.0	0.6 ×
8.5 „ 11.2	5.3	1.9 ×	32.0 „ 44.0	4.0	0.5 ×
11.2 „ 13.5	3.7	1.6 ×	44.0 „ 51.0	1.0	0.1 ×
13.5 „ 16.5	2.0	0.6 ×	51.0 „ 56.5	0.5	0.1 ×
16.5 „ 19.0	1.5	0.6 ×	56.5 „ 62.0	1.5	0.3 ×
19.0 „ 22.5	2.5	0.7 ×	62.0 „ 69.0	1.0	0.1 ×
22.5 „ 26.0	3.0	0.8 ×	69.0 „ 76.0	0.5	0.0 ×
26.0 „ 29.2	1.8	0.5 ×	76.0 „ 81.5	0.5	0.1 ×
29.2 „ 32.8	1.4	0.3 ×	81.5 „ 87.0	0.5	0.1 ×
32.8 „ 36.5	2.3	0.6 ×	87.0 „ 93.0	0.0	0.0 ×
36.5 „ 40.0	2.0	0.5 ×	93.0 „ 99.0	0.5	0.0 ×
40.0 „ 43.5	2.0	0.5 ×	99.0 „ 105.0	0.5	0.0 ×
43.5 „ 51.0	3.5	0.4 ×	105.0 „ 116.0	0.0	0.0 ×
51.0 „ 55.5	1.5	0.3 ×	116.0 „ 122.5	0.5	0.0 ×
55.5 „ 59.0	1.5	0.4 ×	122.5 „ 127.0	— 0.5	— 0.1 ×
59.0 „ 62.5	1.5	0.4 ×	127.0 „ 132.0	0.0	0.0 ×
62.5 „ 67.0	1.0	0.2 ×	132.0 „ 137.5	0.0	0.0 ×
67.0 „ 70.2	2.3	0.7 ×	137.5 „ 143.0	0.0	0.0 ×
70.2 „ 74.2	1.5	0.3 ×	143.0 „ 148.5	0.0	0.0 ×
74.2 „ 78.5	1.7	0.3 ×	148.5 „ 154.0	— 0.5	— 0.0 ×
78.5 „ 82.5	2.0	0.5 ×	154.0 „ 160.0	0.0	0.0 ×
82.5 „ 86.0	1.5	0.4 ×	160.0 „ 166.0	1.0	0.2 ×
86.0 „ 90.0	2.0	0.5 ×	166.0 „ 171.0	— 1.0	— 0.1 ×
90.0 „ 94.5	0.5	0.1 ×	171.0 „ 176.5	0.5	0.1 ×
94.5 „ 97.5	1.0	0.3 ×	176.5 „ 180.5	0.0	0.0 ×
97.5 „ 101.5	1.0	0.2 ×	180.5 „ 185.5	0.0	0.0 ×
101.5 „ 105.0	1.0	0.2 ×	185.5 „ 190.0	0.0	0.0 ×
105.0 „ 108.5	1.5	0.4 ×	190.0 „ 194.0	— 1.0	— 0.2 ×
108.5 „ 112.0	0.0	0.0 ×	194.0 „ 198.0	0.5	0.1 ×
112.0 „ 115.0	0.5	0.1 ×	198.0 „ 201.5	0.0	0.0 ×
115.0 „ 117.5*	— 0.5	—0.2 ×	201.5 „ 204.5	— 1.0	— 0.5 ×

* = apex.

TABLE 17.

Outmost foliage-leaf of bulb F.

