

XIII. *The Longitudinal Symmetry of the Centrospermæ.* By PERCY GROOM, M.A.,
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(26 Text-figures.)

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IN my preliminary communication to the Linnean Society and my paper published in the 'Transactions' of the Royal Society (1908) I suggested a graphic method of recording the longitudinal distances apart of the successive leaves of a shoot. According to this method the successive segments of a stem are recorded on squared paper as successive ordinates, and the resultant curve is termed an "internode-curve."

The application of this method to a typical stem shows an unexpected regularity, and relative constancy, in the internode-curve in a species; the internode-curve of the main axis assumes an ascending-descending (normal) form, while those of the successive branches (proceeding from the base to the apex) exhibit a gradual change from the ascending-descending form to a purely descending one. But in the Chenopodiaceæ, while the opposite-leaved *Salicornia* shows typical internode-curves, the alternate-leaved types are characterized by peculiar zigzag internode-curves, which, when analysed by joining the alternate ordinates, each yield two regular or consistent subcurves. It was shown in my previous paper that the zigzag internode-curve is probably due to the longitudinal diremption of the originally opposite leaves at each of the nodes, and that the two subcurves represent respectively an internode-subcurve and a displacement-subcurve.

In the present paper are recorded additional observations showing the general prevalence of this type of longitudinal symmetry in the alternate-leaved Chenopodiaceæ. The observations concern: on the one hand, numbers of individuals of one species, and the different axes (primary to quaternary), in order to show the range of variation in one species and yet the universality of the two subcurves; and, on the other hand, additional species.

The fact that the Caryophyllaceæ are almost without exception opposite-leaved, and that the majority of the other families of the Centrospermæ include opposite- and alternate-leaved types or opposite-leaved types only, suggested that possibly the original phyllotaxis of the Centrospermæ as a whole was opposite in type, and that throughout the cohort the alternate phyllotaxis was derived from this by leaf-displacement. The present investigation is also designed to test this possibility.

Observations were made on Chenopodiaceæ, Caryophyllaceæ, Aizoaceæ, Amarantaceæ, Phytolaccaceæ, and Portulacaceæ.

In all these families, so far as my observations go, the internode-curves of the alternate-leaved types are irregular and zigzag, but are capable of analysis into two subcurves of greater or less regularity. The internode-curves of the opposite-leaved forms are much more regular and show more or less regularity of form. Thus the evidence points clearly in the direction of the opposite type of phyllotaxis as being the one originally characteristic of the whole cohort, and the alternate type as being derived from this by relative longitudinal displacement of the leaves.

Irregularities in the internode-curves and in the subcurves are due to two causes:--

(1) *Inherent causes*, as in the case, say, of the Chenopodiaceæ, where the recurrent zigzag is due to leaf-displacement; also in the case of branches where, as proved in my previous paper, a double maximum may arise as the internode-curve or subcurve changes from the normal type to the descending type by the relative or absolute increased length of the more proximal internodes or segments.

(2) *External causes*, such as changed supply of water, of light, of heat, and so forth.

At present no detailed observations have been made on the actual changes in the internode-curve occasioned by changes in the surroundings, though the characters of such may be inferred by comparing the internode-curves of the main stems, or of the corresponding branches, of one species. My published and unpublished observations of this nature render it safe to infer that sharp, sudden, and repeated irregularities of the internode-curves in the alternate-leaved Centrospermæ and other species where opposite and alternate phyllotaxis are represented in one genus or species are inherent, and are distinguishable from the occasional or more gradual irregularities that are due to external changes.

But I hope in the future to make more detailed observations on the modifications in longitudinal symmetry induced by external changes.

The Centrospermæ, apart from the structure of their flowers and phyllotaxis, display a number of morphological features common at least to several of the constituent families.

In some families there is a strong tendency for the axes to end in flowers and for the branching to be cymose: for instance, in the Caryophyllaceæ, Phytolaccaceæ, and Portulacaceæ. And the partial inflorescences or branching often assumes a dichasial form, tending towards a cincinnoid type by strengthening of one of the two branches, or may assume a purely cincinnoid form by non-development of the weaker branch. This cymose branching with the strengthening of one branch at a node reaches a climax in the Nyctaginaceæ. In the Chenopodiaceæ, Nyctaginaceæ, and some other families the emission of accessory branches is a very general feature.

In the inflorescence region the precocious development of branches is often associated with the "fusion" of branches with the main axis, as is especially seen in the Chenopodiaceæ, Phytolaccaceæ, and Portulacaceæ. Where the relatively main axis terminates in a flower as in the latter two cases, this fusion is associated with the pushing aside of the true end of the stem and the production of leaf-opposed or extra-axillary inflorescences recalling those of the Boraginaceæ. These "fusions" of the branches in the inflorescence-region, together with the leaf-displacements, are responsible for the formation

of "interrupted" inflorescences in the Chenopodiaceæ. Such "fusions" prepare us for the notorious fasciation of amarantaceous inflorescences.

But in other parts of the stem of Chenopodiaceæ where branches shoot out precociously similar "fusions" take place between branch and main axis or subtending leaf.

The remaining pages give particulars concerning the various families, genera, and species investigated.

CHENOPODIACEÆ.

The species investigated were *Atriplex rosea* (two forms), *Salsola Kali*, and *Chenopodium Bonus-Henricus*.

ATRIPLEX ROSEA. (Curves 1-5.)

The plants were collected on the sea-shore in Anglesey, where there were two varieties:—

(i.) The ordinary prostrate form whose main stem bends over parallel to the surface of the soil almost as soon as it emerges from the sand.

(ii.) An erect form of more slender build, usually found growing on the steeper slopes of the sand-hills on the seaward side farther from the sea than the gently sloping or level sand where the prostrate form abounds: yet the erect variety was not entirely lacking from the latter habitat, so that its difference from the prostrate form is not induced by external circumstances.

Most of my observations concern the more abundant prostrate form, and are of special significance because the open flatness of habitat and the prostrate method of growth reduce to a minimum differences of the various shoots as regards conditions of light, heat, and moisture.

Before discussing the internode-curves of this species some remarks may be offered concerning the phyllotaxis and mode of growth of seedlings and young plants of the prostrate form.

At first the hypogeal development far outstrips the epigeal, and a deep tap-root rapidly descends in the sand to the deeper-lying water, while a relatively short shoot is being produced (this is demonstrated by a comparison of the second and third columns in the following Table, p. 270). The early bending over of the main shoot and the prostrate condition of the branches remove the plant largely from the influence of the wind, also cause it to take a relatively small part in fixing the sand and to evade the danger of early burial.

The leaves at the base show a decussate design of phyllotaxis and are opposite or sub-opposite, as are the branches, which very early grow out horizontally, creep over the ground, elongate rapidly, and therefore soon equal or exceed in length the main stem (see the following Table). The rapid elongation of the branches in comparison with the stem is associated with the greater lengths of their first internodes, which tend to carry the leaves of the branches out of range of those on the main stem or the other branches.

The first branches to appear are either those in the axils of the first pair of foliage-leaves or, less frequently, of the cotyledons. Accessory branches are often produced beneath the true axillary ones, and in one case (seedling Y) arose in an interpetiolar position between the cotyledons. Associated with the early outgrowth of the basal branches are frequent fusions between these and the main axis or the subtending leaf. Higher up the leaves become more apparently alternate; the decussate divergence is lost. Nevertheless the divergence of the leaves of the seedling supplies evidence conforming with the view that the phyllotaxis was originally opposite: for instance, in specimen D 5 the cotyledons and the first four pairs of leaves showed perfect or approximate decussate divergence, though the pairs of leaves were not all opposite as regards height of insertion.

In the subjoined Table the numbers given are lengths in millimetres of the various stems which were still in active growth. Each horizontal line gives particulars concerning one seedling, the parts referred to being named at the heads of the vertical columns. The numbers in brackets beneath those recording the stem-lengths denote the length of the successive internodes. "Shorter" indicates that the branch was of length less than that of the branch at the immediately preceding node.

Name of the seedling.	Length of the hypocotyl and main root (broken at end).	Length of main stem.	Length of branches subtended by:							
			Cotyledons.		First pair of leaves.		Second pair of leaves.		Third pair of leaves.	
			I.	I'.	II.	II'.	III.	III'.	IV.	IV'.
D 3	76	10	bud.	bud.	bud.	bud.				
D 11 . .	..	30 (4.5, 5.5, 8)	young. (4 (young))	young. (4 (young))	30 (18.5)	34 (21)	shorter. (8 (young))	shorter. (8 (young))		
D 7	120	35 (6, 7.5, 8)	bud.	bud.	30 (20)	30 (20)	shorter. (15)	shorter. (15)	bud.	bud.
D 5	125	40	bud.	bud.	bud.	55	shorter.	shorter.	bud.	bud.
Y (erect)	110	45	80 (50, 18,)	60 (40, 11,)	50 (30)	50 (30)	shorter.	shorter.	bud.	bud.
I 34 K . .	..	65	70	90	100	105	65	50	shorter.	shorter.
I 30 . . . .	..	110	bud.	bud.	190	160	125	145		
I 10 . . . .	..	165	bud.	bud.	185	175	225	195	155	
I 38 . . . .	..	164	bud.	short, young.	204	193	174	170	116	72

It will be noted that even in the seedling (Y) with an erect main stem the branches soon surpassed the main stem as regards length. This particular seedling possibly

represented a form transitional between the prostrate and erect form, as, despite of its erect main stem, the lowest two branches were prostrate, and the next two higher ones were slightly descending : moreover, in typical erect forms the branches emitted from the base of the main stem are less developed (at least early in life) than those inserted at some distance higher.

Internode-curves of Atriplex rosea.

Measurements were made along not only primary and secondary, but also tertiary and quaternary axes. They show the general truth of the following conclusions:—

1. The internode-curves are zigzag, and those of the branches are often also irregular, but can be analysed into two regular or consistent subcurves—internode-subcurve and displacement-subcurve.

2. The subcurves of the main axis and lower secondary axes are of the ascending-descending (normal) type, but in branches successively inserted higher up the axis they change towards a purely descending type; and in this change, thanks to the disproportionate gain in length of the proximal segments (early ordinates), an additional maximum (or minimum) is introduced into the subcurve. The subcurve recording the leaf-displacements usually undergoes the change later than the internode-subcurve.

These statements are proved by the subjoined statistics referring to specimens termed I 38, I 10, 191, 192, 187, I 12 Er^1 , I 14 Er^3 , I 18 Er^4 , and represented by Curves 1–5.

Regular *Ascending-descending Subcurves* shown by :—

Nature of the axes.	Internode-subcurve.	Displacement-subcurve.
Main axes	I 38 (Curve 1 <i>m</i>).	I 38 (Curve 1 <i>m</i>).
Secondary axes ..	Relatively main axis of 192 (Curve 3 <i>m</i>).	I 38, Branches 1–4 (Curves 1 <i>i</i> , 1 <i>ii</i>). I 10, Branches 1, 3, 4 (Curves 2 <i>i</i> , 2 <i>ii</i>). 192, Relatively main axis (Curve 3 <i>m</i>). 191, „ „ (Curve 4 <i>m</i>).
Tertiary axes	192, Branch 1 (Curve 3 <i>i</i>).	192, Branches 1, 2 (Curves 3 <i>i</i> , 3 <i>ii</i>). 191, Branch 2 (Curve 4 <i>i</i>).
Quaternary axes .	. . . . .	187, A 1 (Curve 5 <i>i</i>).

Gradual Conversion of the Ascending-descending Subcurves to Descending Subcurves.