Zones on March 28.	Growth from March 28 to April 7.	Growth from March 28 to April 7 expressed in the zone-lengths of March 28.	Zones on April 7.	Growth from April 7 to May 8.	Growth from April 7 to May 8 expressed in the zone-lengths of April 7.
base 0.0 to 2.0	0.5	0.25 ×	0.0 to 2.5	9.5	3.8 ×
2.0 „ 4.5	3.0	1.2 ×	2.5 „ 8.0	14.0	2.5 ×
4.5 „ 6.5	4.0	2.0 ×	8.0 „ 14.0	13.0	2.1 ×
6.5 „ 8.5	7.5	3.7 ×	14.0 „ 23.5	7.0	0.7 ×
8.5 „ 11.0	5.5	2.2 ×	23.5 „ 31.5	3.5	0.4 ×
11.0 „ 13.5	4.0	1.6 ×	31.5 „ 38.0	2.0	0.1 ×
13.5 „ 16.0	4.0	1.6 ×	38.0 „ 44.5	0.5	0.0 ×
16.0 „ 19.0	4.5	1.5 ×	44.5 „ 52.0	1.5	0.2 ×
19.0 „ 22.0	1.5	0.5 ×	52.0 „ 56.5	— 0.5	— 0.1 ×
22.0 „ 26.5	3.5	0.7 ×	56.5 „ 64.5	0.5	0.0 ×
26.5 „ 30.0	3.5	1.0 ×	64.5 „ 71.5	1.0	0.1 ×
30.0 „ 33.0	3.0	1.0 ×	71.5 „ 77.5	1.0	0.1 ×
33.0 „ 36.5	3.0	0.8 ×	77.5 „ 84.0	0.5	0.0 ×
36.5 „ 39.0	2.5	1.0 ×	84.0 „ 89.0	0.5	0.1 ×
39.0 „ 43.5	3.5	0.7 ×	89.0 „ 97.0	— 0.5	— 0.0 ×
43.5 „ 47.5	2.5	0.6 ×	97.0 „ 103.5	0.5	0.0 ×
47.5 „ 51.0	2.0	0.5 ×	103.5 „ 109.0	— 0.5	— 0.0 ×
51.0 „ 54.0	2.0	0.6 ×	109.0 „ 114.0	1.0	0.2 ×
54.0 „ 58.0	2.0	0.5 ×	114.0 „ 120.0	0.5	0.0 ×
58.0 „ 62.0	2.0	0.5 ×	120.0 „ 126.0		
62.0 „ 65.5	2.5	0.7 ×	126.0 „ 132.0	— 0.5	— 0.0 ×
65.5 „ 69.5	1.0	0.2 ×	132.0 „ 137.0	1.0	0.2 ×
69.5 „ 74.0	2.5	0.5 ×	137.0 „ 144.0	0.0	0.0 ×
74.0 „ 78.2	1.3	0.3 ×	144.0 „ 150.5	1.5	0.2 ×
78.2 „ 81.5	1.7	0.5 ×	150.5 „ 155.5	0.0	0.0 ×
81.5 „ 85.0	0.5	0.1 ×	155.5 „ 159.5	0.0	0.0 ×
85.0 „ 88.0	2.0	0.6 ×	159.5 „ 164.5	0.0	0.0 ×
88.0 „ 92.0	1.5	0.3 ×	164.5 „ 170.0	0.0	0.0 ×
92.0 „ 95.0	2.0	0.6 ×	170.0 „ 175.0	0.0	0.0 ×
95.0 „ 99.0	0.5	0.1 ×	175.0 „ 179.5	0.0	0.0 ×
99.0 „ 102.2	1.3	0.4 ×	179.5 „ 184.0	0.0	0.0 ×
102.2 „ 106.0	0.7	0.1 ×	184.0 „ 188.5	0.0	0.0 ×
106.0 „ 110.0	1.0	0.2 ×	188.5 „ 193.0	0.0	0.0 ×
110.0 „ 113.0*	0.0	0.0 ×	193.5 „ 196.5		

* = apex.

TABLE 18.

Outmost foliage-leaf of bulb G.

	Zones on March 28.	Growth from March 28 to April 7.	Growth from March 28 to April 7 expressed in the zone-lengths of March 28.	Zones on April 7.	Growth from April 7 to May 8.	Growth from April 7 to May 8 expressed in the zone-lengths of April 7.
base	0.0 to 2.0	0.5	0.2 ×	0.0 to 2.5	3.5	1.4 ×
	2.0 „ 3.8	2.2	1.2 ×	2.5 „ 6.5	2.0	0.5 ×
	3.8 „ 6.0	4.8	2.1 ×	6.5 „ 13.5	4.5	0.6 ×
	6.0 „ 9.0	3.5	1.1 ×	13.5 „ 20.0	12.0	1.8 ×
	9.0 „ 12.0	2.0	0.6 ×	20.0 „ 25.0	14.0	2.8 ×
	12.0 „ 15.0	4.0	1.3 ×	25.0 „ 42.0	6.0	0.8 ×
	15.0 „ 18.5	4.5	1.2 ×	42.0 „ 51.0	0.0	0.0 ×
	18.5 „ 22.5	5.0	1.2 ×	51.0 „ 60.0		
	22.5 „ 33.0	7.5	0.7 ×	60.0 „ 79.0	6.0	0.3 ×
	33.0 „ 36.0	2.5	0.8 ×	79.0 „ 84.5	1.5	0.2 ×
	36.0 „ 39.5	3.0	0.8 ×	84.5 „ 91.0	— 1.0	—0.1 ×
	39.5 „ 44.0	1.5	0.3 ×	91.0 „ 97.0	0.5	0.0 ×
	44.0 „ 47.0	2.0	0.6 ×	97.0 „ 102.0	1.0	0.2 ×
	47.0 „ 51.0	2.0	0.5 ×	102.0 „ 108.0	— 0.5	—0.0 ×
	51.0 „ 55.0	1.5	0.3 ×	108.0 „ 113.5	0.5	0.0 ×
	55.0 „ 59.0	1.5	0.3 ×	113.5 „ 119.0	0.0	0.0 ×
	59.0 „ 63.0	1.0	0.2 ×	119.0 „ 124.0	1.0	0.2 ×
	63.0 „ 67.0	2.0	0.5 ×	124.0 „ 130.0	— 1.0	—0.1 ×
	67.0 „ 71.5	1.5	0.3 ×	130.0 „ 136.0	0.0	0.0 ×
	71.5 „ 75.0	1.5	0.4 ×	136.0 „ 141.0	1.0	0.2 ×
	75.0 „ 80.0	1.0	0.2 ×	141.0 „ 147.0	— 0.5	—0.0 ×
	80.0 „ 84.5	1.5	0.3 ×	147.0 „ 153.0	1.0	0.0 ×
	84.5 „ 89.0	1.0	0.2 ×	153.0 „ 158.5		
	89.0 „ 93.5	1.0	0.2 ×	158.5 „ 164.0	— 0.5	— 0.0 ×
	93.5 „ 98.0	0.5	0.1 ×	164.0 „ 169.0	0.5	0.1 ×
	98,0 „ 102.0	1.0	0.2 ×	169.0 „ 174.0	0.5	0.1 ×
	102.0 „ 106 0	1.0	0.2 ×	174.0 „ 179.0	— 0.5	—0.1 ×
	106.0 „ 110.0	0.5	0.1 ×	179.0 „ 183.5	— 0.5	—0.1 ×
	110.0 „ 112.0*	0.0	0.0 ×	183.5 „ 185.5	1.5	0.7 ×

* = apex.

TABLE 19.

Outmost foliage-leaf of bulb O.

	Zones on May 10.	Growth from May 10 to June 20.	Growth from May 10 to June 20, expressed in the zone-lengths of May 10.
base	0.0 to 1.5	3.5	2.3 ×
↓	1.5 „ 2.5	0.5	0.5 ×
	2.5 „ 4.0	1.0	0.6 ×
apex	4.0 „ 5.0	1.5	1.5 ×
	5.0 „ 6.5	0.5	0.3 ×
	6.5 „ 8.0	0.5	0.3 ×
	8.0 „ 10.0	1.0	0.5 ×
	10.0 „ 11.5	0.5	0.3 ×
	11.5 „ 13.5	0.5	0.2 ×
	13.5 „ 15.5	1.0	0.5 ×
	15.5 „ 17.5	0.5	0.2 ×
	17.5 „ 19.0	1.0	0.6 ×
	19.0 „ 21.5	0.5	0.2 ×
	21.5 „ 23.5	0.5	0.2 ×
	23.5 „ 25.5	0.5	0.2 ×
	25.5 „ 27.5	0.0	0.0 ×
	27.5 „ 30.0	— 0.5	— 0.2 ×
	30.0 „ 31.5	0.5	0.3 ×
	31.5 „ 33.0	0.0	0.0 ×
	33.0 „ 35.0	0.0	0.0 ×
	35.0 „ 37.0	0.0	0.0 ×
	37.0 „ 39.0	0.0	0.0 ×
	39.0 „ 41.0	0.0	0.0 ×
	41.0 „ 43.5	0.0	0.0 ×
	43.5 „ 45.5	0.0	0.0 ×
	45.5 „ 47.0	0.5	0.3 ×
	Inmost foliage-leaf of bulb J.		
base	0.0 to 1.5	6.5	4.0 ×
↓	1.5 „ 3.0	2.5	1.6 ×
	3.0 „ 5.0	1.5	0.7 ×
apex	5.0 „ 7.0	2.0	1.0 ×
	7.0 „ 9.0	2.0	1.0 ×
	9.0 „ 10.5	2.5	1.6 ×
		further withered	
	Inmost foliage-leaf of bulb K.		
base	0.0 to 2.0	6.0	3.0 ×
↓	2.0 „ 3.5	1.5	1.0 ×
	3.5 „ 5.0	1.5	1.0 ×
apex	5.0 „ 6.5	1.5	1.0 ×
	6.5 „ 8.5	4.0	2.0 ×
	8.5 „ 11.0	4.5	1.8 ×

TABLE 20.
Outmost foliage-leaf of bulb E.