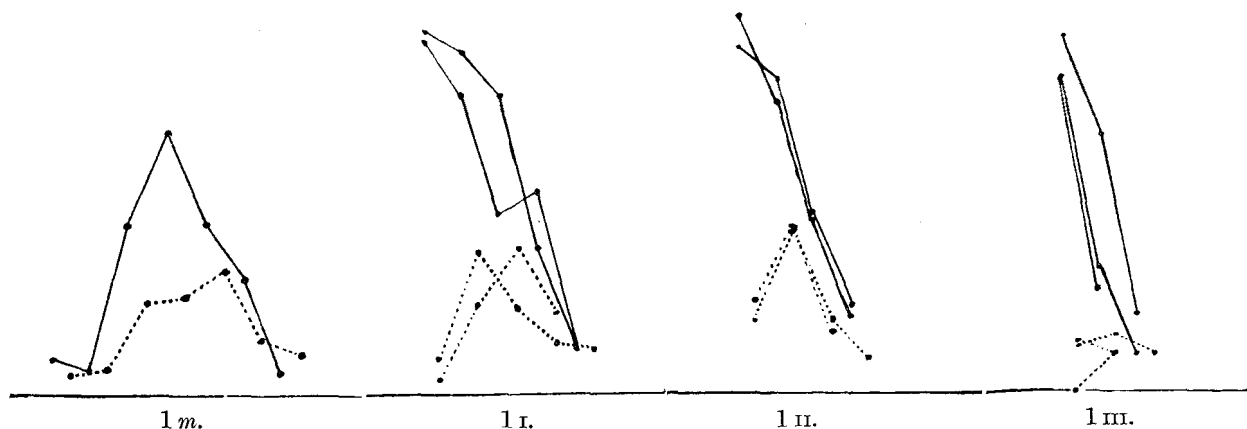
Nature of the axes.	Plant.	Internode-subcurves.			Displacement-subcurves.		
		a.	b.	c.	a'.	b'.	c'.
		Ascending-descending with lengthening of the lower (proximal) segments (earlier ordinates).	Showing double maximum due to gain in length of lowest or lower segments.	Purely descending curve of increasing steepness.	Ascending-descending with lengthening of the lower segments (earlier ordinates).	Showing double maximum due to gain in length of lowest or lower segments.	Purely descending curve of increasing steepness.
Secondary axes.	I 10	....	Branches 1-4 (Curves 2 I, 2 II).	Branches 5, 6 (Curve 2 III).	Branch 1 (Curve 2 I), Branches 3, 4 (Curve 2 II).	....	Branches 5, 6 (Curve 2 III).
	I 38	....	Branch 2 (Curve I I).	Branches 1, 3-6 (Curves 1 I-III).	Branches 1-4 (Curves 1 I-II).		
	191	....	Relatively main axis (Curve 4 m).				
Tertiary axes.	192	Branch 1 (Curve 3 I).	Branches 2, 3, 5 (Curves 3 II-IV).	Branch 5 accessory (Curve 3 v).	Branch 1 (Curve 3 I).	Branches 3, 5 (Curves 3 III-IV).	
	191	....	Branches 2, 4 (Curves 4 I, 4 II).	Branches 5, 7 (Curves 4 III, 4 IV).	Branches 2, 5 (Curves 4 I, 4 III).	....	Branches 4, 7 (Curves 4 II, 4 IV).
Quaternary axes.	187	....	Branches A 1, A 3 (Curves 5 I, 5 II).	Branches A 4, A 6 (Curve 5 III).	Branches A 1, A 3, A 4-6 (Curves 5 I, 5 II-IV).		

In the succeeding Tables the horizontal series of numbers represent the lengths in millimetres of the successive segments of an axis, the nature of which is indicated in the left-hand column. Branches springing from the axils of leaves actually or phylogenetically belonging to the same node are bracketed in the left-hand column. The branches are numbered successively upwards. The vertical columns, so far as they refer to measurements of branches, thus give means of comparing the lengths of corresponding segments of the successive branches.

Atriplex rosea I 34 K.

The following measurements were made:—

Main stem	3.7	1.5	10	3.5	11.5	6	11	0	8	Bud.	Total length of shoot.
											65
{ Basal Branch (I')	47	1	11.5	.5	4	0	Bud.	..	..	..	70
{ " " (I'')	49.5	3.5	17	4.5	6	0	3.5	Bud.	..	..	90
{ 1st Branch (II)	58	6.5	11	9.5	5.5	2.5	Bud.	..	..	..	100
{ 2nd " (II')	62	1.5	17.5	5.5	5	.5	3.5	Bud.	..	..	105
{ 3rd " (III)	44	3.5	8	2.5	4	Bud.	..	..	..	..	65
{ 4th " (III')	32	3	8	2.5	Bud.	..	..	..	..	..	50
Remaining higher branches..	..	..	..	..	..	..	..	..	..	..	Shorter.

Atriplex rosea I 38. (Curves 1 m, 1 I-III.) †

Main stem	4.5	2.5	3	3	22	12*	34.5	12.5	22	16	15	7	2.5	5	Bud.	Total length of shoot.
																164
Basal (I)	Bud.															
" (I')	Short branch.															
{ 1st Branch (II) ..	47.5	1.5	45	11.5	39	19	19	10.5	5.5	..	..	..	..	..	..	204
{ 2nd " (II') ..	46	4.5	39.5	18.5	23.5	11	26.5	6.5	5.5	5.5	..	..	..	..	..	193
{ 3rd " (III) ..	45.5	9.5	41.5	21.5	24	9.5	11.5	4.5	..	..	..	..	..	..	..	174
{ 4th " (III') ..	49.5	12	38	22	23	8	10	..	..	..	..	..	..	..	..	170
{ 5th " (IV) ..	47	6	34	7.5	10	5	..	..	..	..	..	..	..	..	..	116
{ 5th* " (IV*) ..	41.5	0	16.5	5	5	..	..	..	..	..	..	..	..	..	..	72
{ 6th " (IV') ..	41.5	6.5	13.5	5	..	..	..	..	..	..	..	..	..	..	..	72

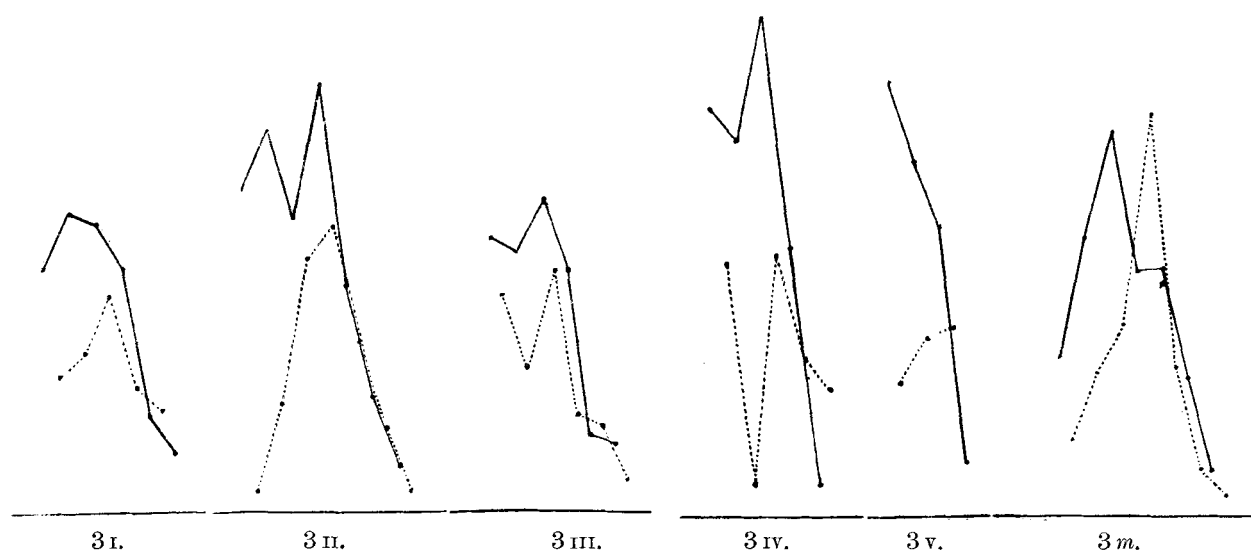
This specimen (I 38) showed a remarkable feature associated with the preservation of the decussate divergence at the base of the main shoot. The sixth measurement along

† For explanation of these and other curves, see pp. 300-302.

Measurements along the main axis of specimen I 10 commenced at the cotyledonary node. After having its first pair of foliage-leaves separated by a distance of 4 mm., the main shoot showed a reversion to the exact opposite phyllotaxis at the next two nodes. The internode-subcurve of the main axis is unusually irregular: it is possible that the abnormal length of the first internode was due to the main stem being deeply buried (though I made no note at the time indicating such a condition).

The preliminary fall in the internode-subcurves of the first four branches, on the contrary, is easily explicable as representing a transition towards the purely descending form of curve which is attained in the 5th and 6th branches.

Atriplex rosea 192. (Curves 3 m, 3 I-v.)



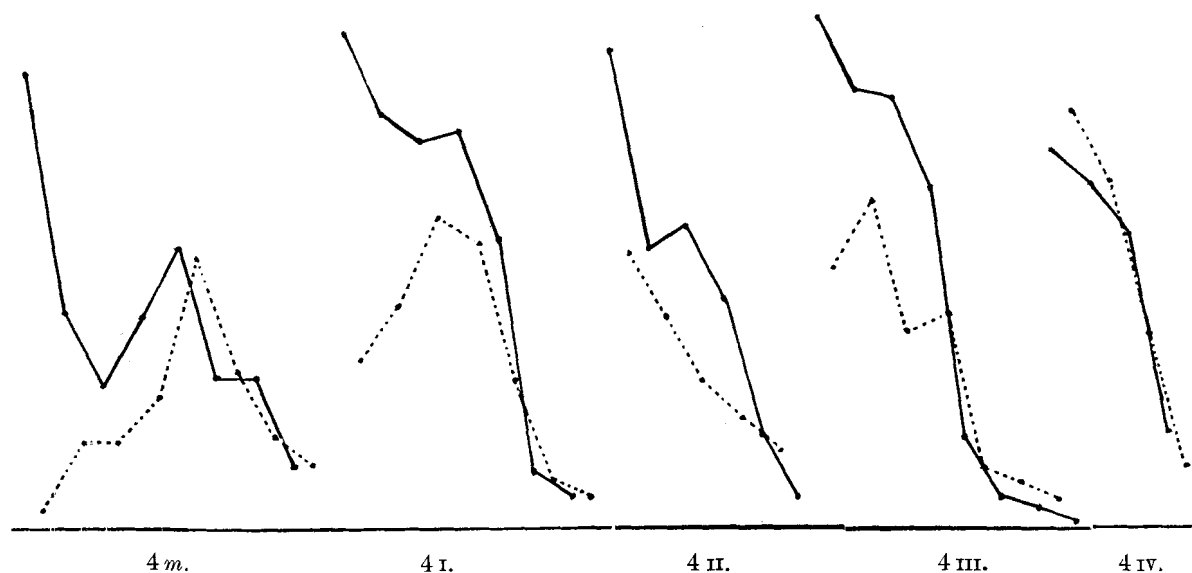
	30.5	14.5	54.5	27.5	75	37.5	47.5	79	48.5	29	26.5	9	8.5	4	Approximate total length.
Relatively main stem (Secondary)	30.5	14.5	54.5	27.5	75	37.5	47.5	79	48.5	29	26.5	9	8.5	4	492
1st Branch (Tertiary 1)	48	26.5	59	31.5	57	43	48	24.5	19	20	12	..	..	..	389
2nd „ („ 2)	64	4.5	76	22	58	50.5	84.5	56.5	45	34	23	16.5	9.5	4	548
3rd „ („ 3)	54	42.5	51	28	61.5	47.5	47.5	19.5	15	17	13.5	6.5	..	..	404
5th „ („ 5)	81	50	74.5	6.5	99	51.5	52.5	31	6.5	25	..	..	..	..	478
5th accessory (Tertiary 5')	84.5	26	70	35	56.5	37	10.5	..	..	..	..	..	..	..	320

In the case of specimen 192 the relatively main axis was a secondary axis. In addition to showing the change of symmetry of the successive tertiary axes, the specimen exhibited a number of “fusions” of the branches with relatively main axes, so that supra-axillary branches were inserted on certain of the tertiary axes. (The Branches are numbered successively upwards, and beneath the fifth branch in the axil of the same leaf was an accessory branch, which is termed “Vth accessory”).