Zones on March 28.	Growth from March 28 to April 7.	Growth from March 28 to April 7 expressed in the zone-lenghts of March 28.	Zones on Mei 8.
base 0.0 to 2.0	0.0	0.0 ×	0.0 to 10.0
2.0 „ 4.5	0.5	0.2 ×	10.0 „ 29.0
4.5 „ 5.5	1.0	0.2 ×	29.0 „ 33.0
5.5 „ 9.0			33.0 „ 38.0
9.0 „ 12.2	4.5	1.4 ×	38.0 „ 56.0
12.2 „ 15.0	4.0	1.4 ×	56.0 „ 66.0
15.0 „ 18.0	5.0	1.6 ×	66.0 „ 77.0
18.0 „ 21.5	5.0	1.4 ×	77.0 „ 88.5
21.5 „ 24.0	4.0	1.6 ×	88.5 „ 96.0
24.0 „ 27.0	2.0	0.6 ×	96.0 „ 101.5
27.0 „ 29.0	3.5	1.7 ×	101.5 „ 108.0
29.0 „ 32.0	2.3	0.7 ×	108.0 „ 114.0
32.0 „ 35.0	2.2	0.7 ×	114.0 „ 120.0
35.0 „ 38.5	2.0	0.5 ×	120.0 „ 125.5
38.5 „ 42.5	2.0	0.5 ×	125.5 „ 132.0
42.5 „ 46.0	3.0	0.8 ×	132.0 „ 138.0
46.0 „ 49.0	1.5	0.5 ×	138.0 „ 143.0
49.0 „ 52.8	1.7	0.4 ×	143.0 „ 149.0
52.8 „ 56.0	2.8	0.8 ×	149.0 „ 155.0
56.0 „ 60.0	1.0	0.2 ×	155.0 „ 159.5
60.0 „ 63.5	1.5	0.4 ×	159.5 „ 160.5
63.5 „ 67.5	1.0	0.2 ×	160.5 „ 171.0
67.5 „ 71.0	2.0	0.5 ×	171.0 „ 177.0
71.0 „ 74.3	2.2	0.6 ×	177.0 „ 182.0
74.3 „ 77.8	1.5	0.4 ×	182.0 „ 187.0
77.8 „ 80.5	1.3	0.4 ×	187.0 „ 191.0
80.5 „ 84.0	0.0	0.0 ×	191.0 „ 194.5
84.0 „ 87.5	1.2	0.3 ×	194.5 „ 199.0
87.5 „ 90.5	1.3	0.4 ×	199.0 „ 203.5
90.5 „ 94.5	0.0	0.0 ×	203.5 „ 207.5
94.5 „ 98.0	0.5	0.1 ×	207.5 „ 212.0
98.0 „ 101.0	1.0	0.3 ×	212.0 „ 215.5
101.0 „ 104.5	0.5	0.1 ×	215.5 „ 218.5
104.5 „ 107.0 = apex	2.0	0.8 ×	218.5 „ 222.0

TABLE 21.

Number of cells in longitudinal direction per 10 micrometer-grades (1,6 mms) of the inmost foliage-leaf.

8 March 22	3 May 22		16 May 22		16 June 22		
n = 4	* n = 2 Ser. A	n = 4 Ser. B	* n = 3 Ser. A	* n = 3 Ser. B	* n = 2 Ser. A		n = 4 Ser. B
base 42	starch- 42	41	44	45	44,5	starch-part 211.2 grades.	42.0
↓ 31	part 25 35.5	36.6	39	38.5	24.0		25.0
apex 28	grades 36	36	37	starch- 38	20.5		22.0
	31.5	30.3	32	part 33	19.0		22.7
	73.5		31	75 30	19.5		19.7
	18.5		29.5	grades 29	16.7		18.7
	(5 grades) 6.5			29	(3 grades) 5.0		8.2 (5.2 gr.)
				26			16.0
				20			16.0
				15			16.1
							15.8
							15.6
							16.3
							16,7
							16.5
							1.5 (1 gr.)
							18.1
							18.3
							17.5
							18.0
							18.3
							22.1
							22.6
							12.0
							6.1 (6.1 gr.)
							10.6
							9.3
							8.8
							7.3
							5.8
							6.0
							6.0
							4.7
							4.0

TABLE 22.

Number of cells and average length of the cells of the inmost foliage-leaf above the starch-part.

3 May 1922.			16 June 1922.		
distance from insertion-spot in mms.	number of cells.	average length of cell in mms.	distance from insertion-spot in mms.	number of cells.	aaverage length of cell in mms.
*5.0 to 20.0	168	0.089	*35.0 to 37.0	18	0.111
20.0 „ 35.0	56	0.267	37.0 „ 52.0	64	0.234
35.0 „ 50.0	41	0.365	52.0 „ 70.0	44 (computed)	
50.0 „ 100.0	146 (computed)		70.0 „ 85.0	36	0.416
100.0 „ 115.0	47	0.319	85.0 „ 120.0	76 (computed)	
115.0 „ 170.0	176 (computed)		120.0 „ 135.0	30	0.500
170.0 „ 185.0	49	0.306	135.0 „ 200.0	142 (computed)	
185.0 „ 230.0	157 (computed)		200.0 „ 215.0	41	0.365
230.0 „ 245.0	56	0.267	215.0 „ 275.0	169 (computed)	
245.0 „ 270.0	122 (computed)		275.0 „ 290.0	51	0.294
270.0 „ 283.0**	83	0.162	290.0 „ 325.0	109 (computed)	
Length of the foliage-leaf-part above the starch-part 278.5 mms.	1101 cells	0.252	325.0 „ 340.0	51	0.294
			340.0 „ 380.0	150 (computed)	
			380.0 „ 395.0	70	0.214
			395.0 „ 414.0**	115 (computed)	
			Length of the foliage-leaf-part above the starch-part 379.0 mms.	1166 cells.	0.325

* = top of starch-part. ** = apex.

TABLE 23.

Outmost sheath-leaf of bulb XIII

Transverse measurement.