On Branch 2, the branch subtended by the seventh leaf was "fused" with the parent-axis for a considerable distance upwards; a ridge and two furrows clearly marked the outline of the "fused" part of the branch. The branch subtended by the ninth leaf was likewise displaced upwards, though in this case there was no such clear projecting ridge denoting the "fused" part of the branch; still, the supra-axillary position of this, the lack of any subtending leaf immediately beneath it, and the lack of any bud in the axil of the truly subtending leaf were sufficient evidence of the "fusion." The branch truly subtended by the tenth leaf was likewise raised (for a distance of 3.5 millimetres) in insertion above the leaf; it was a short sessile fruiting branch. Above this, all the branches were more or less supra-axillary, but there was no suppression of leaves on the relatively main axis (the apparent suppression being due to branch-displacement).

On Accessory Branch V similar "fusions" and displacements occurred, the lowest being that truly subtended by the fifth leaf.

Atriplex rosea 191. (Curves 4 m, 4 I-IV.)

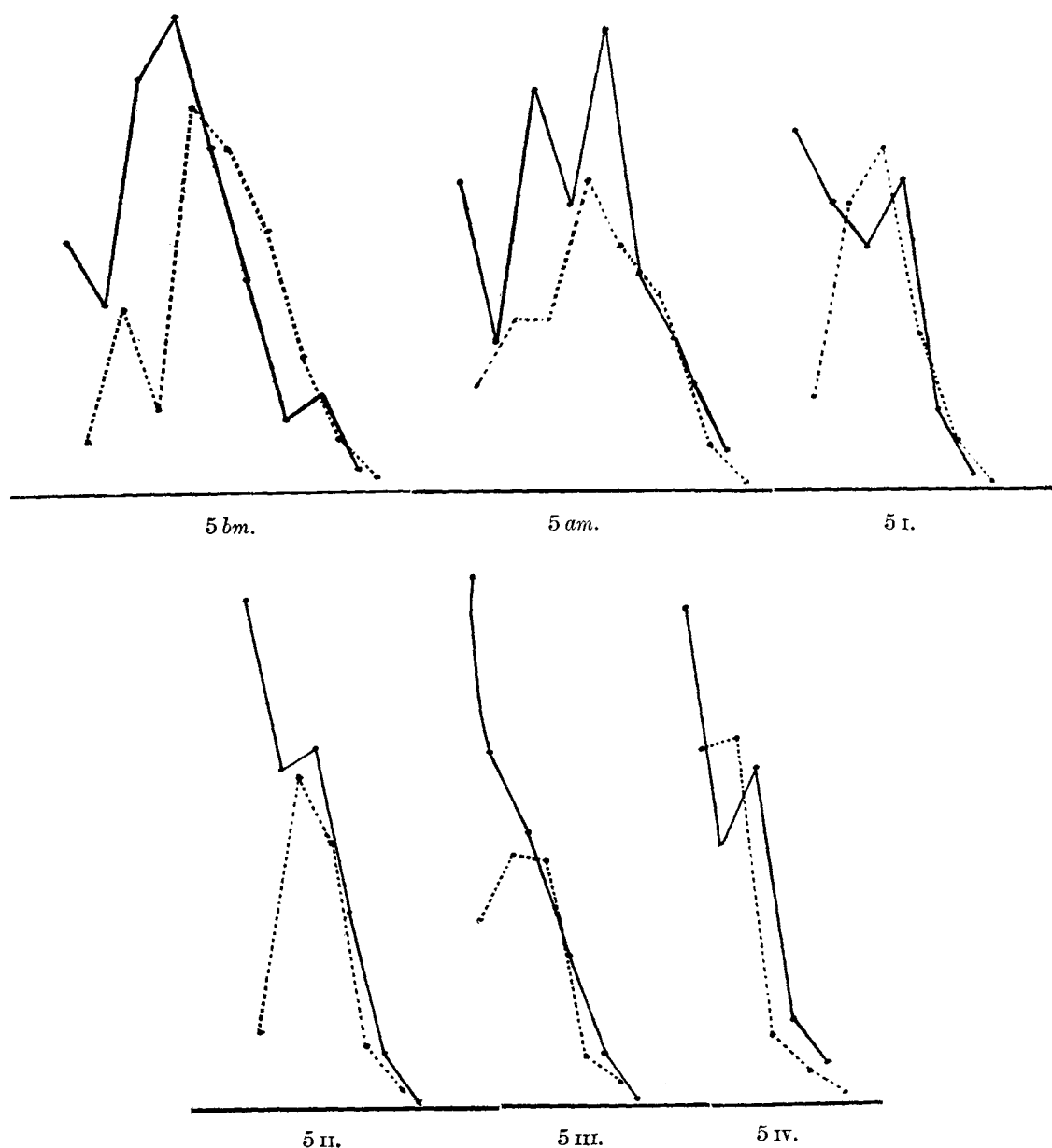


																	Approximate total length.			
Secondary axis	..	60	2.5	28.5	11.5	18.5	11.5	28	17.5	37	35.5	20	21	20	12	8	8.5	340		
Tertiary axis 2	..	65.5	22.5	54.5	29.5	51	41.5	52.5	37.5	38.5	19.5	7.5	6.5	4.5	4.5	..	..	436
„	„	4	..	63	36.5	37.5	28	40.5	19.5	30	14.5	12.5	10.5	4.5	..	..	..	297
„	„	5	..	67.5	35	58.5	43.5	57.5	26	45.5	28	12.5	8.5	4.5	6.5	3	4	1	..	402
„	„	7	.	50.5	55.5	46	46	3	25.5	13	8.5									

The internode-subcurve of the secondary (relatively main) axis shows a double maximum and is intermediate between an ascending-descending and a purely descending

curve. The subcurves of the branches (*tertiary axes*), numbered from below upwards, show an admirable series of transitions to the purely descending curves, and that the changes in the internode- and displacement-subcurves are not synchronous. The irregularity of the internode-curves of these branches and the perfect consistency of the analysis of these into regular subcurves supplies most convincing evidence not only of the utility of the graphic method in elucidating morphological problems, but also of the truth of the view here put forward in regard to the true nature of the phyllotaxis of *Atriplex rosea* and *Chenopodiaceæ* in general. A similar, but even better, series is exhibited by specimen 187, about to be described, but concerning *quaternary axes*.

Atriplex rosea 187. (Curves 5 *am*, 5 I-IV, 5 *bm*.)



																			Approximate total length.
A. Tertiary axis	44	15	21	24.5	57	24.5	40.5	44	65.5	34.5	31	28	21.5	15.5	7	6	1	..	481
A. Quaternary axis 1..	51	13	41	41	34	48	44	22	11.5	7	2	1	..	..	..	..	..	..	316
A. „ „ 3..	72	11	48.5	47.5	51	38	27.5	9	8	2.5	1	..	..	..	..	..	..	..	316
A. „ „ 4..	75	27	50.5	36	38.5	35.5	21.5	7.25	7.5	3.5	.75	..	..	..	..	..	..	..	303
A. „ „ 5..	71	51	37.5	52.5	48	10	12	5	6	1.5									
A. „ „ 6..	70	46.5	53	46.5	43	6													
B. Tertiary axis.....	35.5	7.5	27	26.5	58.5	12	67.5	54.5	49	49	30	37.5	10.5	19	13.5	7.5	3.25	2.25	511
B. Quaternary axis 3..	85	45	53	43.5	52.5	29.5	21	6.5	8.5	4	.75	..	..	..	..	..	..	..	349
B. „ „ 4..	66.5	1	67.5	32	34.5	25	18.5	13	5.5										
B. „ „ 6..	84.5																		
B. „ „ 8..	99																		

Measurements were made along two tertiary axes, A and B, which sprang from a secondary axis at nearly the same level. Measurements were also made along branches (quaternary axes) of these and are numbered from below upwards. Both the tertiary axes, and also the quaternary axes 1-4 on axis A and 1-3 on axis B, had completed their growth in length; the terminal part of Branch 6 on axis A had been broken off, so that the measurements cease abruptly (and its curves are not printed).

The internode-subcurve of the tertiary axis A is rather irregular in the early part of its course, but comparison with that of tertiary axis B indicates that the first descent is due to the curve being transitional towards a descending one. The second depression is probably due to the external circumstances, as we note similar depression taking place in the displacement-subcurve at the immediately preceding point in tertiary axis B. The subcurves of the quaternary axes on axis A show admirable gradual transitions to the descending form.

On several of the stems the branches were displaced upwards into a supra-axillary position. In the following skeletal sketch of these displacements, the number of each leaf is given first in Roman numerals and is followed by the number in ordinary type denoting the number of millimetres of upward displacement.

Tertiary axis A: IX, 7; XI, *x*; XII, 5; XIII, 3; XIV, 3. *Tertiary axis B*: XIII, 5.5; XIV, 4.5 (obliquely above the leaf); xv, 2.75 (obliquely above the leaf).

Quaternary axes:—Third branch on A: VI, 29 (line of fusion very clear). Fourth branch on A: IV, 3.5 (line of fusion very clear). Third branch on B: VI, 8 (line of fusion very clear). Fourth branch on B: VII, 11.5; VIII, *x*.

Observations were made upon four specimens (Er^1 , Er^2 , Er^3 , Er^4) of the erect variety of this species, and upon one specimen (I 28) that appeared to be transitional between the erect and the prostrate form. Between the two extreme forms several differences as regards mode of growth are revealed.

(1) The main axis, at least at first, grows out more strongly in comparison with its branches; this would be anticipated, since it grows erect and has to raise aloft and carry the branches.

In the *transitional form* the branches at the base seemed likewise to be intermediate in their behaviour. Weak branches sprang from the axils of the cotyledons; a weak branch was emitted from the axil of the lowest foliage-leaf, and a stronger one from the other leaf of the first pair, but the branches emitted from the axils of the next pair of leaves were no stronger than the latter.

(4) The internode-curves are clearly compounded of two subcurves. (The curves are not printed.)

[illegible]

Atriplex rosea Er^2 and Er^3 .

Er^2 , Main stem..	22	2	30	2	23	22	63	12	50	27	25	10	Bud.	Whole length.
Er^3 , Main stem..	24.5	0	19.5	3	30	9.5	28	21	22.5	13	7	10	Fruits.	150

In both plants Er^2 and Er^3 the cotyledons subtended buds; the first pair of foliage-leaves subtended minute branches, the second pair of leaves subtended longer branches. In plant Er^3 the third pair of leaves subtended still longer branches, and the fourth pair of leaves subtended the longest branches.

Atriplex rosea Er^4 .

Main stem ..	4	1	5	1	13	4	25.5	2	35	8	32	8.5	19	2.5	4	Bud.	Whole length.
{ Branch II ..	15	0	13.5	..	..	..	..	..	..	..	..	..	..	..	..	..	39
{ „ II' ..	15	0	12	..	..	..	..	..	..	..	..	..	..	..	..	..	35
{ „ III ..	25	0	20	7	13.5	7	10	Bud.	..	..	..	..	..	..	..	..	85
{ „ III' ..	19	2.5	19	3.5	12	3.5	7	Bud.	..	..	..	..	..	..	..	..	65

Atriplex rosea I 28.