Zones on March 27.	Growth from March 27 to May 11 expressed in the zone-lengths of March 27.	Zones on April 12.	Growth from April 12 to May 11 expressed in the zone-lengths of April 12.
edge = 0,0 to 0.5	0.0 ×	0.0 to 0.5	0.0 ×
0.5 „ 5.5	0.5 ×	0.5 „ 7.0	0.1 ×
5.5 „ 10.5	0.7 ×	7.0 „ 14.0	0.2 ×
10.5 „ 17.0	0·7 ×	14.0 „ 21.5	0.5 ×
17.0 „ 23.2	0.8 ×	21.5 „ 31.0	0.2 ×
23.2 „ 30.0	0.2 ×	31.0 „ 38.0	0.1 ×
30.0 „ 35.5 = edge	0.4 ×	38.0 „ 44.8	0.1 ×

TABLE 24.

Outmost sheath-leaf of bulb X

Transverse measurement.

Zones on March 10.	Growth from March 10 to April 12 expressed in the zone-lengths of March 10.
edge = 0.0 to 0.5	0.6 ×
0.5 „ 1.8	0.0 ×
1.8 „ 2.8	0.5 ×
2.8 „ 4.0	0.9 ×
4.0 „ 5.0	1.0 ×
5.0 „ 5.8	1.1 ×
5.8 „ 7.0	0.2 ×
7.0 „ 8.0	0.0 ×
8.0 „ 9.2	0.6 ×
9.2 „ 10.0	1.2 ×
10.0 „ 11.2	0.4 ×
11.2 „ 12.5	1.5 ×
12.5 „ 14.0	0.8 ×
14.0 „ 15.2	0.2 ×
15.2 „ 16.5	0.6 ×
16.5 „ 17.8	0.3 ×
17.8 „ 19.3	1.0 ×
19.3 „ 21.8	0.4 ×
21.8 „ 24.0	0.4 ×
24.0 „ 25.0 = edge	0.8 ×

TABLE 25.

Number of cells per 10 successive grades in transverse direction in the sheath-leaf.

April 16th. 1920.		June 11th. 1920.			
broadest part: 28 to 26 mms. from the apex.		broadest part: 37 to 34 mms. from the apex.		above the broadest part: 28 to 26 mms. from the apex.	
edge 10 grades	31 cells	edge 5 grades	14 cells	edge 2 grades	5 cells
10 „	26 „	10 „	18 „	10 „	19 „
10 „	21 „	10 „	17 „	10 „	17 „
10 „	20 „	10 „	15 „	10 „	15 „
10 „	21 „	10 „	16 „	10 „	13 „
10 „	22 „	10 „	14 „	10 „	13 „
10 „	22 „	10 „	13 „	10 „	12 „
10 „	22 „	10 „	14 „	10 „	15 „
10 „	23.5 „	10 „	14 „	10 „	14 „
1 „	3 „	10 „	16 „	10 „	15 „
10 „	22 „	10 „	14 „	10 „	14 „
10 „	22 „	10 „	15 „	10 „	12 „
10 „	24 „	10 „	16 „	10 „	12 „
10 „	23 „	10 „	14.5 „	10 „	12 „
10 „	21 „	10 „	16 „	3 „	3 „
10 „	22 „	10 „	14 „	10 „	14 „
10 „	20 „	10 „	15 „	10 „	13 „
10 „	22 „	10 „	15 „	10 „	12 „
1.5 „	4 „	10 „	14 „	10 „	12 „
10 „	26 „	10 „	15 „	10 „	12 „
10 „	26.5 „	10 „	17 „	10 „	12 „
10 „	26 „	10 „	16.5 „	10 „	12 „
10 „	25 „	10 „	14 „	1.6 „	2 „
10 „	25 „	10 „	15 „	10 „	12 „
10 „	24 „	10 „	15 „	10 „	12.5 „
10 „	27 „	10 „	15.5 „	10 „	13 „
10 „	29 „	10 „	16 „	10 „	13 „
edge 5 „	14 „	10 „	15 „	10 „	15 „
257.5 grades	614 cells	10 „	15.5 „	10 „	13 „
		10 „	14 „	10 „	13 „
		10 „	14 „	10 „	14 „
		10 „	16 „	10 „	15 „
		5 „	8 „	10 „	14 „
		10 „	15 „	4 „	5 „
		10 „	14 „	10 „	12.5 „
		10 „	15 „	10 „	10 „
		10 „	14 „	10 „	13 „
		10 „	13 „	10 „	12 „
		10 „	13.5 „	10 „	13 „
		10 „	13.5 „	10 „	16 „
		10 „	13 „	edge 8 „	16 „
		10 „	15 „	378.6 grades	512 cells
		10 „	14 „		
		10 „	14 „		
		10 „	15 „		
		8 „	11 „		
		edge 8 „	20 „		
		456 grades	691 cells		

TABLE 26.

May 17th '22. Thickness, number and thickness of cells of the outmost foliage-leaf.