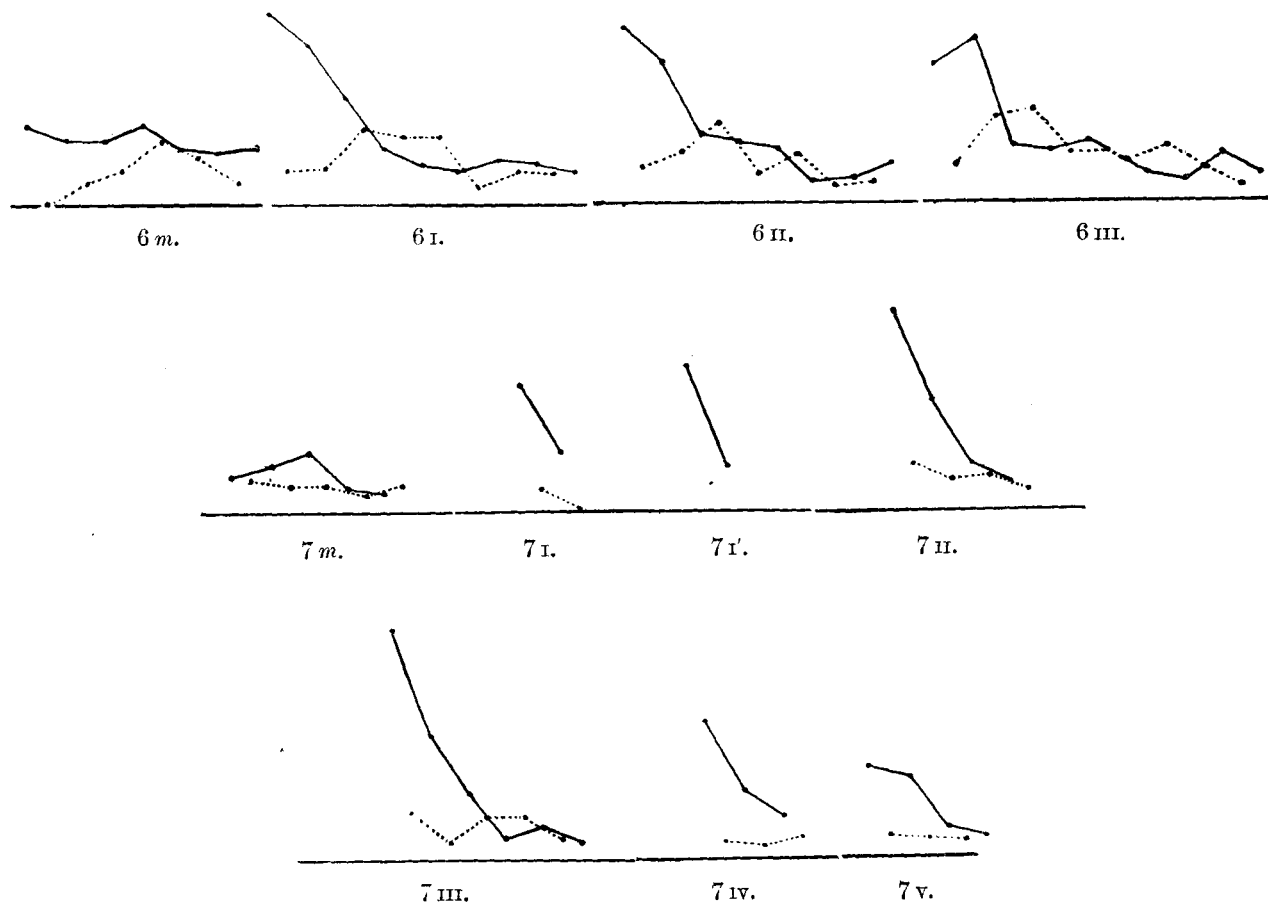
Main stem	21.5	3	19	5	14	16.5	23.5	5.5	45	7	38.5	21	14.5	8.5	..	Whole length.
I and I' .....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	22
{ Branch II	28.5	2.5	14.5	5	..	..	..	..	..	..	..	..	..	..	..	55
{ „ II'	37	1	28.5	7.5	17.5	3.5	12	6	..	..	..	..	..	..	..	120
{ 3rd „ III ..	42	1.5	22.5	6.5	9	7.5	6	..	..	..	..	..	..	..	..	100
{ 4th „ III' ..	51	1	31	11	10	9.5	6.5	..	..	..	..	..	..	..	..	120
{ „ IV ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	80
{ „ IV' ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	65
{ „ V ....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	55
{ „ V' ....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	55

This particular specimen supplied a special proof of the utility of the graphic method. It was one of the first specimens that I measured, and at the time I was unaware of the fusions taking place between branches and main axis in the inflorescence region. My

last six measurements on the main axis originally were 38.5, 21, 6, 8.5, 4, 4.5. The resultant curve differed so entirely from those of specimens previously measured that I examined the axis in this region. I found that the measurement 6 was from a leaf which had no axillary bud to the insertion of a branch which apparently had no subtending leaf. Thus the branch was raised above the true leaf-axil, and the true measurement of the internode was $6+8.5=14.5$. A similar raising of the branch above the axil of the next higher leaf had also occurred, so that the true displacement-measure was $4+4.5=8.5$. These corrections regularized the subcurves and incidentally demonstrated the existence of "fusions" between branches and main axis.

SALSOLA KALI. (Curves 6 *m*, 6 I-III, 7 *m*, 7 I-V.)

Two specimens (Plants 8 and 10) were measured by Mr. A. Deane. The branches emitted at the cotyledonary node are termed cotyledonary branches; the branch in the axil of the first foliage-leaf is Branch I and so forth.



PLANT 8. (Curves 6 m, 6 I-III).																	Length of terminal part.
Main stem	10.5	0	8.5	2.75	8.5	4.5	10.5	8.5	7.5	6.5	7	2.75	7.25	..	..	..	18
Cotyled. branch ..	25	4.75	21	5	14.25	10	7.5	9	5.5	9	5	2.5	6	4.5	5.75	4.25	4.5
Branch 2	23	5	19.5	7	9.5	11	8.25	4	7.5	6.5	3	2.5	3.5	3	5.5	..	13.5
„ 3	18	5	22	11.5	7.5	12.5	7	6.5	8	6.5	5.5	4	7.5	3	4.5	6.25	29.5
PLANT 10. (Curves 7 m-7 II.)																	
Main stem	4.5	4.5	6.25	3.75	8	3.75	3	2.5	2.5	3.5	..	..	..	..	..	..	12
{ Cotyl. branch (a) ..	16.5	3	8	.5	..	..	..	..	..	..	..	..	..	..	..	..	12
{ „ „ (b) ..	19.25	4	6	..	..	..	..	..	..	..	..	..	..	..	..	..	6.5
{ Branch 2	26.5	6.5	14.5	4.25	6.5	4.75	3.75	3	..	..	..	..	..	..	..	..	17
{ „ 3	30.5	6.5	16.5	2.25	8.5	5.75	3	5.75	4.5	2.75	2.5	..	..	..	..	..	13.5
„ 4	18	2.5	9	1.75	5.5	2.75	..	..	..	..	..	..	..	..	..	..	14
„ 5	12	2.75	10.75	2.5	4	2.25	2.75	..	..	..	..	..	..	..	..	..	..

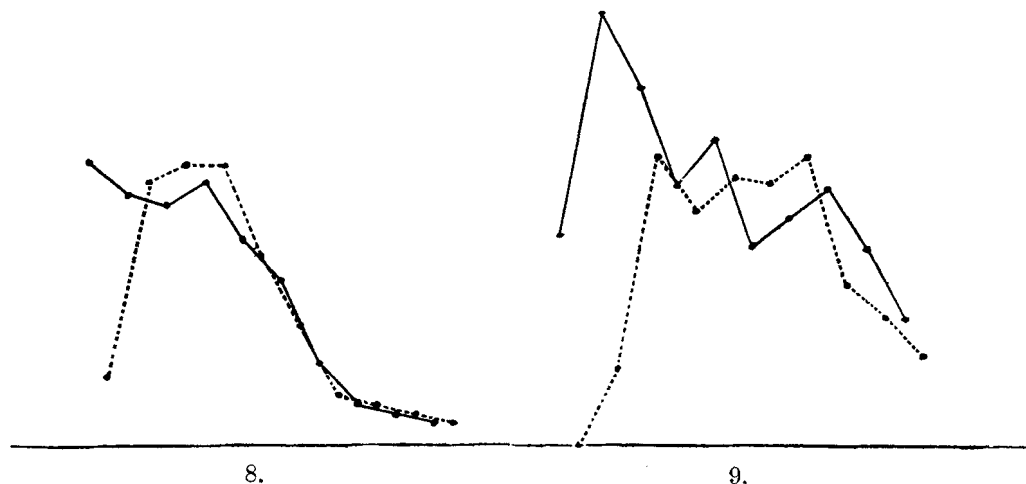
The measurements establish the existence of two subcurves in the internode-curve, though the two specimens show differences in detail and irregularities. The internode-subcurve of the main stem of one specimen and the corresponding displacement-subcurve of the other specimen are of the ascending-descending form, but the other two subcurves of these main stems though not irregular are not of this form; but similar deviations from the type occur in individual plants of *Atriplex rosea*. The internode-subcurves of the branches of both plants are largely of the descending type (possibly in part because of the young condition of some of the branches). The displacement-subcurves of *Salsola* 8 are of the ascending-descending form; those of *Salsola* 10 largely of the descending form (possibly partly because of immaturity of the internodes measured). The irregularities in the subcurves may be due to external variations or to peculiar correlations (see my previous paper).

CHENOPodium BONUS-HENRICUS. (Curves 8, 9.)

Measurements were made (by Mr. A. Deane) along the main stems of two specimens, numbers 32 and 34. The terminal part of the latter was broken off. Records as to the exact height up the stem at which measurements commenced are lacking, but probably this was lower in plant 34. The following are the measurements made:—

Plant.																		
32 ..	36.5	8.5	32.5	34	31.5	36.5	34.5	36.5	27	24.5	21.5	15.5	10.5	6.5	5	4.75	4	3
34 ..	27.5	0	57	10	47.5	38	34.25	31	40.5	35	26.5	34.25	30	38	34	21	25.75	12

The curves clearly are composed of two subcurves, those of specimen 32 being regular and those of specimen 34 irregular. In the latter, commencing at the third ordinate the internode-segment and the succeeding displacement-segment form pairs that show



deviations from regularity always in the same sense, as if they had been abnormally shortened or lengthened by external circumstances.

I also made measurements of two main stems of a species of *Chenopodium*, whose specific name I omitted to record. For this reason, I omit details of the measurements, which gave internode-curves capable of analysis into normal internode-subcurves disturbed by irregularities, and very regular displacement-subcurves of the ascending-descending type.

CARYOPHYLLACEÆ.

This family, almost without exception (e. g. *Pychnophyllum*), shows cyclic phyllotaxis. And in accordance with this the genera *Lychnis* and *Stellaria* show internode-curves that are typical and regular. This fact gains interest when it is remembered that in all the Caryophyllaceæ so far investigated the inception of the two leaves at a node is described as being not simultaneous. The statement is that in the vegetative region the leaf subtending the strengthened branch arises earlier than its fellow, whereas in the floral region the reverse is true. This peculiar behaviour is not in the least reflected in the internode-curves. If the opposite type of phyllotaxis is the primitive one in the Centrospermæ, then this difference in the time of development of the two leaves at the caryophyllaceous nodes would seem to foreshadow the more advanced type of the Chenopodiaceæ, where the two leaves become separated. Even if the primitive phyllotaxis of the Centrospermæ were spiral, the leaf-arrangement of the Chenopodiaceæ equally shows a transition to that of the Caryophyllaceæ. In any case the leaf-arrangement of the Chenopodiaceæ seems to shed light upon the hitherto incomprehensible peculiarity of the successional development of the leaves in the Caryophyllaceæ.

The shoots of *Cerastium arvense* examined did not show such regularity in their internode-curves; yet the irregularities were not of the repeated, sudden, and extensive nature that indicates leaf-displacement.

The internode-curves of Shoots I and II are obviously normal, regular, and very similar.

The internode-curves of the branches *a-c'* show the change from the normal (ascending-descending) type to the purely descending form.

LYCHNIS DIOICA.

Two specimens of this double species were measured by Mr. A. Deane, but as I do not know whether the plant was *Lychnis diurna* or *L. vespertina*, I merely give the statistics (without supplying the curves), in order to show the regular nature of the caryophyllaceous internode-curve.

An erect shoot ending in a flower was measured up to the topmost pair of leaves. The following results were obtained :—20, 117·5, 112, 90, 67·5, 60, 15.

The internode-curve is regular and normal.

The relatively main axis of another specimen had been destroyed above a certain node, and two branches, I and I *a*, springing from this node had functionally replaced it. The question was as to how far the internode-curves of these would be modified. The result showed that in their proximal regions they simulated an erect relatively main axis by having short internodes and producing an ascending internode-curve; but in their distal parts there was no decrease in length of the internodes, so that the internode-curves were purely ascending ones of regularity undisturbed save at one point on Branch I. Both branches ended in fruits :—

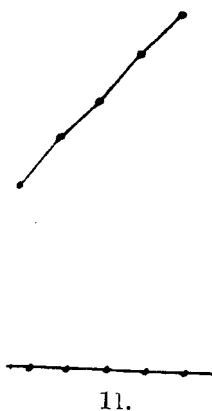
								Total.
I	4·5	8	20	33	53	48	62	228·5
I <i>a</i>	4·5	19	39·5	47·5	56·5	..	..	167

The statistics suggest that these branches did not grow out until after the injury to the parent axis, and show that the strengthened branch still maintained its predominance.

STELLARIA MEDIA. (Curve 11.)

One main stem terminating in a flower was measured, the following being the results :—24, 30·5, 35·5, 42, 47.

(The zero-measurements between the two leaves at each node are omitted.)



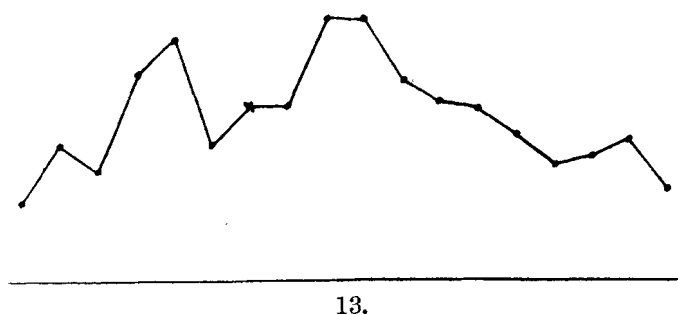
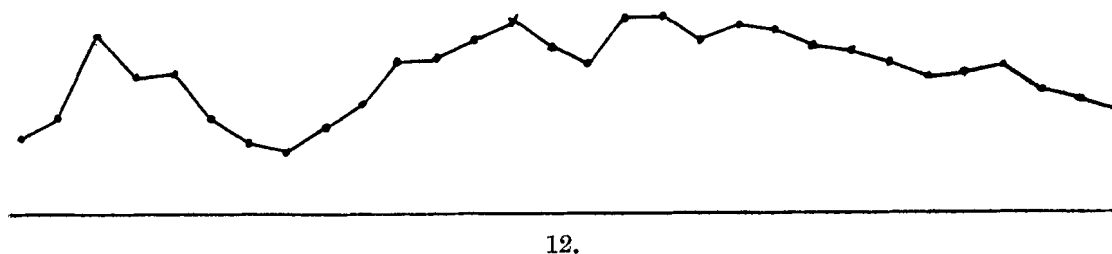
The internode-curve is a purely ascending one, and thus deviates from the typical internode-curve of a main stem. Its regularity is such that, within the limits of possible accuracy of observation, the curve assumes the form of a straight line.

CERASTIUM ARVENSE. (Curves 12, 13.)

This plant is much ramified and is largely constituted of lanky thin shoots which have long, horizontal, monopodial, subterranean parts whose ends emerge from the soil and continue as elongated superterranean shoots.

Both the branches measured arose as branches of a subterranean shoot, and their proximal parts were underground and emitted roots at the nodes, while their more distal portions were above ground. In each case the measurements commenced at the basal internode of the branch.

In the subjoined series of numbers a \times is placed after the number representing the measurement of the highest subterranean internode, and in the curves a \times is placed at the top of the ordinate representing these internodes. The specimens were collected in November, yet the highest measured internodes had not attained their full lengths and the shoots terminated in active buds.



Branch I:—10, 12·5, 23·5, 18, 18·5, 12·5, 9, 8, 11·5, 14, 20, 20·5, 23, 25·5 \times , 22·5, 20, 26, 26, 23, 25, 24·25, 22, 21·5, 20, 18·5, 19, 20, 16, 15·5, 13·5, followed by young internodes.

Branch II:—10·25, 17·5, 14·5, 27·5, 32, 17·5, 23 \times , 23·25, 34, 33·75, 26, 23·5, 22·5, 18·5, 15, 16, 18·25, 12, followed by young internodes.

Both internode-curves show an initial ascent, succeeded in order by a descent, an ascent, and a final descent. These general features are more or less disturbed by minor sudden rises and falls. To what extent the irregularities are due to external circumstances it is impossible to say. It is worthy of note that the first maximum and the first two minima occur in the subterranean part, so that etiolation does not overpower other influences that aid in determining the internode-lengths. The ascents and descents in the curves are not of the sudden and repeated kind characteristic of leaf-displacements (all the leaves were in opposite pairs), but are generally of a more gradual type, suggesting partly innate characters and partly characters induced by temporary change in environment.

AIZOACEÆ.

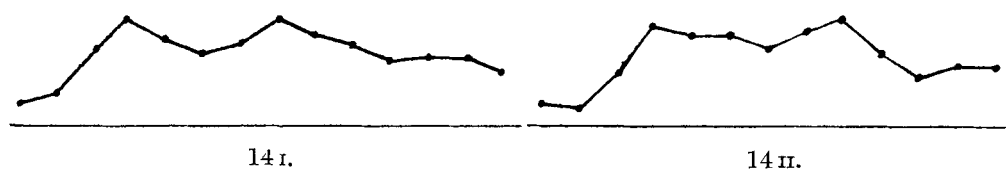
The genus *Mesembryanthemum* includes opposite- and alternate-leaved types. The two species that I examined belonged to the opposite-leaved type. The curves, if not quite regular, showed irregularities of only minor extent and gradual form, such as might easily be due to slight variations in the surroundings or to the different ages of the internodes.

MESEMBRYANTHEMUM ECHINATUM. (Curves 14 I-II.)

Two branches inserted at neighbouring nodes of the same relatively main axis were measured from the base up to the terminal active bud. The following are the measurements obtained :—

Branch I:—3, 4·25, 10, 14, 11·5, 9·5, 11, 14·5, 12, 10·5, 8·5, 9, 9, 7·25, bud.

Branch II:—3, 2·5, 7, 13, 12, 12, 10, 12·5, 14, 9·5, 6·5, 8, 8, shorter internode and bud.



Both the internode-curves show an initial rise, followed by a fall, a rise, fall, rise, fall. The final descent, in any case, is due to the immaturity of the internodes.

MESEMBRYANTHEMUM FILAMENTOSUM. (Curve 15.)

A seedling of this species was uprooted, and the measurements, commencing at the cotyledonary node, were as follow :—2·5, 10·5, 16, 14, 12·5, 11, 10·5, 12, 10·5.

In this comparatively young and actively growing plant it was not possible to tell the



extent to which the internodes had attained their full length. The internode-curve is regular and normal except for the final slight rise.

AMARANTACEÆ.

This family includes both alternate- and opposite-leaved types, and species of both kinds were measured. The alternate-leaved plants belonged to the genus *Amaranthus*, the opposite-leaved plants to the genera *Gomphrena* and *Froelichia*.

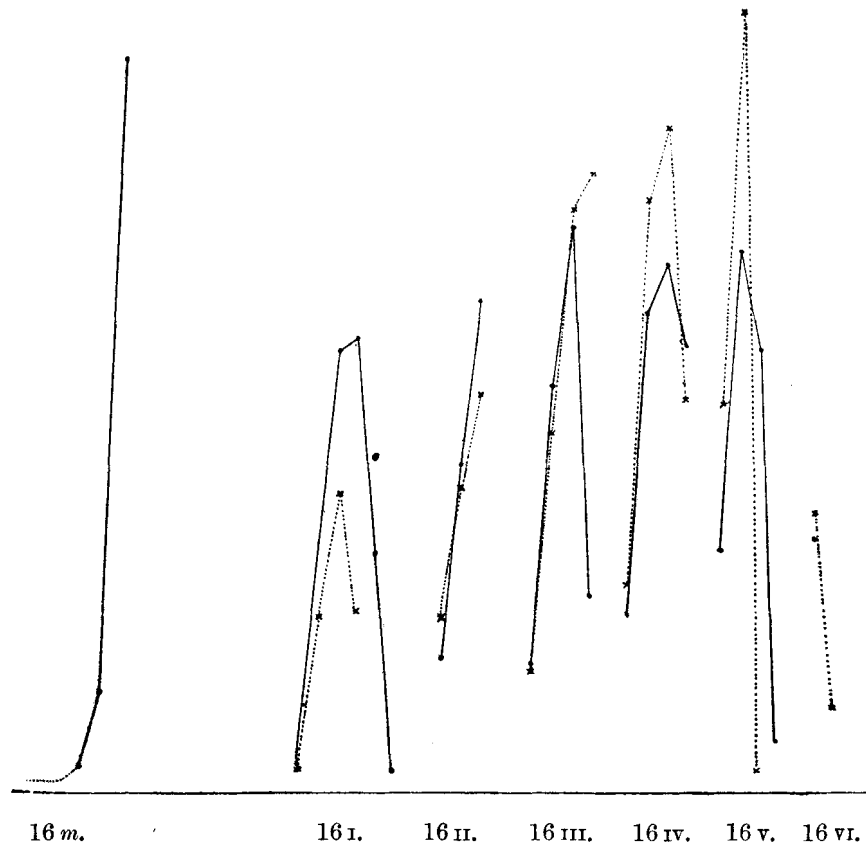
The species with cyclic phyllotaxis exhibited regular internode-curves, which strongly contrasted with the extremely irregular internode-curves of the alternate-leaved species. The sudden and frequent irregularities of the latter clearly indicated displacements of the leaves, yet analysis of the internode-curves did not yield two regular subcurves. Consequently it is impossible to decide whether the plants signify a transitional condition from cyclic phyllotaxis with two or more leaves at a node towards acyclic phyllotaxis, or the reverse. At least the facts denote leaf-displacements due to inherent characters. Yet in the alternate-leaved types the primitive opposite phyllotaxis is suggested by the divergences of the leaves at the base of the main stem, which agreed exactly or approximately with those of decussate phyllotaxis.

In this family the phenomenon of fasciation in connexion with the terminal inflorescence is closely akin to fusion of branches with the main axis in *Phytolaccaceæ* and *Chenopodiaceæ*. In all cases it is probably to be attributed to precocity of outgrowth of branches.

GOMPHRENA DECUMBENS. (Curves 16 *m*, 16 I-VI.)

This annual, opposite-leaved plant was uprooted. From the base of the main stem sprang a number of procumbent branches and accessory branches, so that it was not easy to see instantly which was the main axis; and exact measurements of the lower internodes of this were out of the question.