A				B			
Distance from the base (in micrometer-grades)	Leaf-thickness (in micrometer-grades)	* Number of cells	Cell-thickness in micrometergrades	Distance from the base (in micrometer-grades)	Leaf-thickness (in micrometer-grades)	Number of cells	Cell-thickness in micrometergrades
0.5	7	27	0.25	2	6	24	0.25
5	8	31	0.25	10	9.6	32	0.3
10	8.7	31	0.28	15	10.2	33	0.3
15	9.5	34	0.27	20	11.2	32	0.35
20	10.2	34	0.30	25	11.0	33	0.33
25	10.9	34	0.32	30	11.7	31	0.37
30	11.0	34	0.32	35	12.5	32	0.39
35	10.9	30	0.36	40	12.5	30	0.41
40	10.8	29	0.37	45	12.6	30	0.42
45	10.2	28	0.36	45	13.7	33	0.41
50	9.8	28	0.35	50	14.0	34	0.41
55	9.4	28	0.33	55	13.3	31	0.42
60	8.8	24	0.36	60	11.8	27	0.43
65	8.0	22	0.36	65	10.8	25	0.43
70	7.6	22	0.34	70	10.6	25	0.42
75	7.3	21	0.34	75	9.8	25	0.39
80		vascular bundle		80	9.7	24	0.40
88	7.0	21	0.34	85	9.5	24	0.39
				90	9.3	24	0.37
				95	8.7	23	0.37
				100	8.1	20	0.40
				105	8.1	22	0.36
				110	8.0	22	0.36

TABLE 27.

May 3rd 22. Inmost Foliage-leaf.

Distance from the base (in micrometer-grades)	Thickness (in micrometer-grades)	* Number of cells	Cell-size in micrometer-grades
1	4.7	22	0.21
5	7.2	28	0.25
10	8.0	26	0.30
20	7.7	23	0.33
40	6.7	23	0.29
Another preparation from the same series:			
1	4.3	21	0,20
5	7.3	27	0.27
10	7.9	26	0.30
20	7.9	22	0.35
40	7,0	22	0.31
60	7.5	23	0.32

TABLE 28.

May 17th 22. Inmost foliage-leaf.

Distance from the base (in micrometer-grades)	Thickness (in micrometer-grades)	* Number of cells	Cell-size in micrometer-grades
2	5	26	0.19
5	6	28	0.21
10	6.5	31	0.22
17	7.5	31	0.24
20	7.8	28	0.27
25	7.8	28	0.27
30	7.0	25	0.28
35	5.8	23	0.25
40	5.3	21	0.25
45	4.8	18	0.26
50	4.3	18	0.23
60	4.0	18	0.22

TABLE 29.

June 16th 22. Inmost foliage-leaf.

Distance from the base (in micrometer-grades)	Thickness (in micrometer-grades)	Number of cells	Cell-size in micrometer grades
0	5	22	0.22
5	9.8	31	0.31
10	11.2	36	0.31
20	15.5	40	0.38
30	17.5	40	0.43
40	18.3	38	0.48
55	18.0	39	0.46
75	18.5	32	0.57
95	17.5	30	0.58
105	15.0	28	0.53
115	13.7	24	0.57
125	12.6	25	0.5
140	11.6	23	0.5
155	9.0	19	0.47
155	9.6	20	0.48
165	9.0	20	0.45
175	8.3	18	0.46
185	8.0	18	0.44
195	7.6	19	0.40
205	7.6	20	0.38
223	8.0	19	0.42
238	8.3	20	0.41

TABLE 30.

May 3rd 22. Outmost sheath-leaf.

Distance from te base (in micrometer-grades)	Thickness (in micrometer-grades)	Number of cells.	Cell-size in micrometer-grades.	Distance from the base (in micrometer-grades)	Thickness (in micrometer-grades)	* Number of cells.	Cell-size in micrometer-grades.
0	6.2	25 } vascular bundle	0.24	1	4.8	23	0.2
				4	—	24	—
5	6.6	22	0.30	5	5.2	25	0.2
10	6.6	22	0.30	8	6.7	25	0.26
20	7.4	20	0.37	13	7.5	27	0.27
30	8.8	21	0.41	25	8.4	24	0.35
40	9.0	21	0.42	30	8.5	25	0.34
50	9.7	22	0.44	37	9.0	27	0.33
60	11.2	22	0.50				
70	12.0	22	0.54				
76	11.8	22	0.53				
86	12.0	21	0.57				
96	11.4	19	0.60				
106	9.5	17	0.55				
116	7.7	15	0.51				
126	5.3	12	0.44				
136	4.0	10	0.40				
216 = apex							

TABLE 31.

June 16th '22. Outmost sheath-leaf.