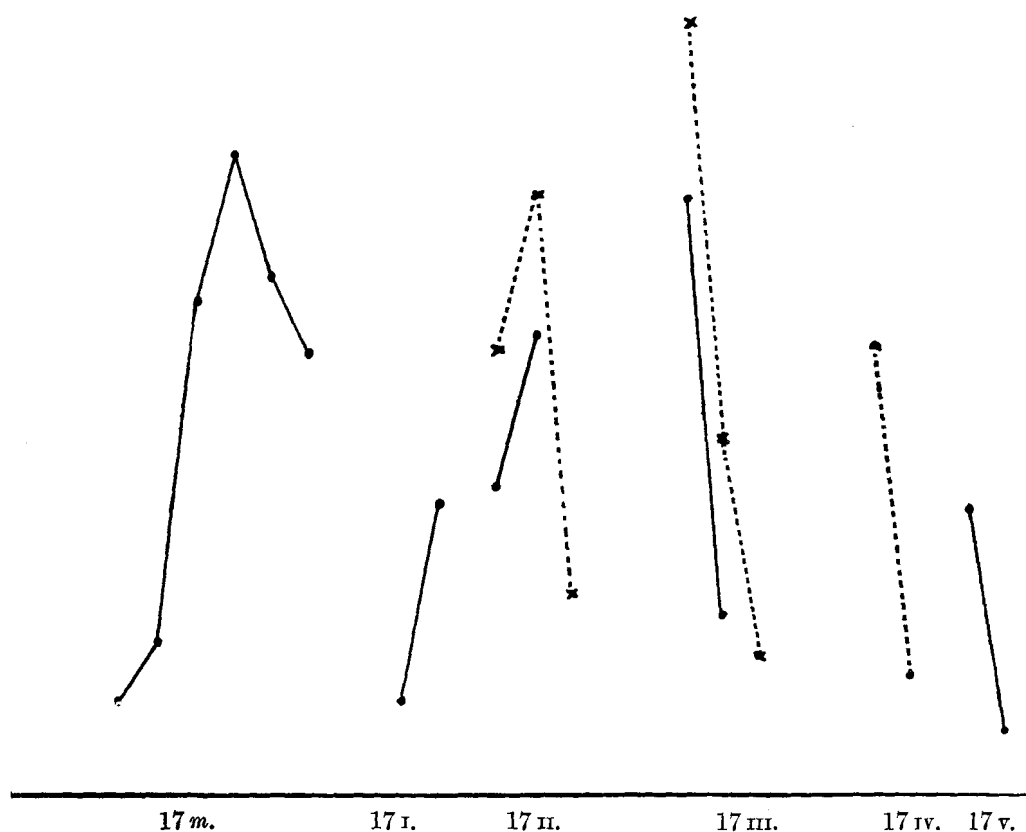
The cotyledonary scars subtended buds. The branches in the axils of the first pair of foliage-leaves are termed Branches I and I', those in the axils of the second pair of leaves Branches II and II', and so forth.



The following are the measurements made (zero-measurements representing the distance apart of the two leaves at each node are omitted) :—

Main axis . . .	? (3 <i>circa</i>)	? (3 <i>circa</i>)	? (3 <i>circa</i>)	7.25	26.5	194	Ending in a terminal infructescence.
{ Branch I . . .	6	46.5	79	..	..	..	Ending in growing bud.
{ „ I' ..	8	53	117	120	63.5	6	Ending in open terminal inflorescence.
{ „ II ..	35.5	86.5	130	..	..	..	Broken off at end.
{ „ II' ..	46	80.5	105	..	..	..	„ „
{ „ III ..	33.5	107.5	149.5	52 (<i>circa</i>)	..	..	Ending in open inflorescence.
{ „ III' ..	32.5	95.5	154.5	164	..	..	„ „ „
{ „ IV ..	47.5	126.5	140	119	..	..	„ „ „
{ „ IV' ..	55	157.5	176.5	104	..	..	„ „ „
{ „ V . . .	64	143.5	117 (<i>circa</i>)	13.5	..	..	„ „ „
{ „ V' ..	102.5	208	6 (<i>circa</i>)	..	..	..	Ending in old inflorescence.
{ „ VI ..	67	..	..	..	..	..	„ „ „
{ „ VI' ..	74	22.5	..	..	..	..	„ „ „

The regularity of the internode-curves and the orderly manner in which the successive branches change their longitudinal symmetry are especially obvious if comparison is made between the strengthened and weakened branches respectively at the successive nodes.

GOMPHRENA GLOBOSA. (Curves 17 *m*-17 *v*.)

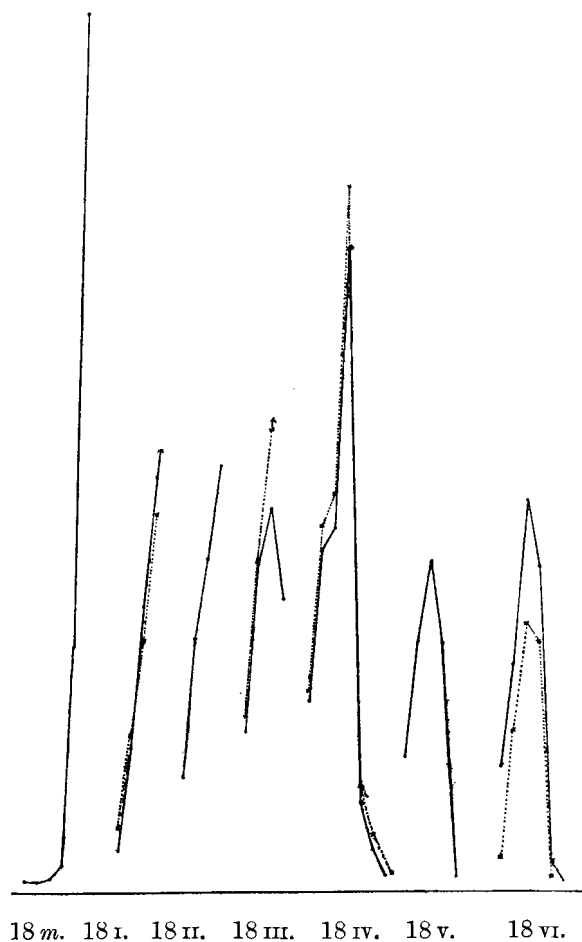
							Remarks.
Main axis....	12.5	20	64.5	85	68.5	58.5	The last measurement was to two bracts, above which succeeded the sessile terminal inflorescence and a lateral sessile inflorescence.
{ Branch I ....	..	..	..	..	..	..	Young and small.
{ „ I'	12.5	38	..	..	..	..	Ended in a young internode and an active bud.
{ „ II ..	40.5	60.5	..	..	..	..	„ „ „
{ „ II' ..	59	79.5	26.5 (young)	..	..	..	„ „ „
{ „ III ..	78.5	23.5 (young)	..	..	..	..	„ „ „
{ „ III' ..	102	47	18.5	..	..	..	„ „ „
{ „ IV ..	..	..	..	..	..	..	Young.
{ „ IV' ..	59.5	15.5 (young)	..	..	..	..	Ending in young internode and active bud.
{ „ V	38.5	8	..	..	..	..	Capped by two sessile leaves, then two bracts, and an open terminal inflorescence.
{ „ V' ..	20	..	..	..	..	..	Ending in young inflorescence (four leaves and two bracts visible).
{ „ VI ..	8	..	..	..	..	..	Ending in leaves and young open inflorescence.
{ „ VI' ..	28	..	..	..	..	..	„ „ „

This annual opposite-leaved plant was uprooted, and measurements were commenced at the lowest distinct pair of leaf-scars (of the cotyledons?). These leaves and the branches they subtend are termed I and I', similarly the branches emitted from the second node are termed II and II', and so forth.

As the leaves at all the nodes were opposite, the zero-measurements representing the longitudinal distance from one leaf to the other at a node have been omitted from the Table on p. 290. The internode-curves, so far as the limited number of internodes present allow one to see, are regular.

FROELICHIA GRACILIS. (Curves 18 *m*, 18 I-VI.)

This opposite-leaved annual herb was uprooted, and measurements began at the lowest visible leaf-scars, which subtended Branches I and I'. The remaining branches are



numbered according to the nodes (as in the case of *Gomphrena*). (In the subjoined Table the \times denotes the commencement of the terminal inflorescence, as all the leaves above this point subtended only inflorescences.)

Main axis . . .	4.5 (circa)	4.5 (circa)	5 (circa)	10	96.5	346	?	End broken off.
{ Branch I . . .	16.5	57.5	112	165	?	..	..	Ends in a long internode broken off at a length of 280 mm.
„ I' . . .	26	62	99	148	?	..	..	Ends in a long broken internode.
„ II . .	45	100	130.5	169	?	..	..	Ends in broken and decayed internode.
{ „ III . .	62.5	129	151	115	?	..	..	Ends in „decaying” internode broken at length of 180 mm.
„ III' . .	69	130	182.5	?	..	..	..
{ „ IV . .	75	134.5	143	253 ×	35	16.5	7	Ending in short internode capped by terminal inflorescence.
„ IV' . .	79	144	158	278 ×	42	22.5	7.5	
„ V . . .	53	98.5	130	97.5 ×	6	..	..	Ending in terminal inflorescence.
{ „ VI . .	49.5	89.5	154.5	127.5 ×	12	4	..	„ „ „
„ VI' . .	13.5	63.5	105	98 ×	6	..	..

All the parts measured had attained their mature length.

The regularity of the internode-curves is striking, as is the agreement between those of the pairs I and I', IV and IV'. The basal branches seem to have ascending internode-curves, but this is due to the fact that the terminal parts were decayed and had fallen. None of the branches show the descending form of internode-curve, yet Branches I to IV' display the extremely regular gradual increase in length of the basal internode as the insertion of the branch rises.

AMARANTHUS RETROFLEXUS and A. POLYGONOIDES.

The internode-curves of these alternate-leaved species contrast excessively with those of the opposite-leaved Amarantaceæ. The main axes of both show very irregular internode-curves, suggesting displacement. At the commencement of the curve it can be analysed into two regular ascending subcurves, on the assumption that the primitive arrangement was cyclic, with two leaves at a node. But soon the internode-curve becomes irregular, and the subcurves produced by the same analysis are also irregular. In both cases the repeated maxima are alternately separated by three and five leaves; such a condition would be produced if the arrangement were primitively composed of nodes with alternately three and five leaves, and these had been relatively displaced, but the original internodes had still continued to be longer than the displacement-segments.

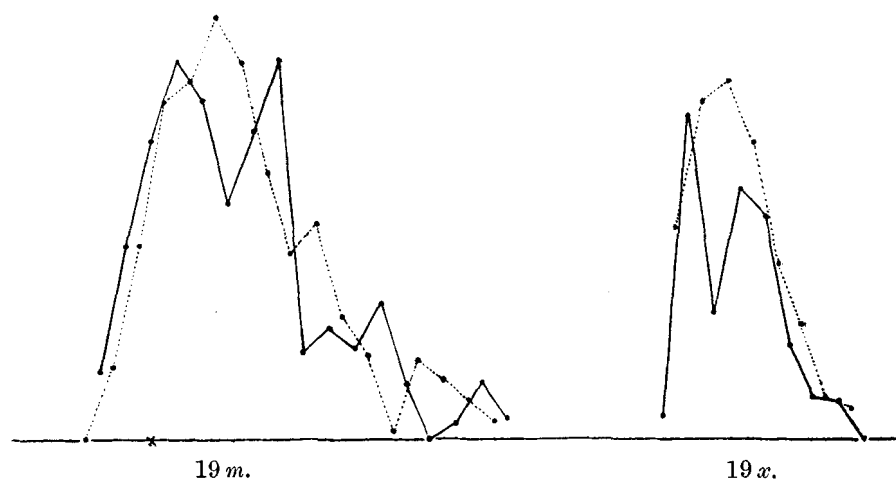
The measured branch of *A. retroflexus*, on the contrary, produced an internode-curve that analysed into two regular subcurves, disturbed only at one point in the case of the internode-subcurve.

AMARANTHUS RETROFLEXUS. (Curves 19 *m*, 19 *x*.)

This alternate-leaved annual plant was uprooted, and the measurements were commenced at the lowest indubitable leaf-scars, which were opposite and probably were

those of the lowest pair of foliage-leaves. The next two pairs of leaves were decussate, or approximately so, as regards divergence, though separated by a considerable length of stem. The following are the measurements made:—

0, 13, 14 (*circa*), 38, 38, 58, 66, 74, 70, 66, 82·5, 46·5, 73·5, 60, 52, 74, 36, 17, 42, 21·5, 24, 18, 16, 26·5, 1·5 (*circa*), 11, 15·5, 0 (*circa*), 11·5, 3, 7·5, 11, 3·5, 4.



Where the curve descends to zero the shoot is in the inflorescence region, and a phyllotaxis commences in which two subopposite leaves at a node decussate with a single leaf at the next node, as if at a number of alternate nodes one leaf in a decussate arrangement were suppressed. The measurements stopped at about the middle of the terminal compound inflorescence.

Branch x was inserted at the fifth node (marked by a \times in the curve). Its successive measurements were:—

4, 42, 63, 66, 25, 70, 49, 57·5, 43·5, 34, 18, 23, 8·5, 8, 7·5, 6, 0.

The measurements ceased at the commencement of the compound inflorescence, where the bracts began an arrangement in decussating pairs of opposite or subopposite leaves, and rapidly dwindled from small foliage-leaves to small bracts.

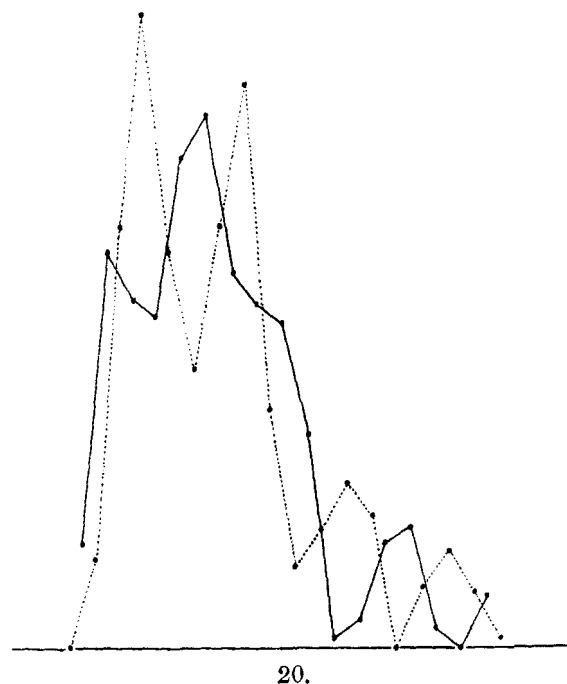
AMARANTHUS POLYGONOIDES. (Curve 20.)

This annual plant was uprooted, and measurements were begun at the lowest two scars which were opposite (and possibly represented the points of insertion of the cotyledons). The next pair of leaves were decussate in divergence, but separated by a considerable length of stem. The following are the measurements made:—

0, 20, 17, 78, 83, 68·5, 125, 65·5, 78, 97, 54·5, 104·5, 82·5, 74, 110, 67·5, 47, 64, 16, 42, 23·5, 2, 32·5, 5·5, 26·5, 21, 0, 23·5, 12, 3·5, 19, 0, 11, 10, 2.

Where the curve first sinks to zero the shoot is wholly reproductive—that is to say, it

is the terminal compound inflorescence—and the leaves begin to show signs of decussate or peculiar paired arrangements.



PHYTOLACCACEÆ.

The Phytolaccaceæ apparently include only alternate-leaved forms. Despite of the fixed nature of the acyclic phyllotaxis the internode-curves are very irregular, and there is no doubt that analysis into two subcurves removes the irregularities entirely, or at least lessens them.

Analysis of the extremely irregular internode-curve into two regular subcurves may be noted in connexion with the main axis of *Phytolacca esculenta* I. (Curve 21) and the branches of *P. decandra* I. (Curve 23 1), *P. esculenta* II. (Curve 22 1). In the first branches of these two the depression in the middle of the displacement-subcurves is doubtless due to this curve being transitional between a normal (ascending-descending) one and a purely descending one.

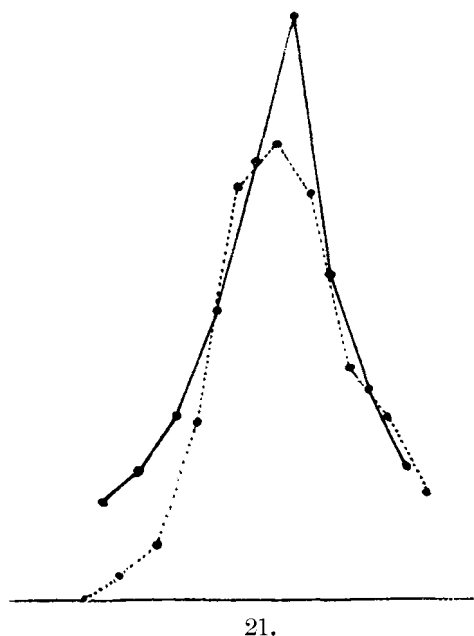
Analysis of the extremely irregular internode-curves into two considerably less irregular subcurves is represented by the relatively main stem of *Phytolacca polyandra* (Curve 24) and Branch A of *Ercilla spicata* (Curve 25 1).

Thus the internode-curves of Phytolaccaceæ point clearly towards the view that the phyllotaxis of the ancestor was cyclic. In harmony with this stands the fact that at the base of the main stems of the species of *Phytolacca* examined the divergences of the leaves more or less perfectly conform with those of decussate phyllotaxis. But, as pointed out in my previous paper, this might represent a necessary mode of transition

from the opposite cotyledons to the alternate higher leaves, and might be equally found in truly alternate-leaved types.

PHYTOLACCA ESCULENTA I. (Curve 21.)

A specimen of the seedling plant of this perennial herb was uprooted in September. Above the tuberous tap-root at the base of the stem were two large opposite buds flanked by a smaller bud on each side and subtended by a single small bud. The large buds I assume to be those on the axils of the fallen cotyledons.



Above these succeeded the decurrent bases of two fallen leaves, decussate in reference to the cotyledons, but not inserted at the same level. The distance from the cotyledons to the lower of these was 12·5 (*circa*), from the latter to the upper leaf 3 (*circa*). The succeeding two leaves were approximately decussate in reference to these, but not inserted at the same level; the interfoliar distances were 17·5 and 7·5 (*circa*) respectively. The next pair of leaves, though showing a decussate tendency, were clearly not separated by an angle of 180°; the interfoliar measurements were 24·5 and 23·5 respectively. In all the remaining leaves evidence of opposite phyllotaxis, as far as angular divergence is concerned, was lacking. The following comprise the complete series of measurements:—

0, 12·5, 3, 17·5, 7·5, 24·5, 23·5, 37·5, 54, 57·5, 60·5, 77, 54, 43, 30·5, 27·5, 24, 17·5, 14.

Measurements were stopped at this point because the internodes above were young and incomplete in length, and a number of the later measurements given here undoubtedly represent immature internodes.

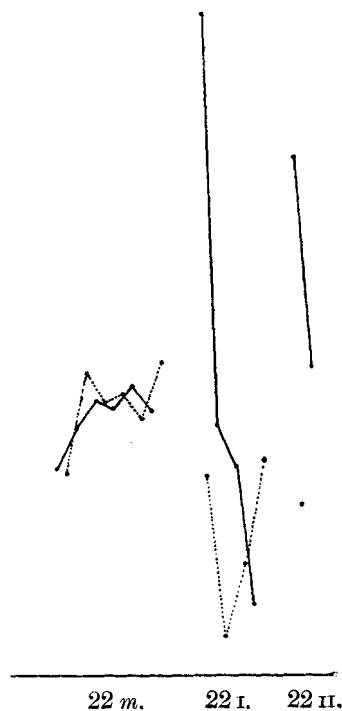
The resultant internode-curve is zigzag, but can be analysed into two very regular subcurves.

PHYTOLACCA ESCULENTA II. (Curves 22 *m*, 22 I-II.)

An erect shoot was removed close to the ground from a specimen more than one year old. The following measurements were made:—

54·5, 53·5, 65·5, 80·5, 73, 72·5, 71, 75, 77, 69, 70·5, ×, 83.

The final measurement was up to the topmost leaf, above which the axis ended in an inflorescence whose axis was “fused” with a branch (Branch II) for a distance of 39 mm. The × denotes the point of insertion of Branch I.



The measurements of Branch I were as follow:—

175, 53, 66·5, 10, 55·5, 30·5, 19, 51·5.

The last measurement is to the topmost leaf, above which the terminal inflorescence was pushed aside and fused for a distance of 7 mm. with an axillary branch.

The measurements of Branch II were as follow:—

137, 46, 82.

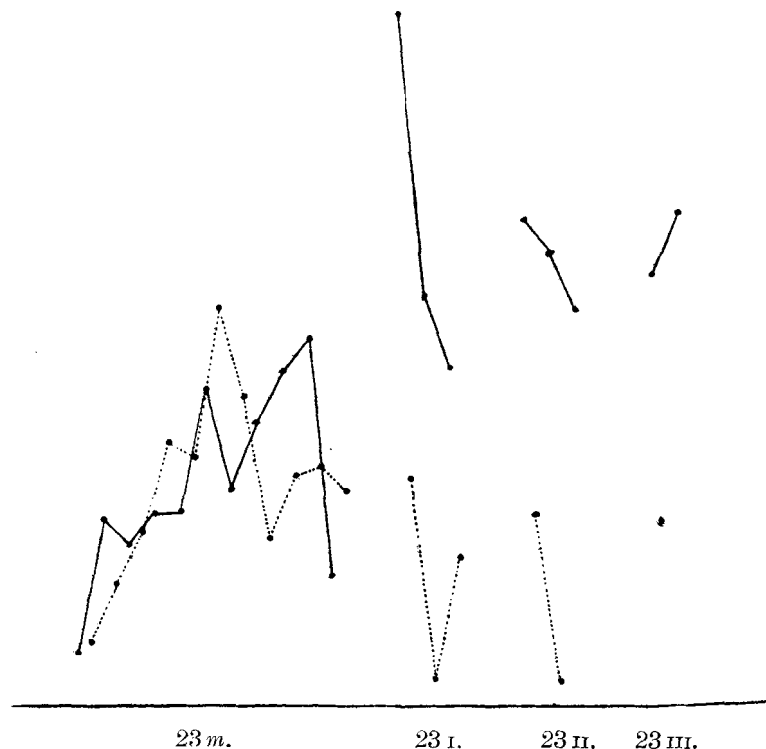
The final measurement was to the topmost leaf, above which the displaced terminal inflorescence was “fused” with an axillary branch for a distance of 11·5 mm.

The irregular internode-curve of the relatively main axis on analysis does not yield subcurves so regular as those of the true main axis; but the zigzag curve of Branch I clearly reflects the existence of two more regular subcurves, into which it can be analysed.

PHYTOLACCA DECANDRA. (Curves 23 *m*, 23 I-III.)

Measurements were made along an erect shoot, which was severed close to the ground, and along three branches of this.

The irregular internode-curve of the relatively main axis produces on analysis two subcurves that are less irregular, but do not give strong indication in favour of the view



that the phyllotaxis is derived from the opposite type. But the internode-curves of the branches, on analysis, lose their marked zigzag character, and yield regular and consistent internode-subcurves and displacement-subcurves. The likeness of the subcurves of Branch I (Curve 23 I) of this specimen to those of the branch of *P. esculenta* (Curve 22 I) is too close and characteristic to be merely accidental; in each case a double maximum of the displacement-subcurve most probably represents transition from the normal to the descending form of curve.

Measurements along the erect shoot:—

10·5, 12·5, 36, 24, 31·5, 34, 38·5, 52, 39, 49·5, 61·5, 78, 42·5, 60·5, 55·5, 33, 66, 45·5, 72, ×, 46·5, 25·5, 43.

The last measurement was from the topmost foliage-leaf to the lowest flower of the inflorescence, whose axis was “fused” with the highest branch for a distance of 31 mm. The × denotes the position of insertion of the lowest measured branch (Branch I). Branch II was inserted in the axil of the next higher leaf, and Branch III in the axil of the one above this (that is, the highest leaf).

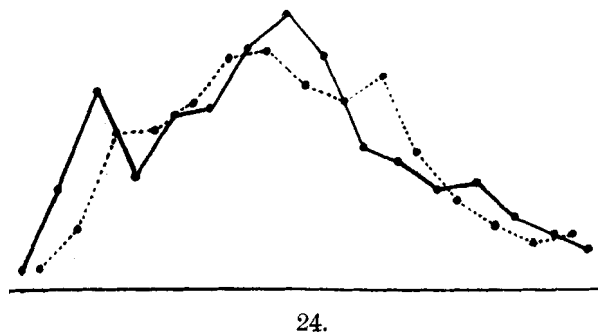
The following are the measurements made along the branches:—

Branch I. . . .	136	45	80.5	5.5	66	29.5	Last measurement was to the topmost leaf, above which was the terminal inflorescence.
„ II ..	96	38	89	5	77.5	..	Above the last measurement the axis was broken off.
„ III..	85	37.5	97	..	..	..	Above the last measurement was the terminal inflorescence.