Distance from the base (in micrometer-grades)	Thickness (in micrometer-grades)	Number of cells.	Cell-size in micrometer-grades.	Distance from the base (in micrometer-grades)	Thickness (in micrometer-grades)	Number of cells.	Cell-size in micrometer-grades.
0	4.6	27	0.17				
5	5.6	23	0.24				
10	6.8	25	0.27				
15	8.0	27	0.29				
20	9.5	26	0.36				
25	9.9	27	0.36				
30	10.8	26	0.41				
35	11.8	28	0.42				
40	12.6	28	0.45				
45	13.1	27	0.48				
50	13.8	26	0.53	50	11.0	22	0.5
55	15.0	27	0.55				
60	15.8	27	0.58	60	11.5	21	0.54
65	16.0	27	0.59				
65	14.0	26	0.53	65	12.5	22	0.56
77	14.5	25	0.58	75	13.0	22	0.59
87	14.8	25	0.59	85	13.3	23	0.57
97	15.2	25	0.60	90	13.2	21	0.62
107	15.7	24	0.65	100	12.8	22	0.58
117	16.2	23	0.70	110	12.7	21	0.60
127	16.7	24	0.69	120	12.7	22	0.57
137	17.0	25	0.68	130	13.0	20	0.65
147	17.5	24	0.72	140	13.7	20	0.68
157	17.7	24	0.73	150	14.0	22	0.63
167	17.7	24	0.73				
170	18.2	25	0.72	160	14.5	22	0.65
180	18.4	27	0.68	170	14.2	20	0.71
190	18.4	25	0.73	180	13.2	18	0.73
200	16.7	23	0.72	190	12.3	19	0.64
210	15.4	21	0.73	200	11.0	18	0.61
220	13.9	19	0.73	210	9.8	17	0.57
230	11.5	16	0.71	220	7.8	13	0.60
240	9.1	15	0.60	230	6.2	12	0.51
249	9.1	18	0.50				
250	7.9	16	0.49				
260	5.7	14	0.40				
270	4.1	9	0.45				
280	3.0	8	0.37				
290	2.2	7	0.13				
300	2.0	6	0.33				
365 = apex							

CONTENTS.

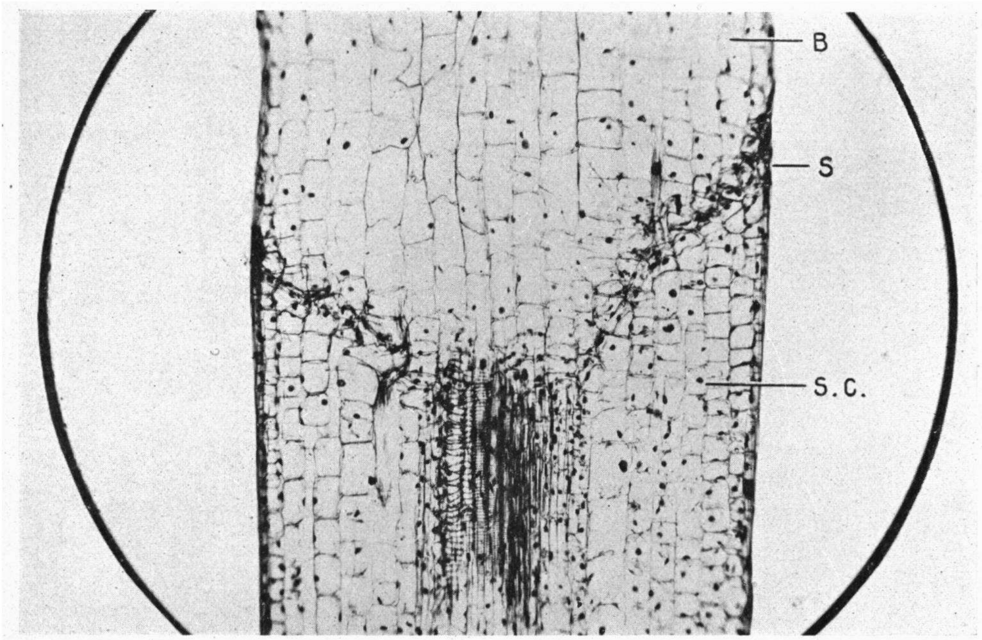

Fig. 6. Micro-photo of a longitudinal section through the separation-layer of the inmost foliage-leaf on June 16th 22 of the group IV bb.
S = Separation-layer. S. C. = Scale-part. B = Foliage-leaf-part that is to decay.