(The measurements of this specimen are not accurate to half a millimetre, as the stems were so thick and their forms were such that it was difficult to determine the exact corresponding points of insertion of the different leaves.)

PHYTOLACCA POLYANDRA. (Curve 24.)

A seedling plant was uprooted in September, and showed at the base of its stem two opposite large buds, both flanked on each side by a smaller bud. Higher up and decussate with these large buds were two that were obviously in the axils of fallen leaves, which, however, were not inserted at the same level. The succeeding two pairs of leaves



showed the decussate design, and the next pair tended towards it, though the angles separating the two leaves were clearly not 180° . In fact the phyllotaxis at the base of this seedling much resembled that of *Phytolacca esculenta*. The following were the measurements made, commencing at the lowest two opposite buds:—

0, 3, 3 (*circa*), 13.5, 8.5, 26, 20.5, 14.5, 21, 23, 25, 24.5, 31, 32.5, 32, 37, 27, 32, 25, 19, 28.5, 17.5, 18.5, 14, 12, 14.5, 8.5, 9.5, 6.5, 7.5, 7.5, 5.5.

The last measurement was to the topmost leaf, above which was the young terminal inflorescence. A number of the upper internodes were obviously immature.

The zigzag internode-curve is clearly capable of analysis into two consistent and fairly regular subcurves.

ERCILLA SPICATA. (Curves 25 *m*, 25 *l*.)

The lateral shoot measured showed at its base a number of very short internodes, which were ignored. Above these the following were the successive measurements:—

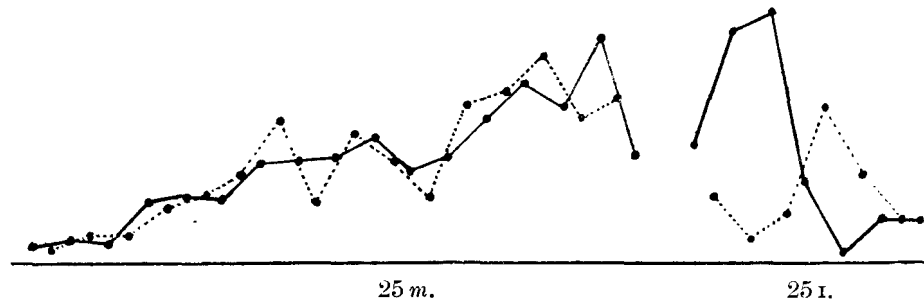
2·5, 2, 3, 3·5, 2·75, 3·5, 8, 7·5, 8·5, 9, 8·5, 12, 13, 18·5, 13·5, 8, 14·5, 17·5, 17, 13·5, 12, 8·5, 14, 21, 19, 22, 23·5, 27, 21, 19·5, 29·5, 22, 14.

A little above the last measurement the branch-end was broken off.

Branch A given off from the preceding gave the following measurements:—

15·5, 8, 30·5, 3·5, 33, 6·5, 11, 20·5, 1·5, 11·5, 6, 6, 6.

Above the last measurement the end of the shoot was broken off.



The irregular internode-curve of the relatively main axis when analysed does not yield two regular subcurves, and thus supplies no evidence of any primitive opposite phyllotaxis (when analysed into three subcurves these are moderately regular). But the Branch A shows an irregular internode-curve which yields two very different but almost regular subcurves, each of which is disturbed at only one point; the double maximum of the displacement-subcurve cannot, however, be assumed to be a sign of a transition from the normal (ascending-descending) curve to a descending curve, for in other cases this curve undergoes such a change later than the internode-subcurve.

PORTULACCACEÆ.

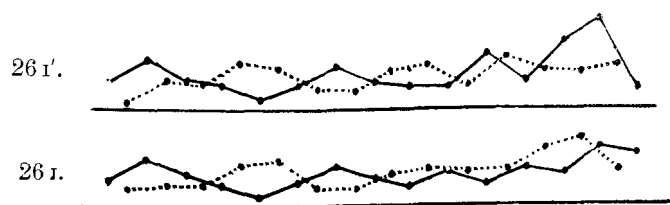
This family includes both alternate-leaved and opposite-leaved species. I examined one of the former, namely:—

CALANDRINIA PILOSIUSCULA. (Curves 26 *l*, *l'*.)

A specimen of this species was uprooted. The base of the main stem showed indistinct scars and, a little higher up, a cluster of branches. The lowest two of these were approximately opposite, and the following pair seemed to be approximately decussate in reference to them. The lowest two branches (Branches *I* and *I'*) were measured. Each ended in a terminal flower, to the peduncle of which the continuing branch was “fused.” The last measurement in each case was to the topmost leaf beneath the terminal flower.

The internode-curves are irregular and zigzag, but show strong likeness to each other, and this likeness is even more striking when comparison is made between the first two-thirds of the two internode-subcurves and the two displacement-subcurves

respectively. The subcurves are certainly consistent, though they show an undulating form, and in each internode-curve there is, in the first two-thirds, a clear indication



of the two subcurves acting in the reverse manner at each point—that is to say, when the one rises the other falls. The internode-curves thus indicate leaf-displacements, while the subcurves, though they harmonize with the view that the phyllotaxis was originally opposite, yet are not sufficiently regular to confirm this view strongly.

Measurements:—

Branch I: 3·5, 2·5, 6, 2·75, 4, 2·75, 2·75, 5·5, 1, 5·75, 3, 2, 5·5, 2, 3·5, 4, 2·5, 5, 4·5, 4·5, 3, 4·75, 5, 7·5, 4, 9, 7·5, 4·5, 6·5.

Branch I': 3·25, 1, 6·5, 3·5, 3·5, 3, 3, 6, 1, 5·5, 3·5, 2·5, 5·5, 2·5, 3·25, 5, 2·75, 5·5, 2·75, 2·75, 7, 6·5, 3·5, 5, 8·5, 4·5, 11·5, 5·5, 2·5 (young).

EXPLANATION OF CURVES.

Excepting where specially indicated, the plain lines denote internode-subcurves, while the dotted lines denote displacement-subcurves.

Atriplex rosea.

Page 273. 1 *m.* Main stem of Specimen I₃₈.

1 I.	1st branch of	„	} Natural size.
	2nd	„	
1 II.	3rd	„	
	4th	„	
1 III.	5th	„	
	5th*	„	
	6th	„	

Page 274. 2 *m.* Main stem of Specimen I₁₀.

2 I.	1st branch of	„	} Natural size.
	2nd	„	
2 II.	3rd	„	
	4th	„	
2 III.	5th	„	
	6th	„	

Page 275. 3 *m.* Secondary (relatively main) axis of Specimen 192.

3 I.	Tertiary axis 1 (1st branch) of Specimen 192.		} Reduced to $\frac{2}{3}$.
3 II.	„	2 (2nd branch) „	
3 III.	„	3 (3rd branch) „	
3 IV.	„	5 (5th branch) „	
3 V.	„	5' (accessory 5th branch) of Specimen 192.	

- Page 276. 4 *m.* Secondary (relatively main) axis of Specimen 191. }
 4 I. Tertiary axis 2 (2nd branch) of Specimen 191. } Natural size.
 4 II. „ 4 (4th branch) „ }
 4 III. „ 5 (5th branch) „ }
 4 IV. „ 7 (7th branch) „ }
- Page 277. 5 *am.* Tertiary axis A of Specimen 187. }
 5 I. Quaternary axis 1 (1st branch) on axis A of Specimen 187. } Natural size.
 5 II. „ 3 (3rd branch) „ „ }
 5 III. „ 4 (4th branch) „ „ }
 5 IV. „ 5 (5th branch) „ „ }
 5 *bm.* Tertiary axis B of Specimen 187. }

Salsola Kali.

- Page 281. 6 *m.* Main stem of Specimen 8. }
 6 I. Cotyledonary branch of Specimen 8. } Natural size.
 6 II. Second branch of Specimen 8. }
 6 III. Third „ „ }
- Page 281. 7 *m.* Main stem of Specimen 10. }
 7 I. Cotyledonary branch (*a*) of Specimen 10. } Natural size.
 7 I'. „ (*b*) „ }
 7 II. Second branch of Specimen 10. }
 7 III. Third „ „ }
 7 IV. Fourth „ „ }
 7 V. Fifth „ „ }

Chenopodium Bonus-Henricus.

- Page 283. 8. Main stem of Specimen 32. Natural size.
 „ „ 9. „ „ 34. Natural size.

Lychnis diurna.

- Page 284. 10 *m.* Relatively main shoots I and II. }
 10 *a.* Branch *a* on shoot II. } Reduced to $\frac{1}{2}$.
 10 *b.* „ *b* „ }
 10 *cc'*. Branches *c* and *c'* on shoot II. }

Stellaria media.

- Page 285. 11. Main axis. Natural size.

Cerastium arvense.

- Page 286. 12. Specimen I. Natural size.
 „ „ 13. „ II. Natural size.

Mesembryanthemum echinatum.

- Page 287. 14 I. Branch I. }
 14 II. „ II. } Natural size.

Mesembryanthemum filamentosum.

- Page 288. 15. Main axis. Natural size.

Gomphrena decumbens.

- Page 289. 16 *m.* Main axis. }
 16 I. Branch I (plain line) : Branch I' (dotted line and ×'s). } Reduced to $\frac{1}{2}$.
 16 II. „ II „ „ II' „ „ }

16 III.	Branch III (plain line):	Branch III' (dotted line and ×'s).	} Reduced to $\frac{1}{2}$.
16 IV.	„ IV „ „	IV' „ „	
16 v.	„ V „ „	V' „ „	
16 VI.	„ VI (a plain dot): „	VI' „ „	

Gomphrena globosa.

Page 290.	17 m.	Main axis.	} Natural size.
	17 I.	Branch I'.	
	17 II.	„ II (plain line): Branch II' (dotted line and ×'s).	
	17 III.	„ III „ „ III' „ „	
	17 IV.	„ IV'.	
	17 v.	„ V.	

Froelichia gracilis.

Page 291.	18 m.	Main axis.	} Reduced to $\frac{1}{3}$.
	18 I.	Branch I (plain line): Branch I' (dotted line and ×'s).	
	18 II.	„ II.	
	18 III.	„ III (plain line): Branch III' (dotted line and ×'s).	
	18 IV.	„ IV' „ „ IV' „ „	
	18 v.	„ V.	
	18 VI.	„ VI (plain line): Branch VI' (dotted line and ×'s).	

Amaranthus retroflexus.

Page 293.	19 m.	Main axis.	} Reduced to $\frac{2}{3}$.
	19 x.	Branch x on the main axis.	

Amaranthus polygonoides.

Page 294.	20.	Main axis.	Reduced to $\frac{2}{3}$.
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Phytolacca esculenta.

Page 295.	21.	Main axis of Specimen I.	Natural size.
Page 296.	22 m.	An erect shoot (relatively main axis) of Specimen II.	} Reduced to $\frac{1}{2}$.
	22 I.	Branch I on the relatively main axis of Specimen II.	
	22 II.	„ II „ „ „	

Phytolacca decandra.

Page 297.	23 m.	Erect (relatively main) stem.	} Reduced to $\frac{2}{3}$.
	23 I.	Branch I on the erect stem.	
	23 II.	„ II „ „	
	23 III.	„ III „ „	

Phytolacca polyandra.

Page 298.	24.	Main stem.	Natural size.
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Ercilla spicata.

Page 299.	25 m.	Shoot (relatively main stem).	} Natural size.
	25 I.	Branch A on the relatively main stem.	

Calandrinia pilosiuscula.

Page 300.	26 I.	Branch I.	} Natural size.
	26 I'.	„ I'.	