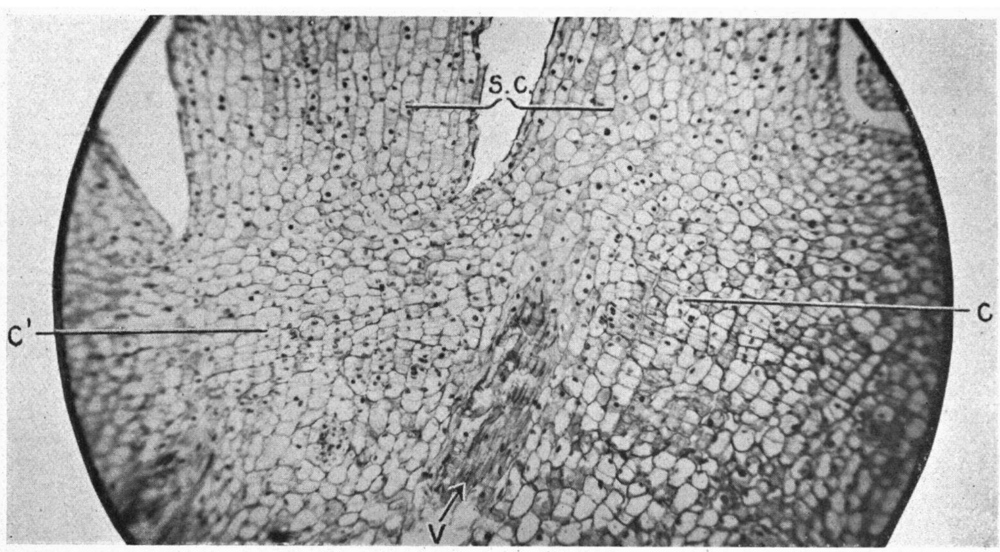

Fig. 7. Longitudinal section through the bulb-disc on May 3rd 22 of the group IV bb.
C. = Cambium. S. C. = Scales. V. = Vascular bundle.

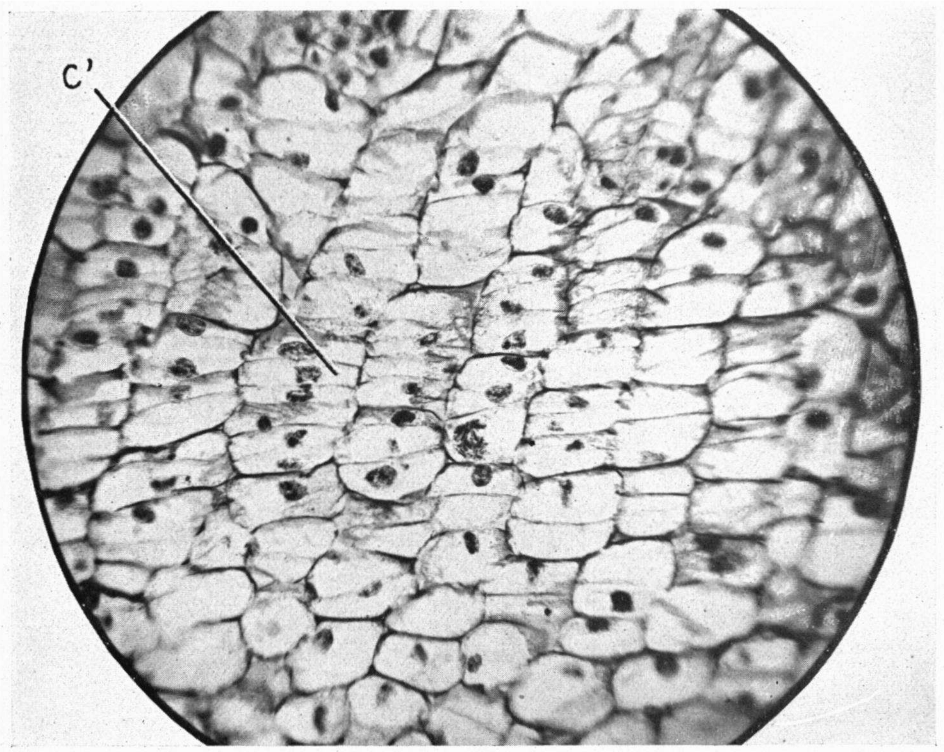

Fig. 8. The cambium-part indicated with C' in fig. 7, stronger magn.

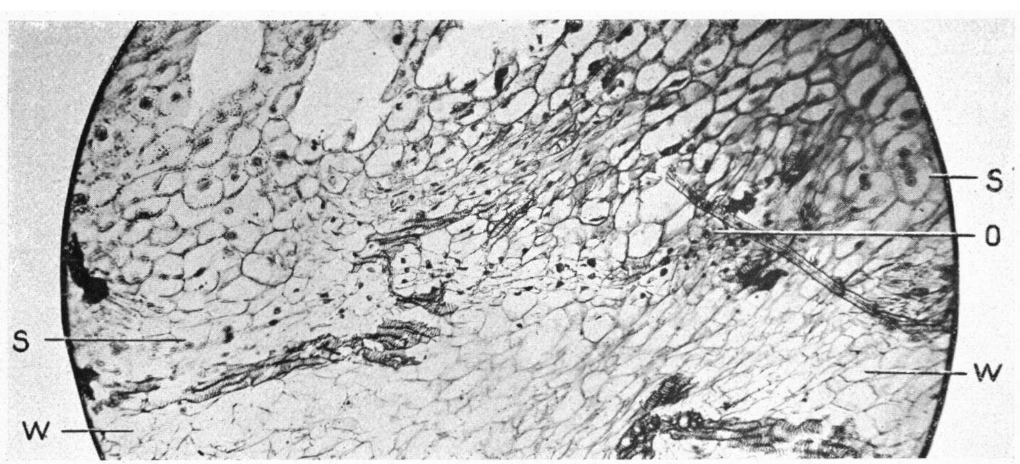

Fig. 9. Micro-photo of a longitudinal section through a portion of the bulb-disc on July 19th 1919.
S. = Separation-layer. W. = Decayed portion of the disc. O. = Nuclear-division.